The Changing Academy – The Changing Academic Profession in International Comparative Perspective 22

Timo Aarrevaara
Martin Finkelstein
Glen A. Jones
Jisun Jung *Editors*

Universities in the Knowledge Society

The Nexus of National Systems of Innovation and Higher Education

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Volume 22

The landscape of higher education has in recent years undergone significant change. This has been particular the case for research training, academic life, employment, working conditions and entrepreneurial activities of universities around the globe. The academy is expected to be more professional in teaching, more productive in research and more entrepreneurial in everything. Some of the changes involved have raised questions about the attractiveness of an academic career for today's graduates. At the same time, knowledge has come to be identified as the most vital resource of contemporary societies. The Changing Academy series examines the nature and extent of the changes experienced by the academic profession. It aims to address these changes from an international comparative perspective, focusing at both the higher education system level as well as the STEM fields of science, technology, engineering and mathematics in particular. It explores both the reasons for and the consequences of these changes. The series considers the implications of the changes for the attractiveness of the academic profession as a career and for the ability of the academic community to contribute to the further development of knowledge societies and the attainment of national goals. It provides analyses on these matters drawing initially on available data-sets and qualitative research studies with special emphasis on the international studies of the Changing Academic Profession and the national surveys in STEM fields. Among the themes featured will be: • Relevance of the Academy's Work • Enrolment, graduation and the institutional setting of STEM • Research, development and technology policies with regards to STEM • Internationalization of the Academy Governance and Management • The new generation in the academic profession – the doctoral graduates Editorial Board: Elisabeth Balbachevsky, Department of Political Science, University of Sao Paulo, Brazil Jung Cheol Shin, Department of Education, Seoul National University Ulrich Teichler, International centre for Higher Education research (INCHER), University of Kassel William Cummings, Graduate School of Education and HD, George Washingtion University Akira Arimoto, Kurashiki Sakuyo University, Okayama.

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Editors

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Editors
Timo Aarrevaara
Faculty of Social Sciences
University of Lapland
Rovaniemi, Finland

Martin Finkelstein
Higher Education Department
Seton Hall University
South Orange, New Jersey, USA

Glen A. Jones
OISE
University of Toronto
Toronto, ON, Canada

Jisun Jung
Faculty of Education
The University of Hong Kong
Hong Kong SAR, China

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This is the first volume of a new Springer book series entitled “The Changing Academy – The Changing Academic Profession in International Comparative Perspective” that will focus on the analysis of data from a major international study entitled the Academic Profession in the Knowledge-based Society (APIKS). The history and development of the APIKS study is described in detail in chapter four of this volume. The APIKS project relies fundamentally on the hard work and collegiality of research teams located in jurisdictions around the world that have come together to further our knowledge of the academic profession through international/comparative analysis. This volume provides an essential foundation for this continuing work, and we acknowledge the tremendous scholarly contributions of our authors. We also note that most of these papers were written in the context of a global pandemic, and that many of our contributors faced unique personal and professional challenges. Our sincere thanks to all of you!

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Part I
Overview

Chapter 1
Universities and the Knowledge Society: An Introduction

Timo Aarrevaara, Martin Finkelstein, Glen A. Jones, and Jisun Jung

Abstract This chapter introduces the foundational volume in Springer's Changing Academy Series, previewing the results of the Academic Profession in the Knowledge-Based Society [APIKS] global survey of 22 higher education systems. It begins by introducing the twin concepts of the *knowledge society* and the *knowledge economy* and provides a quick overview of the emerging literature, chronicling the transformation of the global economy and the associated pressures to reform and redesign higher education systems in its wake. We trace much that is common among those reforms globally, including declining public subsidies to the university, the introduction of new stakeholders into the academic enterprise, the decline in faculty control, the rise of academic management, and new work pressures to be entrepreneurial, and focus on income-generating research activity. This is followed by 18 chapters that provide case studies of the responses of 18 higher education systems to the new regime. The cases span five continents and various stages of economic development and wealth. The chapter concludes with a few emerging generalizations.

Keywords Academic profession · Globalization · Knowledge economy · Knowledge society · Research and innovation

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T. Aarrevaara (✉)
Faculty of Social Sciences, University of Lapland, Rovaniemi, Finland
e-mail: Timo.Aarrevaara@ulapland.fi

M. Finkelstein
Seton Hall University, South Orange, NJ, USA
e-mail: Martin.Finkelstein@shu.edu

G. A. Jones
OISE, University of Toronto, Toronto, ON, Canada
e-mail: glen.jones@utoronto.ca

J. Jung
Faculty of Education, The University of Hong Kong, Hong Kong SAR, China
e-mail: jisun@hku.hk

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Introduction

We are in the midst of a transformation in the world economy and society at least as profound as that precipitated by the Industrial Revolution in the nineteenth century. While vantage points and nomenclature may differ, there is a broad awareness that the world economy is increasingly interconnected and increasingly laser-focused on knowledge and innovation as the "coin of the realm." Wars that were once fought over physical territory are now increasingly fought over intellectual property and access to knowledge, using weapons of international finance. As the historic institutional seat of formal learning and scholarship, the world's universities are now increasingly thrust—somewhat reluctantly, to be sure—into the very center of the new knowledge-based order. There are new pressures and expectations for universities to contribute to scientific and technological advancement and to serve increasingly as the drivers of the new, knowledge-based economy. This newfound centrality has raised the stakes with multiple constituencies, including government and industry, aggressively asserting their interests and politicizing the enterprise.

Basic Concepts

Basic research as the province of universities has yielded its centrality to broader societal expectations associated with the *knowledge society*, the *knowledge economy*, *targeted research*, and *mode 2* knowledge production (Teichler et al., 2013). External activities, societal interaction, and engagement are challenging the traditional modes of work in the academy. The knowledge society refers to the processes typical of post-modern societies (Bell, 1972; Drucker, 1993). In the literature, the knowledge society is linked to the importance of knowledge in society, the phenomenon of the knowledge economy, internationalization and, more broadly, the theme of globalization, and the relevance of markets to higher education. Although these global trends are strong, they manifest in different ways in different higher education systems and, given unique jurisdictional contexts, indicate very different implications for, and impacts on, higher education institutions and the academic profession (Trowler, 1998; Leisyte, 2011).

The knowledge *society* can be considered to encompass at least three dimensions of globalization (Delanty, 2002). First, the role of the state as a gatekeeper for knowledge and its production is diminishing; second, access to knowledge is more equitably distributed in society; and third, there is a growing demand for knowledge and its credible production in society. These three features of the knowledge society may emerge at different times in different settings, as they provide a framework and concepts for interpreting distinctive experiences and contexts. Knowledge society-based frameworks also provide a tool for understanding national and regional interests and the origins and importance of national higher education systems (Välimaa & Hoffman, 2008).

The knowledge *economy*, a concept that is closely related to the knowledge society, looks at how intellectual capital is fast replacing production capital as an arbiter of value and transforming the nature and structure of work, efficiency, and the division of labor (Drahos & Braithwaite, 2017). Both concepts have been applied to the understanding of higher education and its roles in society. Over the last few decades there has been a dramatic increase in research focusing on the ways in which the knowledge economy repositions the university in the context of national research and innovation systems, and the shifting relationships between universities and communities, defined both broadly and locally, in which institutions reside. All of these shifts and transitions have important implications for the nature of the academy and for the future of work in the academy.

The Academic Profession in the Knowledge-Based Society (APIKS)

As a direct response to the increasing centrality of knowledge to global economic development and the repurposing of national higher education systems across the globe, the Academic Profession in the Knowledge-Based Society (APIKS) project emerged from a series of meetings beginning in 2014 to channel/focus the continuing work of a cadre of scholars and researchers. Many of these scholars participated in the implementation of earlier surveys, such as the Carnegie Foundation for the Advancement of Teaching's International Survey of the Academic Profession in 1992–1993 (Altbach & Boyer, 1996) and in 2007–2008 with the Changing Academic Profession (CAP) project (Teichler et al., 2013), and/or successor studies, including the Academic Profession in Europe—Responses to Societal Challenges (EUROAC) and Academic Profession in Asia (APA), among others (Teichler et al., 2013). The APIKS project is a collegial consortium of national research teams administering a common survey that will provide essential data on the changing academic profession in the shifting context associated with the knowledge economy/society. It is the largest comparative/international study of higher education that has ever been undertaken.

This volume is the first in a series of ten volumes that reflect the scope and substance of the APIKS project—providing an empirical snapshot of the state of higher education and the academic profession as it navigates the transition to a new order and finds its footing in the new knowledge society and economy. The comparative focus of subsequent publications will be thematic (focusing on the detailed exploration of a specific topic or issue) and/or longitudinal (analyzing trends over time and drawing on results from earlier, related studies, as described in Chap. 4). We invite the reader to join us for this tour of the new terrain of global higher education!

The Purpose of This Volume

In light of these developments, this volume has two purposes. First, it provides a conceptual overview of the extant discourse on the knowledge society/economy: its historical emergence, the major threads of contemporary analysis of these developments, and, most importantly, a conceptual map of how, in response, public and private higher education systems are being transformed—and in some cases, transforming themselves—to respond to the imperatives of the new order. Second, it complements the conceptual analysis with a descriptive (and analytical) overview of how the 18 higher education systems—developed and developing, Western and Eastern—are in practice redesigning their research, development, innovation, and educational research systems to compete in what is becoming an increasingly globalized knowledge production market. The description and associated analysis highlight the "messiness" and unevenness of the transformation and both the common and distinctive elements of negotiating this great academic disruption.

The Emergence of Knowledge as a Driver of Economic Growth

In Part I, this volume considers how the knowledge society is interrelated to higher education systems as well as economic production systems. Different disciplines have approached analyses of the knowledge society from differing perspectives. In sociology, the Mertonian concept of public knowledge has long dominated academic discussion, challenged by emerging trends toward being more proprietary, local, authoritarian, commissioned, and expertise-based (Ziman, 2000). This zimanian development has emphasized the significance of strong research evaluation systems, competitive research funding, and research management. In addition, V. Bush's proposal for the division of labor between university, government, and private sectors has provided the political and financial grounds for designing research systems in the United States of America (USA) (Dickson, 1984). However, the sociological understanding of scientific knowledge and the division of labor between sectors to promote scientific development were challenged by the political and economic changes of the 1970s and 1980s, when the British and US governments suffered from financial constraints and economic recession. The Thatcher Administration (UK) and the Reagan Administration (USA) began to encourage universities to participate in innovative activities to generate external resources while at the same time both governments reduced public funding for higher education.

The US government passed the Bayh-Dole Act in 1980 to encourage universities to become involved in innovation and entrepreneurial activities (Slaughter & Rhoades, 2004). The Act allows an individual university to use research outputs (e.g., patents) to generate economic resources for their own benefit. The Act was a turning point, transforming policymakers' views of knowledge from a public good to a *semi*-public good. This approach to knowledge and innovation has been widely embraced with the globalization of the world economy since the 1990s. In addition, new industries such as information technology have grown rapidly and the successes of some countries are benchmarked by others. These policy initiatives were supported by innovation researchers in the fields of economics and business administration and work contexts (Olssen & Peters, 2005). In addition, the view of knowledge as an economic driver has changed as a result of the theoretical interdisciplinary discourses and approaches. For example, Gibbons and associates' (1994) concept of *mode 2* knowledge production emphasizes socially relevant and marketable knowledge rather than disinterested academic inquiry-driven knowledge.

Higher Education System Reforms

In the changing policy and economic contexts, public policy for higher education, especially funding policy, has changed dramatically (Austin & Jones, 2016). Government policy encourages universities to produce socially relevant knowledge and technology to support the economic competitiveness of the jurisdiction. In addition, governments increasingly emphasize employability and market relevance in relation to education. These changing policy directions were reinforced through new funding mechanisms which emphasized institutional performance, frequently measured by predetermined performance indicators. Examples of these mechanisms include performance-based funding and assessment-based contract funding as distinguished from enrollment or consumer demand-driven funding. The new funding mechanisms do not necessarily require the government to be directly involved in decision-making at an individual university. Rather, the government steers the university through the funding mechanisms and this policy approach has been widely adopted under the banner of new public management (Austin & Jones, 2016). As a result, evaluation and assessment by the government and/or through its agencies is becoming a major policy tool to influence the university from a distance. More recently, universities have begun taking a leading role in technology transfer processes, including engagement and external activities, and establishing on-campus patent and technology transfer offices that span boundaries between their science laboratories and the design and production capabilities of industry. Second, universities—especially in their professional and graduate programs—educate the human capital to staff the engines of research, development, and innovation (RDI). Finally, universities and their academic staff play a key role in applying knowledge production to social betterment, in terms of improving health, longevity, political participation, personal happiness, and prosperity (Shin & Cummings, 2014).

With these transformative reforms in public policy, higher education systems have been rapidly changing in many countries and regions. European countries launched the European Union (EU) in 1993 to address globalization after the Cold War. The EU is a continuation of the Treaty of Rome (1957) and, after the Brexit process, consists of 27 European countries in 2021. In the higher education sector, the Lisbon Strategy of 2000 and the Bologna Process of 1999 were the political responses to the new economic and political challenges. The Bologna Process led European countries to shift the focus of their higher education policies to emphasize future human resource needs in a world increasingly without borders. The Lisbon Strategy identified knowledge production as an engine of economic competitiveness in Europe.

Strong government-driven policies to foster the research capacity of higher education institutions were a common direction of reforms in East Asian territories like China, Japan, South Korea, and Taiwan. Although the key policy directions were complex in each geographic context, they were all based on aggressive investment in research and development and in doctoral education. This has resulted in significant improvements in research performance over the last two to three decades, not only in outputs but also in terms of visibility on the international scene (Altbach & Balán, 2007). These policies were intertwined with economic development targets in a global knowledge economy, and the focus has been moving toward scientific advancement with global relevance. They also address challenges like working conditions for academics and training future generations of scholars, most notably doctoral education, in the wake of the rapid expansion of research and development. Similar policies were implemented in Latin America to build research-intensive universities and lead the global knowledge economy. Although some policies led to remarkable achievements, many institutions and academics are still struggling to develop research capacity due to limited resources and the traditional emphasis on teaching as the university's core mission (Horta et al., 2016).

A Repurposed, Newly Vulnerable Academic Profession

At the center of this re-orientation of higher education, we find an academic profession that is at once more central to the long-term economic strength of nations but also increasingly vulnerable as many of its values and practices are questioned and indeed disrupted, and it seeks to re-establish its footing in the emerging new order. Formerly, academics were the key actors in higher education institutions, but external stakeholders, such as policymakers and business leaders, began to emerge as more powerful actors within university governance (Austin & Jones, 2016). Institutional managers who were previously regarded as the "first among the equals" began to emerge as *chief executive officers*. Although academics enjoy significant freedom in their research and teaching, their performance is increasingly monitored and evaluated by institutional managers and external stakeholders (Geschwind et al., 2019). Concerns about the deteriorating nature of the academic work environment, and the increasing use of precarious academic workers to fulfill functions previously performed by faculty (academic staff) with considerable job security and autonomy, have been noted in many systems (Finkelstein & Jones, 2019). In this context, there are concerns that academic job satisfaction may be declining and job stress increasing. It is ironic to think that academics are not very happy in the knowledge society even though their knowledge production is highly encouraged, funded, and valorized.

The View on the Ground

The book is divided into three parts. Part I (Overview) starts with this introductory chapter by the co-editors, Timo Aarrevaara, Martin Finkelstein, Glen A. Jones, and Jisun Jung. Then, Teresa Carvalho discusses the changing role of knowledge in contemporaneous societies. She traces the evolution of the nineteenth-century Humboldtian university focused on basic research to the post-industrial university focused on transforming the university—and integrating it—as the engine of the larger innovation system driving and sustaining economic growth (Chap. 2). Olga Bain and William Cummings define the emerging role of higher education in the globalized knowledge economy, reviewing the economic and sociological metrics that are employed to assess competitiveness in the knowledge economy (Chap. 3). Timo Aarrevaara, Martin Finkelstein, Glen A. Jones, and Jisun Jung discuss the development, evolution, and objectives of the Academic Profession in the Knowledge-Based Society (APIKS) project (Chap. 4). This large, international/comparative research initiative will explore the experience of academics within the changing context associated with the knowledge economy/society.

In Part II of this volume, we focus on the adaptations of 18 higher education systems to the demands of the knowledge society and economy. Each chapter starts with a description of the research and innovation system and the recent structural and policy changes—in and outside the higher education system—in response to the imperatives of the knowledge society. The goal of each individual chapter is to tell a clear and compelling story about the organization of the higher education system, its relationship with the national research and innovation system, and adjustments over the past quarter century to address the twin pressures of massification and of the demands of assuring competitiveness in the global knowledge economy. Second, each chapter describes the changing contours (profile) and fortunes of the academic profession and prospects for its future reflected in the increasing importance of graduate and advanced professional education. Third, each chapter provides an overview of the *service* role of universities—to the extent it exists—in the national context.

In Part III the co-editors provide a summary of key findings through a cross-case analysis of the 18 system chapters and highlight a number of key questions for further investigation in the APIKS project. The volume provides the critical background for interpreting the data analyses reported by individual countries of their academic surveys in subsequent volumes of the Springer Changing Academy series. At the same time, we are also seeking to provide a modicum of common content across national chapters so that the reader can be provided with a set of categories and metrics which allow them to begin to compare national stories.

Some Preliminary Findings

Across these 18 stories, a few key themes have begun to emerge. The first is the urgent and pro-active policy re-direction of public higher education systems. In the past decade, every jurisdiction has experienced major reform initiatives designed to expand and to strengthen the research and innovation system, seeking to create, sometimes from scratch, "world-class" universities. Such initiatives typically include a focus on increasing competition among institutions and among individual faculty, seeking to target resources to increase research quality and productivity. It typically involves the adoption of international standards of scholarship and expanding the locus of competition beyond national boundaries—in effect globalizing the industry. This has meant increasingly engaging the private sector in national and regional RDI initiatives and extending greater autonomy from government to individual institutions to chart their own futures—a newfound independence that promises greater freedom for new initiatives but also courts the greater risks of failure. For the academic profession it has meant, in some systems, the increasing elimination of secure employment and dependable sources of research funding upon which to fashion a career. It has increasingly rewarded—indeed demanded—a new set of entrepreneurial behaviors and skills on the part of academic staff. In some jurisdictions, it is fragmenting the academic profession into a small contingent of well-resourced, permanent staff and a large and growing group of temporary or contingent staff with increasingly loose ties to the enterprise and its future.

As the first case study chapter, Florence Ndibuza, Patrício V. Langa, and Ronald Bisaso describe the role of higher education in Uganda's national research and development system (Chap. 5). Despite a low level of scientific outputs, the Ugandan government is making efforts to turn universities into active knowledge producers and drivers of economic development. Certain positive improvements are noted, such as an increase in research outputs and further investment plans for university research; however, as in many other African countries, the Ugandan case reveals the challenges of limited resources and research infrastructure for research and development. The authors also expose the difficulties involved in developing system-wide research capacity given a lack of human resources.

Turning to the Asian region, Hong Shen and Jinwen Luo define the relationship between higher education and the knowledge economy in China from the angle of talent flow in the research and innovation system (Chap. 6). They emphasize the important role of higher education institutes and human resource development within the national innovation system. They conclude that there is a need for reform in the innovation and higher education systems in China and for an open academic market for high-quality innovation in ideas, science, and technology.

Robin Jung-Cheng Chen and Sophia Shi-Huei Ho examine the interaction between research infrastructure and higher education in Taiwan (Chap. 7). They analyzed how the Taiwanese system has been trying to promote academic distinction after a period of rapid system expansion while also shrinking in response to demographic decline.

Akira Arimoto, Tsukasa Daizen, and Futao Huang describe how the national research and development system in Japan has contributed to the research competitiveness of the country's higher education institutions (Chap. 8). They offer a chronology of key national innovation policies and suggest upcoming challenges in the Japanese academic profession, such as employment markers for new doctorates and the creation of a working environment that encourages a commitment to research among academics.

Soo Jeung Lee and Hyejoo Jung describe the advances in scientific knowledge and technology in South Korea and how the research and development system is related to its economic growth (Chap. 9). In addition, they present how the research and development system has affected the expansion of higher education and the remarkable growth of knowledge production. Driven by top-down government policies, the authors raise important questions on the implications of increased research funding on the development of institutional research culture and the academic profession.

The higher education and innovation system plays a crucial role in Turkey's vision to become one of the top ten global economies by 2023. The gap between system development and science and technology policy is obvious, as the innovation ecosystem has made financially possible the expansion of the scholarly profession in last 15 years. Baris Uslu, Alper Calikoglu, Fatma Nevra Seggie, Sedat Gumus, and Yasar Kondakci describe the dynamics of private and public institutions in the national innovation system in Turkey (Chap. 10).

Russian Federation universities have traditionally had a responsibility for education and research, and there is a non-teaching research sector that is differentiated into separate academies under Ministries. This system is partly overlapping and has been complemented since the 1990s by the private research sector and private universities. Anna Panova and Maria Yudkevich (Chap. 11) draw attention to how reforms have fundamentally changed the role of the scholarly profession in society, status, and prestige. Convergence of the higher education and non-teaching research sectors has also meant an increasing role of the higher education sector in research and development.

Developing systems face profound challenges as they seek to compete without a well-developed infrastructure as seen in the cases of the former Soviet republics of Lithuania and Estonia. While Lithuania (Chap. 12) has sought to leverage public-private investments and European structural funding to bolster research and innovation, this effort has been complicated by unfavorable demographic trends. Estonia (Chap. 13) was successful in rapidly transforming its economy and its research and development infrastructure, but now faces important challenges associated with low salaries for academic professionals and new research funding mechanisms.

The importance of higher education for human capital formation and its consequences for higher education policy in Germany is the key perspective of Nicolai Götze's paper on higher education and the knowledge economy in Germany (Chap. 14). The author makes an important distinction between higher education "for" and "in" the knowledge economy, notes major shifts in funding mechanisms, and describes the evolving roles associated with universities of applied sciences, technical universities, and universities within the national research and innovation system.

In Portugal's knowledge society, the role of higher education is crucial in new knowledge production, dissemination, and knowledge transfer systems. Teresa Carvalho, Sara Diogo, and Rui Santiago analyze the Portuguese higher education, research and innovation systems, and contemporary concepts of knowledge society (Chap. 15). They discuss the impact of the new modes of knowledge production in the context of the defective scientific system. These innovation policies are discussed in terms of the academic profession's orientation to knowledge production and dissemination.

The Finnish innovation system has changed significantly in the last 10 years in terms of both structures and policy objectives. Changes in the research system have changed the conditions of research toward competition and internationalization in higher education. In their chapter, Timo Aarrevaara and Ville Pietiläinen emphasize that the state directs universities to build multidisciplinary and cross-institutional research projects (Chap. 16). The chapter describes four stages of comprehensive structural reform and the funding reform of the research institutes implemented by the Finnish Government in the last 10 years.

Stefan Lundborg and Lars Geschwind analyze the key Swedish policies in RDI and provide a policy overview and discussion of the innovation capacity and research performance of this system (Chap. 17). Based on a historical overview and current data, they find that the Swedish innovation system is heavily reliant on its higher education institutions.

Chapter 18, by Monica Marquina and Lucas Luchilo, provides an overview of the relationships among universities, research, and innovation in Argentina in recent decades. The innovation system of the country is strongly government driven, and this has been influenced historically by expenditure on R&D funding for the sector, the demographic characteristics of researchers, and the level of academic productivity. The university sector plays a relevant role, either through government policies or by the institutions themselves. The innovation system is limited by the insufficient dynamism of industry, the characteristics of academic culture and training programs, and low institutional interest as a result of the absence of incentives that foster a close relationship between knowledge production and the development of the country.

Daniela Véliz and Sergio Celis describe how the Chilean higher education system has changed its structures and resources to encourage knowledge production with a particular focus on the STEM fields (Chap. 19). The issues of doctoral education and internationalization are addressed as key drivers in changing the academic profession in Chile, while the challenges that remain are described in terms of developing academics' research capacity to reach international standards.

In last decade the academic profession in Mexico has benefited—slowly but steadily—from growing resources in the innovation ecosystem. This has increased scholarly productivity and promoted a stronger role for private funding instruments in higher education and social dynamics in society. In Chap. 20, Etty Haydeé Estévez-Nenninger, Angel Alberto Valdés-Cuervo, Edgar Oswaldo González-Bello, Juan Pablo Durand-Villalobos, Marion Lloyd, Jorge G. Martínez-Stack, and Lizeth Parra-Pérez analyzed the roles of Mexican science, technology, and innovation in the higher education system.

Advanced economies such as Canada (Chap. 21) have managed to preserve the best of traditional academic structures and enhanced academic productivity and international competitiveness. Olivier Bégin-Caouette, Glen A. Jones, Grace Karram Stephenson, and Amy Scott Metcalfe discuss the evolution and impact of increasing federal government investments within a highly decentralized higher education system with strong faculty labor associations. The USA, on the other hand, in the absence of any national innovation policy (Chap. 22), has experienced a decline in its RDI investment and a concomitant decline in its share of scholarly publication. Martin Finkelstein, Olga Bain, Gustavo Gregorutti, William Cummings, W. James Jacob, and Eunyoung Kim find the academic profession to be splintering and weakening at an accelerating pace, as academic tenure comes under increasing attack and as contingent academic appointments increasingly predominate.

In the concluding chapter (Part III), Jisun Jung, Glen A. Jones, Martin Finkelstein, and Timo Aarrevaara look across the 18 system cases studies, note common trends and distinctive elements, and provide suggestions for further research. The editors discuss the historical, empirical, and comparative perspectives of this volume.

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Timo Aarrevaara is a Professor of Public Management at the University of Lapland, and Principal Investigator of the research team of Professions in Arctic Societies. He has professional experience in public administration as well as in research and teaching. He is chair of the APIKS coordinators group.

Martin Finkelstein is Professor of higher education at Seton Hall University, South Orange, New Jersey, USA. He is the author of *The American Academic Profession* (Ohio State, 1988) and co-author of The *New Academic Generation* (Johns Hopkins, 1998), *The American Faculty* (Johns Hopkins, 2006), Scholars in the Changing American Academy (Springer, 2011) and *The Faculty Factor* (Johns Hopkins, 2016). He is co-editor of *The Internationalization of the Academic Profession* (Springer, 2013), and *Professorial Pathways: Academic Careers in a Global Perspective* (Johns Hopkins, 2019).

Glen A. Jones is Professor of higher education and Dean of the Ontario Institute for Studies in Education, University of Toronto. His research focuses on higher education systems, governance, policy, and academic work. He is the author or editor of more than a dozen books and has published more than 100 papers. Recent books include *International Education as Public Policy in Canada* (with Merli Tamtik and Roopa Desai Trilokekar, McGill-Queen's University Press, 2020) and *Professional Pathways: Academic Careers in a Global Perspective* (with Martin Finkelstein, Johns Hopkins University Press, 2019).

Jisun Jung is Assistant Professor in the Faculty of Education at the University of Hong Kong. Her current research focuses on the academic profession, doctoral education, master's education and employment, and higher education research in Asia. Her recent co-edited books include: *The changing academic profession in Hong Kong* (with Gerard A. Postiglione, Spriner, 2017), and *Researching Higher Education in Asia: History, Development, and Future* (with Hugo Horta and Akiyoshi Yonezawa, Springer, 2017). She is a co-editor of *Higher Education Research & Development*.

Chapter 2
The Transformation of Universities in Response to the Imperatives of a Knowledge Society

Teresa Carvalho

Abstract Industrialisation in the late nineteenth century gave birth to the modern Humboldtian university in the West that combined scientific research and teaching. Over the past two decades, the emergence of a new knowledge economy and society has given rise to a new model of the 'entrepreneurial' university that seeks to re-imagine it as both the economic engine of a new knowledge-based economy and the engine of a more progressive, equitable, and sustainable society. This chapter reviews the emerging literature on the knowledge society, the knowledge-based economy, and its impact on the mission of higher education and the nature and prospects of the academic profession. It sets the conceptual stage for the Academic Profession in the Knowledge-Based Society (APIKS) project that seeks to document the changing profiles, roles, careers, and prospects of the academic profession—the knowledge workers and innovators of the new order.

Keywords Entrepreneurial university · Humboldtian · Knowledge economy · Knowledge society · Third mission · Social engagement

Introduction

It is not possible to identify a precise moment for the emergence of knowledge society, nor for the substitution of one dominant model for another. While transformations in the social and economic order of societies may, in retrospect, appear abrupt and discontinuous, they proceed gradually and result in the coexistence and overlapping layers of the norms and values that rule social relations. Nevertheless, it is not

T. Carvalho (✉)
Department of Social, Political and Territorial Sciences, University of Aveiro & CIPES (Research Center on Higher Education Policies), Aveiro, Portugal
e-mail: teresa.carvalho@ua.pt

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possible to understand the concept of knowledge society without taking into consideration the social and historical context of its emergence.

Knowledge in contemporaneous societies can be classified as a 'total social fact' (Durkheim, 1982) since it manifests in a wide range of dimensions (economy, legislation, aesthetics, science), interwoven in highly complex ways and with the potential to directly and indirectly influence individual behaviours. Knowledge becomes a total social fact because it penetrates in all spheres of life, including in daily routines. As a total social fact, knowledge substitutes labour and propriety as the foundational mechanisms of social relations. This substitution allows the idea that we are no longer in the industrial society but in the presence of a new society—the knowledge society.

Reflecting on knowledge society and knowledge economy required reflecting also on the social context of its emergence, on the individuals who are producing knowledge, and in the way it is produced and disseminated, meaning on the epistemic environment in which it emerges. However, this reflection implies taking into consideration two of the major intellectual concerns at the core of many classical theories, namely, the sociological analysis of the economy along with the interrelation of science and society. The aim of this chapter is not to describe in detail the historical evolution of these macro developments nor their relevance to the constitution and development of theoretical paradigms, but instead to frame the context for emergence of knowledge society and to reflect on its potential consequences in different contexts. The main aim of this chapter is thus to present a reflection on the concept of knowledge society and economy and on the epistemological and ontological transformations that it entails.

The chapter starts by trying to clarify the concepts of knowledge economy and knowledge society and then presents a reflection on the changes in the epistemological framework in the Modern University from the Humboldtian prototype to the new modes of knowledge production and within universities' third mission. Finally, a reflection on the potential changes of these transformations for the academic profession is presented. At the end, an attempt is made to identify the main ideas exposed and to raise relevant questions for further analysis.

Concepts Related to the Knowledge Society Emergence and Configuration

Knowledge has always represented an important role in human lives. Stehr (2018) assumes knowledge as an anthropological constant due to three main reasons: social groups depend on and are mediated by knowledge, power has been based on advantages in knowledge, and social reproduction is based on the reproduction of knowledge. Along the same lines, the relevance of knowledge for society is not exclusive to contemporaneous societies. Different examples of societies highly framed by knowledge can be found in pre-modern societies such as in ancient Egypt where religious, astronomical, and agrarian knowledge served as the organisational principle and as the basis of authority (Stehr, 2018).

Resorting to the classical studies of sociology, one can say that what allows the attribution to contemporaneous societies the epithet of *knowledge society* is the fact that knowledge has been transformed into the total social fact, since it penetrates in all spheres of life (Durkheim, 1982).

The penetration of most spheres of social action by scientific knowledge, along with the resort to scientific knowledge to legitimate ideas, attitudes, and behaviours (like in their use by professionals or experts and advisors), and the changes in structures of power (technocracy) and institutionalisation as the basis for social inequality are proof of the relevance of knowledge in contemporaneous societies. These elements are also the legitimating factors for its designation as a knowledge society. Along with them, the relevance of knowledge and of information to foster networks and sustain social relations imposes the presence of knowledge as a structural factor of our daily lives, especially with digital information and communications technologies. Attempts have already been made to capture this new reality, with the concepts of the information society and network society (Castells, 1996; Van Dijk, 2020). However, it is mainly due to the relevance of knowledge to the economic sphere that it is elected as the most adequate term to classify contemporaneous societies. The *Knowledge economy* incorporates the emergence of knowledge as a productive force and the creation of a new sector of production.

The expression knowledge economy is particularly associated with the notion that knowledge is a new productive force in the economic system of modern societies (Bell, 1973; Denison, 1962; Drucker, 1986; Lipsey, 1992; Machlup, 1962; Stehr, 2002). For the philosophers of the economy such as Roberto Unger (2018), knowledge economy means the disruption with the productive paradigm that characterised industrial capitalism. This transformation is largely associated with the use of cutting-edge technology, such as robots and artificial intelligence, and is to a great extent derived from new companies started within higher education institutions, as the large, high-tech community of Silicon Valley demonstrates (Colyvas & Powell, 2006). Knowledge in this context is a new means of production that has the capacity to promote the transformation of production practices in all sectors. Nevertheless, the use of knowledge in production in the current context is not confined to the most advanced industry, but rather, it is present in all sectors of economic activity (agriculture, industry, and services) making the division between sectors unclear.

In the same way as steam, steel, and coal early supported the capitalist model of the nineteenth century, in our days the economic model relies prominently on information and especially on big and transactional data, their harvesting, processing, selling, trading, and exploiting. Other traditionally, non-reified human activities and non-commodified products and searching for monetary value through various forms of control rights over information and knowledge produced (as the intellectual propriety) now have a predominant role in the accumulation strategies of contemporary capitalism. Distinct labels are being used to define this new reality, as digital, biocognitive, technoscientific, or algorithmic.

The course of action in the capitalism transformation seems to be irreversible, based on the assumption that it will increase productivity and enhance economic growth and social development. However, this assumption does not emerge without criticism and apprehension, mainly associated with its excluding and unequal nature. For instance, Roberto Unger (2018) identifies knowledge as having the potential to increase productivity and enhance growth, but he also considers that knowledge economy is presently characterised as insular and underdeveloped. The insularity of knowledge economy derives precisely from the fact that the new systems of production are concentrated in small islands, meaning only in some countries and in a very small group of elite enterprises, which excludes an extraordinary number of workers. This is also associated with its underdevelopment, since the traditional way of producing, based on the Fordism paradigm, is no longer adequate in the new context but the alternative modes of production are still not implemented everywhere.

Transformations in capitalism inevitably affect academia, being not only intertwined on countless levels (Hackett, 1990, 2014; Slaughter & Leslie, 1997; Slaughter & Rhoades, 2004) but also co-dependent and capable of inducing or generating new social realities.

The discussion on how the transformation of economy and society impacts academia and epistemic continuity needs to take into account that higher education institutions are not, as sometimes evidenced in existing social scientific discourses, a separate entity with a distinctive, privileged, and passive role. Instead, academia is simultaneously interpreted as the result of the environment and historical determinations and as a co-producer of phenomena and practices that structure the involving social world.

Assessing the potential impact of knowledge economy and society in academia also involves exploring the role of academia and academics in the processes, phenomena, and transformations occurring in society at large. Knowledge economy and society along with new public management and managerialism tendencies have been considered as pivotal, affectual forces dramatically re-shaping how higher education systems are conceptualised and how knowledge is produced. In this context, one can expect a reconfiguration of the way knowledge is produced and in the traditional locus of its production—higher education.

As the Humboldtian university institutionalised a new configuration of higher education institutions promoting the modern epistemologies of knowledge production, the knowledge society is also expected to reconfigure the epistemic environment of academia.

The Nineteenth-Century Idea of Knowledge Production in the Frame of the University

The idea of the university, influenced by the European perspective embedded in the Humboldtian philosophy which proclaims the need to have teaching and research as intertwined roles in academia, is said to have influenced the creation and development of the modern university. This Humboldtian philosophy focused on principles such as the integration of teaching and research, addressing the university's obligation to promote the creation of knowledge, as well as to ensure its preservation and transmission in the name of a constant and disinterested search for the truth (Nybom, 2003). Knowledge thus became the matrix for the reconstruction of the university as an institution of modernity. Although the humanities have decisively contributed to this reconstruction, the academic institutionalisation of the natural and physical sciences has strongly boosted it, transforming the university into a systematic research structure (Barnett, 2003).

At this time, the university's purpose was associated with the long-term vision for the future. As Guy Neave stated:

> (...) for most of the 19th century and on into the present era that is now closing, the university was viewed as a transcendental institution, seeking to preserve a sense of identity, continuity and learning whose quintessence consisted precisely in being above immediacy, devoted to those enduring and continuing aspects of human endeavour which remained after regimes had decayed and fashion passed on. The university was, to revert to the earlier religious analogy, **in** the world, but not **of** it. (Neave, 1995, p. 10)

In this context, the production of knowledge was associated with the search for truth and assured by the distancing of university from society. This distancing allowed universities the reflexive process of thinking on its role within society.

The social and cultural adaptation of Humboldtian philosophy to the welfare state (Scott, 1995) allowed, to a certain extent, research to be relatively protected from political, social, and market pressures. In historical terms, the exceptions to this protection are well known, as well as the instrumentalisation of research and science by different industrial, colonial, and political-military devices (Martins, 2004, 2011; Garcia & Martins, 2009). Despite these exceptions, basic and applied research remained, until the early 1970s, essentially an activity of a public nature, which included the widely shared assumption that science was a public good that produced substantial social benefits and positive externalities. The transfer of knowledge from the university to society, and especially to industry, was not a strange phenomenon, but the political and academic logic of science's public interest and benefit was prevailing against private interest and benefit (Lazerson, 1998).

In this context, academic research was mainly conducted based on endogenous processes (Bourdieu, 2000), linked to individual scientific initiatives (Olssen & Peters, 2005) and supported in the articulation between the researchers' intrinsic and extrinsic motivation. Extrinsic motivation was (and in part continues to be) driven by symbolic rewards, materialised in the achievement of social prestige, power, and scientific leadership in a given disciplinary or sub-disciplinary field. The internal organisation of science was sustained on a disciplinary basis and on the distinction between basic science (discovery of basic knowledge) and applied science (application for specific purposes).

The articulation of Humboldt's philosophy with the Mertonian *ideal type* of science production and dissemination emerged as a dominant cultural cognitive framework in guiding researchers' and institutions' behaviour. In his seminal work of 1942, Merton conceptualised the norms for scientific knowledge which became the frame for the entire community of scholars regardless of the disciplinary or scientific background. According to Merton (1942), knowledge production needed to be ruled by four dominant norms: universalism, where scientific claims are based on preestablished and impersonal criteria, which is assured by the use of scientific method or by the peer-review process; communality, or communism as Merton identified, relies on the idea that the findings of science are common property to the scientific community and that scientific progress relies on open communication and sharing; disinterestedness, meaning that knowledge should search for the sake of knowledge, rather than for the self-interest and power; and organised scepticism, which implies that knowledge production should always be more scrutinised than any other field, sustaining the value of reproducibility in research. These norms became known by the acronym CUDOS, translating a set of tacit norms that seeks to legitimise the idea of creating free knowledge (for its own sake) and the principles of curiosity and neutral values of science (Pels, 2003), separated from political or economic interests. In a sense, the acronym CUDOS served as inspiration for Gibbons et al. (1994) in the construction of the ideal type Mode 1, which seeks to characterise traditional science. In the same way, Ziman (1994, 2000) also proposed the notion of 'academic science' to mean the 'institutional space-time' in which science is endogenously located (in universities), conducted by autonomous academics/researchers and submitted exclusively to peer control.

This definition of university mission aligned with the traditional modes of knowledge production sustained the political-economic dominant model, meaning that they were an integral part of welfare state and industrial capitalism.

The Reconfiguration of the Epistemic Environment of Knowledge Production

These dominant models of university and knowledge production survived without being questioned until the end of the 1960s, which is the same as saying along the welfare state golden years. The political economy was supported by a Fordist model of production in which large industrial chains ensured the proper functioning of the system, from the production of the raw material to its distribution in the consumer market, with social peace being ensured by the search for full employment and the important role of the union movement.

However, with the fiscal crisis of the state in the beginning of the 1970s, this frame of reference, simultaneously ideological, institutional, and epistemological, has been the subject of strong critical scrutiny starting in the Anglo-Saxon context and spreading all over the world. The origins of this scrutiny can be analysed in two directions, articulated with each other. First, more than in previous periods, strong government and business pressures were exercised to promote a reconfiguration of traditional industrial capitalism. The main assumption for this reconfiguration was the belief that knowledge could have a role in improving national competitive advantages in the globalisation arena (Feldman, 2001). Second, changes in narratives and practices which have fuelled this reconfiguration have been driven, in a dominant way, by neoliberal assumptions, centred on productivism and utilitarianism, in close connection with the principles of the market, which have progressively immigrated to higher education and the science and technology system at the hand of managerialism/new public management (NPM).

The role of knowledge in reproduction of capitalism is obsessively overvalued, leading national states to (re)conceptualise higher education and science and technology policies in order to transform knowledge into a new form of 'capital accumulation' oriented towards the competitiveness of the economy (Calhoun, 2006). In this perspective, the concept of intellectual capital constitutes a key device in the legitimation of legal knowledge protection practices, materialised in the possibility to link individual property with the notion of intellectual property. This phenomenon allows us to understand, on the one hand, why the university is politically represented as a key collective actor in the reconfiguration of capitalism, even if it no longer holds a monopoly on the production of knowledge, and on the other hand, why teaching higher education and science and technology were elected as a political priority. This priority has repeatedly insisted on the need to align higher education with the economy and the labour market, as well as the establishment of close interactions and/or partnerships with industry. The assumption that supports this alignment clearly endorses the belief about the possibility of rebuilding a more solid economy based on the transfer of knowledge and its transformation into technology and innovation.

Nevertheless, it is not possible to claim that universities played a passive role; instead, this new political strategy was to a great extent legitimated by scientific discourses and theories, as well as by higher education institutions' practices. Within this theoretical framework it is inevitable to refer to the triple helix model proposed by Etzkowitz (2003a, 2003b). For him, the institutionalisation of a third mission for the university—the economic mission—and simultaneously, the creation of value through intellectual capital would be the basic conditions required for the establishment of a new alliance between the university/science, industry, and the State. As he stated: 'intellectual capital is becoming as important as financial capital as the basis of future economic growth' (Etzkowitz, 2003a, p. 295). This alliance takes for granted mutual reconfigurations: the transformation of the university into a quasi-business actor, the industry into a quasi-academic, and the state into a supervisor, or third partner, transformed into the guardian of national economic interests and the guarantee of the system consistency. In this context, higher education systems started to become dominated by productivity, competition for resources, and income generation. From distant *ivory towers* closed-off from society, universities became embedded in society, and more specifically, in the economic field at the same time, becoming framed by short-term action and fast results (Barnett, 2008). The preferences for short-term thinking and achieving fast results are particularly evident in knowledge production (Vostal, 2020).

This paradigmatic change has implications for the dominant modes of knowledge production. Among the biggest challenge identified in changes in knowledge production is the potential emergence of epistemological dependence, linked to the simplification and reduction—to utilitarian mechanisms—of the cognitive, cultural, and social complexity involved in the concept and processes of science construction

(Pels, 2003). In fact, the domain of utilitarianism in science largely ignores disinterested cultural, moral, and social knowledge, emptying it of its human content (Muller & Subotzky, 2001). The economic transdisciplinarity; the devaluation of isolated disciplinary themes; the overlapping of problem solving with critical, free, and self-interested research; and the replacement of the long and medium term by the short term, in obtaining results, appear as factors that can contribute decisively to this emptying.

Ziman (1994, 2000) characterises this new context of science production with the notion of 'post-academic science' which, to some extent, covers a similar set of phenomena that Gibbons et al. (1994) proposed to analyse with the ideal type Mode 2 of knowledge production. Common to both theoretical frameworks is the growing relevance of transdisciplinary and organisational diversity in the locus of knowledge production. Both also highlight the relevance of economic rationality over research processes and results as well as the potential control of knowledge by economic values (Olssen & Peters, 2005). Ziman's (1994, 1996, 2000) acronym—PLACE—expresses well the growing dominance of this 'market order' over contemporary science. Exogenous dynamics and heteronomy in the social construction of science, dependent on the satisfaction of clients/investors, may be obtaining a hegemonic position in relation to endogenous dynamics and the autonomy of researchers (Bourdieu, 2000).

However, critical voices sustain the inexistence of the expected results. For example, Calhoun (2006), referring to American universities, stressed that if some have recently increased their income from the commercialisation of science, few have really benefited from partnerships with the business sector, related with licences or other activities. In the same vein, Vestergaard (2007) found that few universities managed to raise significant funds from the commercialisation of research.

Despite this balance, many universities seem to have substantially internalised this external project at least in the dominant institutional narratives and discourses. In this perspective, they try to impose a specific research agenda on academics—concentration on limited and potentially more commercial topics—as well as creating inter- and transdisciplinary research centres clearly oriented to benefit from potential commercial profits with the direct transfer of knowledge and technology to economy (Calhoun, 2006). It is also possible that this internalisation obeys another logic: the achievement of social prestige, within the framework of the dominant narratives about the knowledge society, and subsequently, the opening of new opportunities to access other external sources of knowledge funding (Santiago et al., 2008). In this way, the involvement of universities with strategic, commercial, and technoscience research can also represent an opportunity for them to (re)build their symbolic capital, which would allow them to gain positional advantages in the inter-institutional competitive game.

Regardless of the universities' commitment to commercial, symbolic, or social objectives, this dynamic seems to attract many universities to the sphere of corporate culture (Clark, 1998, 2003, 2004; Barnett, 2003), academic capitalism (Slaughter & Leslie, 1997), or capitalism of knowledge and learning (Slaughter &

Rhoades, 2004). This attraction induces universities themselves as well as the academics/researchers to become actively involved in the market game at the level of knowledge production and dissemination. With this involvement, the entrepreneurial university (Clark, 1998; Foss & Gibson, 2015) becomes effective, aligning institutions with the commercialisation of knowledge and the development of entrepreneurial skills.

Within this context, the reconfiguration of knowledge production and dissemination along with its increasing relevance for the economy resulted in the emergence of knowledge politics as a new field of political activity (Stehr, 2003). As the author describes it,

> Knowledge politics, or governance of knowledge, is about attempts to channel the social role of knowledge; to generate rules and enforce sanctions pertaining to relevant actors and organisations; to affix certain attributes (such as property restrictions or legal prohibitions) to knowledge; and – likely the most controversial strategy – generally to restrict the application of new knowledge and technical artifacts; mainly, of course, by efforts located outside the immediate boundaries of the scientific community. (Stehr, 2003, p. 644)

Without claiming a radical and disruptive change with the historical path of universities and knowledge production, there is a critical perspective on the potential effects of the knowledge society/economy paradigm over science development. In effect, it is undeniable that concerns about the social consequences of knowledge production always existed, as there are no illusions that science was not always developed having humankind and the mitigation of human suffering as its main purpose (Martins, 2004, 2011; Garcia & Martins, 2009). However, what may now be at stake is the possibility of a slowdown in the improvement and advancement of fundamental knowledge, since the focus of knowledge production may shift mainly to the short term and to applicable knowledge.

The Idea of the University's Third Mission

Along with this more pessimistic and Western approach to the notion of knowledge society and its effects on the role of university in society, it is also possible to find in the literature broader perspectives, sustained in the historical role of universities as social institutions and in the potential benefits of the idea of knowledge society for social improvement and development.

Actually, this movement of universities to assume knowledge transfer, commercialisation, and innovation as a third pillar to gain a leading role in economic growth and regional development has been also assumed in the literature as universities' third mission. However, this perspective presents a broader notion of knowledge transfer, since third mission activities of the university include all dimensions performed by universities in relation to external environments, including transfer and innovation but also civic and social engagement (Benneworth & Humphrey, 2013).

Taking this general perspective, it is relevant to remember that despite the epithet of *ivory towers*, universities have always had an important role in their external environment. First and foremost, with its training role, not only have universities historically provided qualified staff for state bureaucracies and professionals for the world of industry and services, a pillar of the nation-state formation and development, but they have also promoted national culture and social improvement (Benneworth et al., 2016).

As a matter of fact, other ideas about the university and its role in society can be found both in the Western and non-Western world. On the Western side, John Henry Newman proclaimed that the university should be the place for teaching universal knowledge, having a holistic and inclusive view of this knowledge, which would sustain the education of liberal arts and professional fields (Murphy, 2011). In the non-Western world, the Buddhist University has been institutionalised, offering degrees in liberal arts and professional fields sustained in the whole person with wisdom and values, with personal and social responsibility (Storch, 2013). This diversity of approaches reveals that higher education systems are not exclusively constituted by universities; they integrate a plethora of other higher education institutions such as universities of applied sciences, technical universities, polytechnics, and university colleges, with a mission aligned with training for professional fields and producing knowledge oriented to local/regional development (Benneworth et al., 2016).

The expansion of the third mission idea to all higher education institutions seems to entail more profound epistemological transformations. Within this perspective, the transformation and reconfiguration of knowledge is not limited to the substitution of academics' values and norms. The main concern is not with the knowledge creation, its scientific impact, and commercialisation but with co-creating knowledge both with and for society, and with social impact. Knowledge co-creation is developed with the inclusion of different actors such as higher education institutions, industry, government, and the social sector. It is applied at distinct territorial levels including the city, the region, state, and even the supranational (Jaeger & Kopper, 2014). The third mission, in this perspective, does not exclude the other two missions of the university—teaching and research—but integrates them instead.

In this framework, the narrow concept of *knowledge transfer*—assumed as a process in which the knowledge is unidirectionally transmitted from the academia to the industry (Roux et al., 2006; Rossi & Rosli, 2015)—is expanded to a bi-directional model in which both parties are co-creators of knowledge (Sengupta & Ray, 2017; Rossi et al., 2017). The idea is to develop knowledge *with* and *for* society and not *about* society (Soler-Gallart, 2017).

The notion of academic engagement is thus expanded to include all interactions, both formal and informal, and all different types of non-academic actors (Perkmann et al., 2013). In this regard, the academic engagement is defined as an inter-organisational collaboration, involving personal interactions and not necessarily commercial relations. Furthermore, the outputs of the co-created knowledge are not measured in financial terms, but instead as symbolic rewards (Abreu & Grinevich, 2013) with the researcher being motivated by the research rationale and not by remuneration, or even by scientific publishing (Perkmann et al., 2013; D'Este & Perkmann, 2011). In brief, the reflections over academics' engagement have been shifting from technology transfer and the commercialisation of knowledge towards knowledge exchange, from biotechnology to all disciplines, and from the private to the public and social sectors.

The importance of knowledge co-creation and civic and social engagement is particularly relevant in the social sciences, humanities, and arts, given the type of outcomes which differentiate them from science, technology, engineering, and mathematics (STEM) disciplines (Whitley, 2000; Bastow et al., 2014) and the potential to promote societal development (Bastow et al., 2014; Benneworth & Jongbloed, 2010). Nevertheless, assessing the societal impact of research is a difficult task (Reale et al., 2018; Girkontaitė et al., 2020), not least because the notion of impact is academically centred; for example, impact needs to be recognised as a feature of good research, implying that it needs to be delivered by academics themselves (Girkontaitė et al., 2020).

Within this framework the importance of knowledge is not only epistemological but also political. In different scientific areas or disciplinary fields, claims emerge for knowledge to become public and democratic (Soler-Gallart, 2017; Stivers, 2010). The epistemological turn seems to be the deconstruction of science as the result of systematic study pursued by experts (scientists) and the emergence of a new process of producing knowledge based on collaborative processes in which citizens and experts participate on an equal footing. There is also a claim for epistemic justice, framed by the need to promote a decolonisation of knowledge. This notion intends to challenge the universality of the Western knowledge system and the supremacy of some disciplinary fields. If it is true that the decolonisation of knowledge was first applied to a North-South divide, with criticisms of the use of a Eurocentric conceptual model (as democracy, modernity, industrial revolution, or even economic development) to read other national contexts/realities (Connell, 2007; Quijano, 2000), the more recent approaches also reveal how this model excludes the diversity *within* the European continent (Eisenstadt, 2003; Boatcă, 2010).

Some studies in countries with distinct human development conditions and technological capabilities, as in sub-Saharan Africa, reveal that the university-industry linkages are weak and assume an informal and indirect character, being more concentrated in embodied (e.g. the share of ideas in informal meetings) than in disembodied knowledge (e.g. patents or technology prototypes) (Kruss et al., 2012; Lundvall et al., 2002; Lall & Pietrobelli, 2002; Zavale & Macamo, 2016). However, further comparative studies including between distinct geographical environments are needed to better capture the different meanings of the concept and notions of knowledge society/economy that can assume in higher education, in knowledge production, and in its relations with society.

Coming again to the beginning of the reflection in this chapter, one needs to ask not only *what is the knowledge society?* but also *which dimensions can it assume?* Taking its insular nature (Unger, 2018), it is also important to discern local specificities of the concept. Does it mean the same in different regional and national geographic contexts? What does it mean to produce scientific knowledge in the knowledge society? And equally relevant, what is the role of academics in this new context?

The discussion on the emergence of knowledge society/economy, its effects in universities, in the epistemic contours of knowledge production, in science in general, and in society at large, can only improve if it is opened up to include distinct geographical realities in a comparative perspective.

Academics in Knowledge-Based Society

Taking a Eurocentric approach, academics tend to be defined by reference to the Humboldtian modern university as professionals who have the duty of and 'monopoly' on teaching, research, and service to society within the division of labour. This professional group is also expected to have a predominant role in the legitimation of other professional groups, since they produce the epistemic support for professional practice, being classified as a meta-profession (Carvalho, 2017).

Taking their prominent role in the production of knowledge, academics are expected to have a relevant role within this general context of transformation towards a knowledge economy and society. In this frame, the expectations are not only that academics are able to reach excellence in their teaching and research roles but also that they do it in an efficient and measurable way, with impact on economic development and for society at large (Ćulum et al., 2013). The pressure to present results which will be useful for society may potentially produce, in the long term, a mistrust of science; this is exacerbated by the proliferation of experts who are consulted by the media and politicians to help solve problems and take decisions sustained in scientific knowledge, as the recent example of the way the scientific world has been dealing with the COVID-19 pandemic seems to evidence (Carvalho, 2020).

Academics who engage in knowledge transfer and commercialisation, contributing to national innovation and competitiveness, are expected to assume more entrepreneurial roles (Jain et al., 2009). However, these potential changes in roles and identities are not expected to be universal, taking the institutional variances along with the national, regional, and local differences in the higher education. In societies with a less developed economic, industrial, and innovative environment, academic roles may be more aligned with the dissemination of knowledge.

Taking this broad conceptualisation of academic engagement which includes not only commercial activities but also civic and societal engagement, academics are expected to assume academic citizenship behaviours. The term 'academic citizenship' is

> (...) used to describe the service duties and responsibilities that academics have, both to their scientific communities and to the society at large, beyond the core tasks of teaching and research (...) involving not only formal membership of academic institutions, but also the relational and emotional aspects of participation, recognition and belonging, within Higher Education and Research Institutions (HERIs) and broader academic communities. (Sünner et al., 2020, pp. 1–2)

Within this context, there seem to be increasing expectations over academics and their potential contribution to society. Academics are expected to be teachers, researchers, entrepreneurs, innovative, good citizens, resilient, and simultaneously experts, smart and excellent. Different authors have described how these increasing pressures result in work overload, with busy academics facing time pressures (Ylijoki, 2013; 2020; Vostal, 2020). Nevertheless, it is important to develop further worldwide comparative studies to understand how changes in academia and in the academic professions are effectively global or have local specificities.

Conclusions

The way scientific knowledge is produced and disseminated is not static but changes, depending—to a great extent—on the evolution of the socially dominant conceptions of higher education institutions, particularly universities, in society. However, the dominant conceptions of knowledge production and dissemination are intrinsically linked with major changes in society, since academia and society are intertwined.

Transformations occurring in current societies are defined as based on disruptions to the modes of production, which are based mainly in new knowledge and technologies inducing the replacement of industrial capitalism by knowledge society and economy.

The knowledge economy/society promotes epistemological disruptions which are captured by the substitution of the traditional Mertonian norms of knowledge production (CUDOS) with Ziman's PLACE or by substitution of Mode1 with Mode 2. This substitution, however, does not represent the unproblematic replacement of an epistemological and ontological context. Actually, it is relevant to call attention to the fact that it was precisely within the frame of the traditional/classical epistemic context of modern science that the need for new ways of controlling knowledge emerged, as well as the genesis of knowledge politics. This breaking point can be identified with the nuclear age, particularly with the atom bomb of 1945 and the subsequent movements of resistance to nuclear power (Weart, 1988). The new epistemic context is also embedded with new and diverse challenges, mainly associated with the implications of a more commercially oriented research, namely, in its capacity to maintain academic freedom and assure the advance of science.

However, this more pessimistic perspective contrasts with a more positive one. Academic engagement is, in this perspective, historically embedded in higher education and is not restricted to commercial purposes related with knowledge transfer but includes social and civic engagement. In this perspective, knowledge is expected to be produced *with* society and from a perspective that allows epistemic decolonisation. Under this general framework, it is fundamental to understand the extent of the notion that a knowledge-based society is 'insular' and mainly associated with economies of advance capitalism. At the same time, further research is also needed to try to understand the potential impact of knowledge-based society on academics in different national contexts.

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Teresa Carvalho is an Associate professor with agregação (Habilitation) at the University of Aveiro, Portugal. She is the Vice-dean of the Department of Social, Political and Territorial Sciences, the Director of the PhD program in Public Policies, and member of the Board of CIPES (Center for Research in Higher Education Policies). She has been a member of the Executive Committee of the ESA – European Sociological Association – since 2017. She was also a member of the executive committee of RC52 Sociology of Professional Groups of International Sociological Association (ISA). Her research focus is on governance and new public management, academic profession, and gender in higher education.

Chapter 3
Higher Education in the Era of Knowledge Economy

Olga Bain and William Cummings

Abstract The concept of knowledge economy goes back to the 1960s but received renewed attention in the 1990s when first global metrics attempted to quantify the advent of the knowledge economy. These metrics focused on various inputs and their effect on the rate of economic growth. From this perspective, higher education (HEd) provided major inputs to the growth of the knowledge economy in the form of skilled human resources and research products as measured by research publications, citations, and patents. This view on the role of HEd in the knowledge economy dominates to date despite the United Nations index of human development that focused on progress in education, safety, health, ecology, and human rights. Since the rise of the neoliberal regime in the 1980s, an increasing emphasis on economic growth and efficiency reoriented HEd and the academic profession to that end. Economic innovation indicators suggest that there are multiple pathways for sustained economic growth for nations of varying resources and development stages. The academic profession has a responsibility to determine how to educate knowledge workers, how to shape the research agenda and promote the public value of knowledge, and how to connect the national and global economy with the responsibility to social demand—such as through the model of the *service university*—with the ultimate goal of advancing the human condition.

Keywords Human capital · Innovation system · Public good · Service university · Social sustainability

O. Bain (✉)
Independent Scholar, Waxhaw, NC, USA
e-mail: olgabain011@gmail.com

W. Cummings
George Washington University, Washington, DC, USA

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Knowledge Economy for the Knowledge Society

Both the terms –*knowledge society* and *knowledge economy* –were coined in the 1960s (e.g., Lane, 1966; Drucker, 1969) to capture the increasing role of knowledge in contemporary society. Knowledge can be defined as "a model for reality," "a generalized capability to act on the world" (Stehr & Ruser, 2017), and thus it may be applied in hindsight to various societies in the history of humankind as knowledge societies.

The most salient transformation in the modern knowledge society is its economy, which is given the primary focus in the theory of the knowledge economy. According to Peter Drucker, one of the pioneers of the knowledge economy theory which gained attention in the 1990s, knowledge is "the only meaningful resource today" (Drucker, 1999, p. 87). It is the dominant resource for production and is far more significant than land and physical or financial capital. It stresses know-how rather than facts and information. Knowledge is widely assumed to be the principal factor that determines economic growth with the associated increasing reliance on information and communication technologies.

The knowledge economy identifies people, processes, and technology as its core productive forces. Human capital serves as the major capital asset, in which knowledge workers own the means of production as opposed to industrial workers who are alienated from the means of production. Starting with the industrial revolution, knowledge has been primarily associated with scientific achievements and technological innovations. Machinery instead of labor greatly affected economic development. In the post-industrial society, the role of knowledge and knowledge workers as a way to transform or even to re-create the world—as research in biology shows—becomes essential.

Higher education (HEd) as a knowledge-intensive industry logically attracts focal attention for its increasing importance for the knowledge economy. In the area of higher education policy, the concept of knowledge economy has been given far more emphasis through various metrics and rankings. These metrics were developed both at the national and international levels, and the international metrics and rankings exerted a substantial influence on the shaping of the national level metrics. Publications by the World Bank, the Organisation for Economic Co-operation and Development, the World Economic Forum, and regional associations such as the European Community, Asia-Pacific Economic Cooperation, national economic agencies, and others further enhanced the economic production function of HEd for the knowledge economy.

We discuss below several indicators that are used to measure the emerging knowledge economy and how they are matched by the indicators for higher education in supplying the economy with human capital development and research products. In doing so we identify several themes and assumptions guiding the understanding and policies regarding the link between universities and the knowledge economy. We further challenge some of the assumptions about the connection of HEd and the knowledge economy. We believe an examination of these taken-for-granted assumptions is warranted at the time of the global corona virus pandemic, which has challenged all of us to overhaul many principles of our daily lives.

Inputs and Outputs of the Knowledge Economy

The interest toward the emerging knowledge economy peaked in the 1990s and led to the need to quantify the signs of the emerging phenomenon. To benchmark knowledge economies, national governments and international organizations developed different Knowledge-Based Economy composite scores. Such composite scores covered several areas including the business environment, human resources, information infrastructure, and innovation systems (Chen, 2008). The scores heavily relied on the traditional quantifiable input variables and, additionally, institutional factors such as the legal and regulatory framework and institutional norms—e.g., proprietary protection, transparency of enterprises, and openness of the national culture to foreign influence. These input and throughput variables are then related to output variables with average annual *gross domestic product* (GDP) *growth* as the most common variable across multiple knowledge economy scoring systems. In 1990 a Human Development Index (HDI) was developed by Pakistani economist Mahbub ul Haq as the basis for the annual report by the United Nations Development Programme to redirect the focus of economics from national income and economic growth toward human progress and improving the lives of people. The HDI initially covered three areas: health, education, and income. It was further developed to include the standard of living, participation in political and community life, environmental sustainability, human security and rights, and gender equality (UNDP, 2017). However, the HDI had only modest influence on how the goals and benchmarks of the knowledge economy were constructed. Out of the 11 benchmarking systems of the late 1990s to early 2000s, only one had *quality of life* as an input indicator, and another had a poverty index, an unemployment rate, and gender development as output indicators (Chen, 2008, p. 25).

Although GDP is the traditional input indicator of capital formation, GDP per capita measures the wealth of the nation relative to its population and serves as a precursor to the emerging knowledge economy. The assumption is that the more wealth that nations accumulate relative to their population, the greater is the share of services and knowledge-intensive industries, and the larger is the portion of funds available for investment in research and development (R&D) and tertiary education. This indicator is correlated with the growing knowledge sector and the demand and supply of knowledge-intensive products and services.

For the purposes of the knowledge economy, the quantifiable outputs are of primary importance. From this perspective, higher education is viewed first in terms of production of human capital, that is, highly skilled knowledge workers, and second in terms of research output as measured, for example, by the number of publications, citations, and patents. Several input indicators such as the relative size of investment into R&D, the size of the economy, per student investment in tertiary education, and others are used to assess the economic production function of tertiary education.

While in the industrial society the tertiary education participation rates are the foremost indicators of higher education expansion and increasing inclusiveness, the emerging knowledge economy had shifted the focus to completion and graduation rates as an output indicator. Degree completion rates represent those who complete a degree program as a percentage of those who started such programs. A degree completion indicator tells how productive and efficient higher education is as an industry with the cohort of students it takes in. By international comparison, the higher degree completion rates of women stand higher than for men consistently across the reported nations (see Fig. 3.1). Yet higher education attainment rates, which capture the completed tertiary education in the society as a whole, give a snapshot of how well educated the public is. Educational attainment rates highlight the spread of tertiary education completion in the general economically active population and are indicative of the society that can both produce and consume knowledge-intensive products and services. There is considerable variation in the educational attainment rates among advanced OECD economies and world economies for which OECD collects the data (see Fig. 3.2).

The need for quantifiable indicators of HEd performance in R&D has led to the booming industry of bibliometrics and scientometrics. The Institute for Scientific Information (ISI), one of the first bibliometric services launched in the 1990s by Thomson Reuters, maintained citation databases on its website *Web of Knowledge* for academic disciplines grouped in three indices: *Science Citation Index*, *Social*

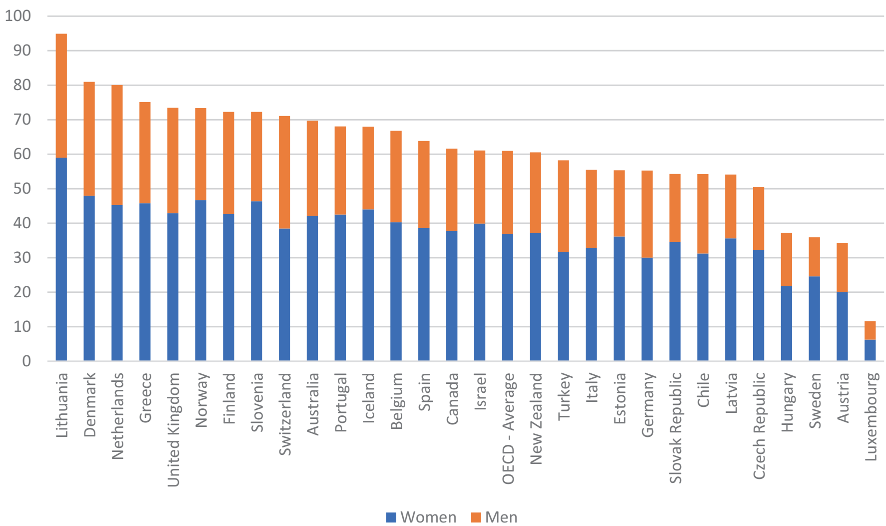

Fig. 3.1 Tertiary graduation rates: bachelor's or equivalent level, women and men, 2018. (Source: OECD 2020)

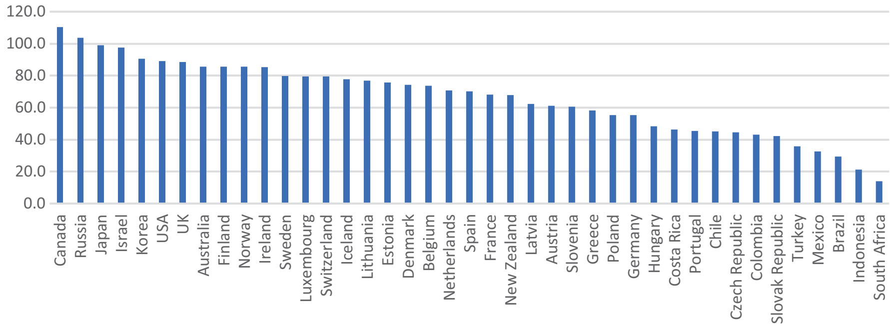

Fig. 3.2 Tertiary education attainment in the population of 25–64-year-olds, 2015. (Source: OECD 2020)

Sciences Citation Index, and *Arts and Humanities Citation Index*. Today this citation database is known as the *Web of Science* and is maintained by Clarivate Analytics. Other competing abstract and citation databases are *Scopus* and *Google*. The former is maintained by Elsevier—the leading publisher of science journals. The latter provides open access to many articles in addition to abstracts and citations.

The data on publications are reported in terms of the overall research output, highest citation index, and distributions of articles by academic fields. Colleges and universities across countries are by far the largest producers of science and engineering publications compared to non-academic sectors. The top six world producers of science and engineering publications in 2016 were China (18.6% of the world total), the United States (USA, 17.8%), India (4.8%), Germany (4.5%), the United Kingdom (UK, 4.3%), and Japan (4.2%) (National Science Board, 2018). The share of publications produced by developing countries continually rose between 2006 and 2016, and the share of the developed nations remained constant or declined during the same period. However, in terms of average citations, the USA and the European Union (EU) by far exceeded other countries' citations during 1996–2014 (National Science Board, 2018). The producers of top 1 percent most-cited publications relative to the country's overall publication output are Switzerland, the Netherlands, Sweden, and the USA (National Science Board, 2018). The distribution of fields of study in nations' research publication output points out national research priorities. Figure 3.3 represents the world's top producers of science and engineering research publications in 2016 (National Science Board, 2018). Thus, in the USA, almost half of the publications (49.6%) are in the area of medical sciences, biological sciences, and other life sciences—higher than any other country or region. The USA also has a greater share of research publications in psychology and social sciences than any other country. The science and engineering portfolio of the EU countries and Japan are also dominated by medical sciences and biological sciences, with mathematics and astronomy being a top priority in the EU and physics in Japan. In its research portfolio, China has a greater share of publications in engineering, chemistry, and geosciences, while India leads in the share of publications

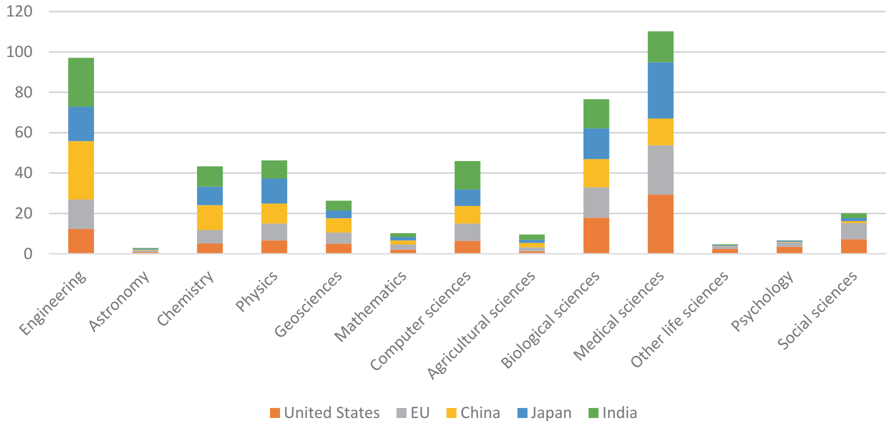

Fig. 3.3 Science and engineering research portfolios of selected countries by field, 2016 (percentage). (Source: National Science Board 2018)

in computer sciences and has a top second share of publications in engineering, chemistry, and physics.

Knowledge and Higher Education as Primarily a Private or Public Good

After the end of the WWII, the generous public investment into higher education and research around the world led to the expansion of higher education, increased participation rates, and basic research breakthroughs. This time has become known as the golden age of higher education around the globe. Private rates of returns to higher education also increased, which signaled that higher education is a good private investment and might benefit individuals more than the general public. The view of HEd as primarily a private good started to dominate HEd policies during the 1980s and early 1990s, resulting in the policy shift toward fiscal austerity, accountability, cost efficiency, and privatization. Often referred to as neoliberal policies in the public arena, they have been heavily critiqued. The recent volume prepared under the leadership of the economist Joseph Stiglitz (2020) examines how these policies failed to bring Europe onto the road of recovery and growth after the 2008 global financial crisis. The book points out that austerity backfired as it drenched EU economies of much-needed investment, so did the price stability and the below 60 percent of GDP debt doctrine. Privatization turned out not to be a panacea. Some privatizations were successful and others disastrous. Overall, the *Stability and Growth* pack did not work—economic growth stagnated for more than a decade, unemployment was on the rise, income inequality was rapidly increasing, and average R&D investment as the percent of GDP for EU and Eurozone countries significantly lagged behind the leaders in R&D funding, such as South Korea, Japan, and the USA. The authors argue that Europe's maladies will continue unless there are changes to the economic and social policies, rules, and structure (Stiglitz et al., 2020).

Similarly, protection of intellectual property rights through patents may backfire when the loopholes in the rules are exploited and knowledge, in effect, becomes privatized. Large corporations have enough resources to buy patents, but instead of creating new products or using them for research, they may try to prevent other firms from entering the market and competing, or they acquire intellectual property rights to make money by suing infringers (Stiglitz et al., 2020, p. 144). At the same time, knowledge is public in its essence. Knowledge does not get used up; the gains from knowledge dissemination only increase and diffuse wider without any particular societal costs. Knowledge is ultimately a public good.

Recognizing that public and private interests may not always be well aligned, it is an important reminder that the goal of public policy is to prevent the abuse of market power. *Elsevier*, a leading publisher of science journals, came under criticism and was boycotted by mathematicians and scientists when they reported a 36 percent profit on revenues of $3.2 billion for 2010 collected for the access to database *Scopus* which is comprised of paywalled published scientific research (Lin, 2012). *The Federal Research Public Access Act* and its successor *The Fair Access to Science and Technology Research Act* in the USA require open access to publicly funded research to prevent market power abuse. As of December 2020, *Scopus* extended open access to 17 million articles. The response of research and innovation systems to the pandemic has been impressive as demonstrated through opening access to scientific publications, increasing the use of digital technologies, enhancing international collaboration in science, technology, and innovation, and spurring public-private partnerships. The recent OECD report concludes that COVID-19 has accelerated the ongoing trends toward a socially responsible, more equitable, and sustainable future for all (OECD, 2021).

It is generally assumed that experimental development and applied research are mainly conducted by the business sector. However, it is often ignored that the long-term basic research serves as the foundation for development and applied research, and governments around the world fund the largest share of basic research. HEd has been maintaining its leading position in producing most of the basic research in the USA, while businesses have focused primarily on experimental development and applied research, the two other types of research that fall under R&D (National Science Board, 2020). Even seed funding and enabling governmental investments go far. Thus, the initial governmental funding of start-ups through venture capital in Israel helped to boost its venture capital industry so that it now by far exceeds the share of public investment. Public funding of grassroots innovation in the Philippines secured an inclusive, integrated approach that propelled the economy's innovation output. The governmental agency for industry-academia interface and technology transfer in India proved crucial for leapfrogging Indian start-ups into a circle of global innovators and creating the enabling innovation ecosystem. Yet, this takes place through the *innovation commons* groups of knowledge volunteers who developed platforms for digital highways for everyone to access and then build their innovations on top of them. This was made possible thanks to the critical mass of expert enablers in business, academia, and start-ups who developed solutions that would not be accomplished by one company and open them to the public. This was also possible thanks to a critical mass of young minds grown in the culture of academic excellence and innovation (Dutta et al., 2020).

The Number of Graduates in Science, Technology, Engineering, and Mathematics (STEM) as a Foremost Indicator of the Knowledge Economy

The number of graduates in STEM fields has gained preeminent importance in the competitiveness and innovation metrics for the knowledge economy. The knowledge economy will thrive if there are numerous high-skilled human resources trained in the fields key to technological advances and innovation. However, research shows that it is not just STEM that feeds technological innovation, but rather a mixture of humanities, social sciences, and STEM: *social innovation* may explain as much as 75 percent of total innovation (Ritzen, 2010, p. 95). Florida (2002) and Pink (2005) arrived at similar conclusions.

An OECD report on Science, Technology, and Innovation Outlook 2021 points out that the global science and innovation system's response to COVID-19 has been decisive, rapid, and significant as seen through the development of the COVID-19 vaccine and rollout of digital technologies (OECD, 2021) for e-learning and e-communication. Yet, it also uncovered challenges such as the need for transdisciplinary research to which current science system norms and institutions are ill-adapted, the need to reform doctoral and post-doctoral training to prepare for a diversity of career paths, and the need to emphasize digital skills in training research support professionals and scientists.

The critical mass of researchers and knowledge workers as well as young and recent graduates, in addition to enabling infrastructure and government investment are ingredients for the creation of the enabling innovation ecosystems in India, Israel, the Czech Republic, and the Philippines—the up and coming global innovation hubs according to the recent report (Dutta et al., 2020).

Sustainability of the Knowledge Economy: Economic Efficiency and Innovation

With the goal of perpetual economic growth, it is questionable whether the knowledge economy might be sustained indefinitely. This concern resulted in a group of indicators for knowledge economy that capture efficiency and productivity of economic performance. The use of information and communication technologies set the bar high: these technologies became exponentially less expensive to produce over time. It was technological innovation that spurred this cost efficiency.

Improving efficiency relies to a great extent on innovation of processes and products. Innovation can be defined as a process (knowledge innovation proliferation) in the knowledge economy that connects inputs (science and technology ability, and knowledge transmission efficiency) and outputs (knowledge products and services). The indicators for such innovation systems include trade manufacturing industry as percent of GDP, R&D public and private expenditures as percent of GDP, foreign direct investment, number of researchers in R&D, proportion of hi-tech and service exports, patents, science and technical publications, enterprise and university research cooperation, tertiary enrollment, and availability of venture capital (Chen, 2008). Innovation systems serve as a mediating environment where high-skilled human resources in the right business infrastructure can be highly productive and innovative.

Sustainability of Knowledge Economy: Ecological and Social Sustainability

The definition of sustainability has also evolved to include ecological sustainability and reduction of carbon footprint of supply chains and products of the companies. Digitization and smart manufacturing grounded in the advanced robotics, 3D printing, innovative software, and new materials result both in increased productivity and efficiency and reduced burden on the Earth's biosphere. Creating a virtual twin universe is enabling efficient and environmentally friendly management of complex processes of city life and production.

Social sustainability (as in reduction of poverty and income inequality; gender parity; human health and well-being; safety; education; human rights including for children, indigenous people, and people with disabilities; rule of law) has been emphasized by the *United Nations Global Compact* as the basis for all human activities and therefore a core aspect for economic, ecological, political, and cultural sustainability. It is a two-way road: socially sustainable business is done in ways that benefit society and protect people, and businesses capitalize on social sustainability to ensure economic success and growth.

Broadly speaking, socially sustainable economy is the economy that is able to grow, and the ultimate question is whether economic growth and knowledge economy is a means to the end or an end in itself.

Measuring Innovation

The global innovation index (GII) has been produced annually since 2007 by the World Intellectual Property Organization for the World Economic Forum. Now it comprises 80 indicators grouped into 5 input categories and 3 output categories. Input categories are 1) institutions (political regulatory and business environment), 2) human capital and research (education, tertiary education, R&D), 3) infrastructure (ICT technologies, general infrastructure, and ecological sustainability), 4) market sophistication (credit, investment, trade, competition and market scale), and 5) business sophistication (knowledge workers, innovation linkages, knowledge absorption). Output categories include 1) knowledge and technology outputs and 2) creative outputs (intangible assets, creative goods and services, and online creativity). The GII index evolved over time to include ecological sustainability while maintaining its focus on efficiency, that is, economic sustainability.

The input and output innovation scores are combined in the global innovation index for national economies. National economies are ranked by their GII according to the income level of the country—high-income, upper middle-income, lower middle-income, and low-income groups of countries.

Input indicators reflect the potential of the national economy for innovation, and output indicators represent actual performance. The national economies can be then compared as to whether they perform according to their capability (inputs) or perform above or below the expectation. The economies may perform above their expectation irrespective of the income level of countries. In particular, the outperformers in the high-income group of countries for 2020 are Switzerland, Sweden, and the USA, with Switzerland maintaining its rank since 2011. For upper middle-income income countries, the outperformers are China, Malaysia, and Bulgaria. Among lower middle-income countries, Vietnam, Ukraine, and India performed above their capability, while Tanzania, Rwanda, and Nepal are outperformers in the low-income group (Dutta et al., 2020).

An economy can achieve a high innovation performance via several combinations of input conditions. The research shows that for low-income countries, none of the input conditions are necessary—on their own or as a group—for predicting high innovation performance and high GII. However, for the high-income group of economies, the infrastructure and human capital and research conditions are sufficient to obtain innovation performance (Crespo & Crespo, 2016). Thus, the GII index appears not to be an absolute value ranking. Furthermore, while studying the relationships among the factors affecting a country innovation performance, business sophistication (which includes such indicators as knowledge workers, university-industry linkages, and knowledge absorption), and infrastructure (ICTs, general infrastructure, and ecological sustainability) have shown the strongest direct and indirect effects, respectively, on creative output (Sohn et al., 2016).

Abilities and Skills of Knowledge Workers

One of the important questions is what kind of intellectual and cognitive capabilities are required of knowledge workers in the knowledge economy. Robert Reich was one of the first to address the education of symbolic analysts—high-skilled knowledge workers in the knowledge economy. According to Reich, the education of symbolic analysts entails the development of four basic skills: abstraction, system thinking, experimentation, and collaboration (Reich, 1992, p. 229). The capacity for abstraction helps the knowledge worker to discern patterns and meanings in myriad observations. System thinking provides a lens to see how observable phenomena and processes are connected to each other and to uncover hidden links that lead to multiple and novel perspectives on a phenomenon. Both skills are trained through experimentation, and working in groups and across fields of study requires specific skills in how to collaborate, how to communicate complex concepts, and how to achieve a consensus.

While it will be a daunting task to develop a quantifiable scale to measure these skills, the alternative would be to not even attempt to do so. No matter how attractive such benchmarking might seem, the cognitive skills for knowledge workers would be best left to curricular developers and teaching method specialists who design the learning process.

Dan Pink (2005) added an important nuance that balances the minds in the knowledge economy, which he referred to as the rising conceptual age. According to Pink, conceptual right-brain analysts and system thinkers with the ability to see the big picture should also understand the needs of people in an age of abundance—their need to seek meaning and fulfillment. Hence, "high-concept" aptitudes go hand in hand with "high-touch" aptitudes. Appealing design, argument as storytelling, synthesis that combines pieces into a striking new whole, empathy in addition to logic, and play and lightheartedness in developing products and services are in high demand during the conceptual age.

Are Some HEd Systems Better Positioned to Serve Knowledge Economy than Others?

One can wonder whether some HEd systems may have an advantage over the other systems in the way they adjust to the challenges and demands of the knowledge economy. A guiding idea to this understanding is whether HEd institutions develop an outward look into their environment for possible knowledge-based service. This shift is so significant that William Cummings has called it the third revolution of higher education (Cummings, 2006). According to Cummings, during the first HEd revolution which started in the middle ages in continental Europe, universities gained the privilege of offering licenses to practice the various professions and became teaching institutions with a guaranteed flow of students and tuition revenue.

The second HEd revolution began in the early nineteenth century, when universities added basic research as an important activity which governments and other donors were willing to support. In both the first and the second revolutions of HEd, the universities were looking *inward* to the academic community for guidance on what to teach and research. The third revolution of HEd involves an *outward* shift to increased responsiveness of universities to social demand. The reasons for this shift are at least threefold: (1) the demands for the university's traditional activities have peaked, (2) there is a growing societal demand for new knowledge products, and (3) there are new competitors other than established universities that are able to supply these products (Cummings, 2006).

Some universities and higher education institutions might be more open and more prepared for such a shift. University *service* has an outward orientation that enhances institutional connection to the economic and social partners in their environment. Service can be defined as "the delivery, installation, and maintenance of knowledge-based applications to clients wherever they may be" (Cummings, 1998, p. 1).

The concept of service in HEd institutions entails being more open to opportunities in their environments and more attuned to outside changes while being buffered from their direct impact, thanks to HEd institutions' autonomous status (Bain, 2003). Many universities and colleges in the countries transitioning to market economies in the 1990s embraced the renewed concept of service, at the time having established innovative linkages with secondary schools, state entities, and private companies through regional, inter-regional, and international collaborations (Bain et al., 1998). The HEd in the USA may be well prepared to look outward and has a history, as well as structure, of what could increasingly become a *service university* model. Historically, American higher education has been more locally rooted and attentive to the needs of the founding community. This local rootedness is also reflected in the principles of shared governance involving equal say of various stakeholders. The American invention of the department system allowed for a greater interdisciplinary collaboration. A widening set of course offerings extended beyond the set of traditional disciplines to address every possible need for any student, and it is captured in the famous motto, "any person, any study," succinctly put by Eric Ashby (1971). The US higher education system has been known for its innovation in creating graduate schools, the double-tiered structure of studies (undergraduate and graduate), and interdisciplinary departments that compensated for the shortcomings of the matured European chair model that initially helped drive specialization of scientific inquiry that later stalled innovation in HEd (Clark, 1993). The double-tiered structure of studies differentiating between undergraduate and graduate levels helps to diversify individual study paths, allows career change, and accommodates non-traditional-age student populations. This in turn helps to meet the demographic challenge of decreasing traditional-age students in mature national economies, a challenge particularly acute in Europe and parts of the USA. Responding to this challenge, established US universities as well as new for-profit institutions succeeded to reach out to adults with incomplete HEd through self-paced online programs, a move that also helped HEd in the USA to redirect programs to digital platforms during the COVID-19 pandemic. Lastly, university-industry linkages rank high in securing innovation output according to the studies of global innovation index (GII) and experience in such countries as Israel, India, and the Czech Republic that have broken into a group of top global innovation performers (Dutta et al., 2020). The critical mass of researchers and knowledge workers as well as of young and recent graduates, in addition to enabling infrastructure and government investment, are ingredients for the creation of the enabling innovation ecosystems.

Conclusion

The concept of knowledge economy goes back to the 1960s but received renewed attention in the 1990s when first global metrics attempted to quantify the advent of the knowledge economy. Knowledge-based economy composite scores focused on various inputs and their effect on the rate of economic growth as their major output. From this perspective, higher education produced major inputs to the growth of the knowledge economy in the form of skilled human resources, or knowledge workers, and research products as measured by research publications, citations, and patents. To date, this view on the role of higher education in the knowledge economy dominates, despite the UN-developed index of human development that focused on human progress in education, safety, health, ecology, human rights, and well-being. Since the rise of the neoliberal regime in the 1980s, an increasing emphasis on sustained economic growth and efficiency reoriented higher education and the academic profession to that end. Economic innovation indicators suggest that there are multiple pathways for sustained economic growth for nations of varying resources and development stages. Higher education and the academic profession have a responsibility to determine how to educate knowledge workers, how to shape the research agenda and promote the public value of knowledge, and how to connect the national and global economy with the increased responsiveness to social demand—such as through the model of the *service university*—with the ultimate goal of advancing the human condition.

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Olga Bain, Ph.D. is an independent consultant and scholar, formerly at the Graduate School of Education and Human Development at the George Washington University, Washington, DC. Her research focuses on change in higher education as influenced by global, institutional, faculty, and student agencies. She has published on internationalization and globalization of higher education, faculty productivity, and women's advancement in academia, higher education financing, and institutional strategies of change. Olga has authored the book titled *University Autonomy in the Russian Federation Since Perestroika* (2003, RoutledgeFalmer).

William Cummings is Professor Emeritus of international education at the George Washington University, Washington, DC. He received his Ph.D. in sociology from Harvard University in 1972. Since then, he has taught at the University of Chicago, the National University of Singapore, Harvard University, and the State University of New York at Buffalo. He is the author of *Education and Equality in Japan* (Princeton University Press, 1980), *Profiting from Education* (Institute of International Education, 1990) (with Gail Chambers), *The Japanese Academic Marketplace and University Reform* (Garland Publishing, Inc., 1990), and *The Institutions of Education* (Symposium Books, 2003). He coedited *Scholars in the Changing American Academy* (with M. Finklestein, 2012, Springer) and *Crossing Borders in East Asian Higher Education* (with G. Postiglione and D. Chapman).

Chapter 4
The Academic Profession in the Knowledge-Based Society (APIKS): Evolution of a Major Comparative Research Project

Timo Aarrevaara, Martin Finkelstein, Glen A. Jones, and Jisun Jung

Abstract This chapter argues for the importance of a comparative perspective on the academic profession, as higher education globally assumes an increasingly central role in the knowledge society and economy. We begin with an overview of the surge in empirical research on the academic profession over the past three decades and culminate with an introduction to the APIKS project: the Academic Profession in the Knowledge-Based Society. The project, involving research teams from 22 countries across 5 continents, designed and executed surveys of the academic profession in 2019–2020, including their role, working conditions, career trajectories and prospects, and the changing pressures and expectations for contributing to economic growth and social betterment through research, teaching, and external activities. Sampling and survey processes, including planning and design and datafile management, are described. The chapter concludes with a discussion of the challenges of conducting a large-scale comparative survey and considers the project's likely future directions.

T. Aarrevaara (✉)
Faculty of Social Sciences, University of Lapland, Rovaniemi, Finland
e-mail: timo.aarrevaara@ulapland.fi

M. Finkelstein
Seton Hall University, South Orange, NJ, USA
e-mail: Martin.Finkelstein@shu.edu

G. A. Jones
OISE, University of Toronto, Toronto, ON, Canada
e-mail: glen.jones@utoronto.ca

J. Jung
Faculty of Education, The University of Hong Kong, Hong Kong SAR, China
e-mail: jisun@hku.hk

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Keywords Academic profession · Knowledge-based society · Carnegie Survey · Changing Academic Profession (CAP) · Formative years · Data management

Introduction

In this chapter we provide an overview of the development of the Academic Profession in the Knowledge-Based Society (APIKS) project, an enormous, international comparative research project, in which teams from different jurisdictions, working in collaboration, have administered a common survey questionnaire. The project currently includes 22 research teams. In this chapter we identify the importance of a comparative perspective on the academic profession, present the main purpose of the project regarding the knowledge society and its impacts on the nature of academic work, and describe survey processes like planning, framework design, and data management. We also identify the challenges of conducting a large-scale comparative survey and describe the project's likely future directions.

Scholarship on the Academic Profession

Institutions of higher education fulfil an extremely important role within society. They are responsible for educating highly skilled professionals, knowledge workers, critical professionals, and citizens in almost every realm of contemporary society, from healthcare, law, technology, and business, to philosophy and fine arts. They are increasingly asked to play key roles in knowledge creation and dissemination, to add to existing knowledge through research and reflection, and in doing so, to contribute to human, social, and economic development. These core roles in teaching, research, and service do not take place in the office of university administrators or the board rooms of governance; they are the work of the academic profession and take place in the heartland of higher education—the classrooms, laboratories, and academic workplaces of the professoriate. In order to understand higher education, we need to understand the academic professionals who fulfil its core functions; we need to understand who they are, what they do, and the context in which their work takes place.

Biographies and institutional histories have long focused attention on the life, work, and accomplishments of renowned individual scholars; however, the systematic study of academic work and the academic profession received surprisingly little attention until the mid-twentieth century and largely paralleled the increasing interest in research on higher education in the context of what Martin Trow termed the transition from elite to mass—and universal—higher education. As national systems of higher education were expanded and transformed, there was an increasing interest in understanding issues of supply and demand within national academic labour markets and the shifting conditions and challenges of academic work. There was also an increasing interest in understanding differences within the academic profession, in exploring discipline differences within the 'academic tribes and territories', and differences related to issues of gender and other forms of inequity, in hiring, working conditions, and advancement (Jones, 2020).

One recent development has been the increased blurring of the lines, distinguishing academic staff employed full time in institutions of higher education and engaged in more than one of the historic components of the academic role (teaching, research, and service), from a broader array of knowledge workers who are engaged in research and development. These knowledge workers may collaborate closely with university-based academic staff but are housed outside university walls in organisations such as national academies of science (China, Russia, France), government entities such as national laboratories including Los Alamos, Fermi, and Livermore in the United States (USA), as well as government bureaucracies such as the FDA or NIH in the USA; that also does not include the large number of scientists conducting full-time research in business and industrial settings. There are two points to pay attention to: (1) the number of non-university R&D staff may actually exceed the number of full-time, university-based academic staff in the USA and (2) such non-university staff are increasingly working with university staff and lines of demarcation are becoming increasingly fuzzier. We see such boundary crossing (spanning) increasingly in the French (Musselin, 2019) and Russian systems (Yudkevich, 2019); in the USA, it has long been common for scholars to shuttle back and forth between university and government settings, even when individual scholars are officially listed in university staff rosters (although they may be paid entirely with non-university funds). Most recently, institutions in the USA such as MIT and Caltech have developed strong and consistent exchange relations between academe and industry with scientists and doctoral students moving freely across settings. While the APIKS project explicitly recognises the increasing blurring of lines across higher education, government, and industry, our focus has explicitly targeted the university-based academic staff in the interests of manageability. Indeed, a decade earlier, the Changing Academic Profession (CAP) survey had sought in its initial sampling frame to target government and industrial researchers and found it necessary, in light of the very different national systems, to abandon that approach. Academic staff in Japan and Germany at the time were government civil servants, albeit university based. There was surprisingly little comparative/international scholarship on the academic profession until the last few decades of the twentieth century. The dramatic reforms in higher education policy, funding, and governance within many national systems led to an increasing scholarly interest in understanding both common trends and important national differences. Higher education had become increasing international in scope, but also increasingly subject to the external pressures of global competition, international rankings, and in at least some jurisdictions, an increasingly international academic labour market.

Comparative studies of the academic profession allow us to understand the implications of these multiple pressures, reforms, and challenges on those who fulfil the core functions of higher education, to understand the ways in which broader shifts and trends influence the work taking place in the classrooms and laboratories. It helps us understand differences in academic work and careers both within and between jurisdictions and illuminates the pressures and challenges of the academic profession in global, regional, and national terms.

Moreover, the ubiquitous presence of the Internet has allowed a new model for such comparative research to emerge, what we have called the radically decentralised, networked model. The CAP project was originally conceived as a 10-year follow-up to the 1991–1992 Carnegie Foundation for the Advancement of Teaching International Survey of the Academic Profession led by Ernest Boyer and Philip Altbach (Altbach, 1996). That earlier model had been sponsored and led by a single, private corporate entity, the Carnegie Foundation. It was an informal group of alumni of that Carnegie survey who brought themselves together as a collegium to explore the feasibility of launching the 2007 follow-up survey. A basic principle of this collaborative effort was that each participating team would seek to secure its own sources of funding for their national survey. A total of 19 jurisdictions managed to secure external funding, typically from their central government directly or through a national social science competitive grant programme. In cases in which national funding could not be attracted—such as in the USA—self-appointed principal investigators (national team leaders) managed to self-fund (often with modest support from their home institutions and doctoral student assistance) online surveys. It was the radically decentralised, network model of CAP that provided the foundation for the APIKS project; many current team members either worked on CAP or were recruited by former CAP researchers (Teichler, 2017).

International Comparative Studies on the Academic Profession: From the 1990s to the Early 2010s

Since understanding the academic workforce has become an important issue in global higher education, a number of research projects have been undertaken since the early 1990s to study the academic profession in comparative perspective. This comparative approach was essential in exploring common challenges that academics experience across the world, even though they are situated in different traditions and deal with varied higher education policies. Moreover, as academics have been more actively engaged in international communication and research collaboration, comparisons between higher education systems have become more relevant and feasible. The academic labour market has also become increasingly international; the great brain race has become a global phenomenon.

The first international comparative survey on the academic profession was the Carnegie Foundation Survey of the Academic Profession, which took place from 1991 to 1993. The project was designed to examine the academic profession in different higher education systems in terms of demographic composition, employment and working conditions, teaching and research demands, and perceptions of university governance and management. Fifteen teams from around the world joined in the project, representing Australia, Brazil, Chile, Egypt, Germany, Hong Kong, Israel, Japan, Mexico, the Netherlands, Russia, South Korea, Sweden, the UK, and the USA. Based on 19,000 survey responses, the project team identified similar values, attitudes, and behaviours of academics in different regions, even as they found differences in employment structure, working conditions, and priorities of the professoriate (Altbach & Lewis, 1996). The survey design and findings of the first Carnegie project had significant impact on subsequent studies of the academic profession.

In 2007–2008, higher education scholars from several countries initiated a second comparative project on the academic profession: the CAP initiative. The scale of this project was larger than its predecessor. It was administered in 19 higher education systems: Argentina, Australia, Brazil, Canada, China, Finland, Germany, Hong Kong SAR, Italy, Japan, Malaysia, Mexico, the Netherlands, Norway, Portugal, South Africa, South Korea, the UK, and the USA. Based on the reflections from the first survey, the project team leaders were more cautious in designing the survey and clearly defining the project's main themes. For example, it was critical to design a survey that would reflect the new realities in the academic environment while still allowing for comparisons across time for teams participating in both surveys (Höhle & Teichler, 2013). Approximately half the survey items from the 1991–1993 questionnaire were retained, but there were many new items to explore the emerging realities and changing nature of academic work. In particular, the CAP project focused on new trends in academia, such as higher expectations of relevance for academic work, growing internationalisation, and the increase of managerial power in universities (Teichler et al., 2013).

The CAP survey received more than 23,000 responses from 19 teams, and the findings were substantial in showing changes in the views and activities of academics through a comparison with the earlier survey findings and demonstrated significant variations in the realities of different higher education systems around the world. Certain broad trends were common, including demographic changes (i.e. the increasing number of female academics, non-tenure track academics, and internationally mobile academics), a greater emphasis on research, increased research productivity, and powerful performance-based management climates in universities.

Building on the successful implementation of this comparative survey, spin-off studies were undertaken at the regional level. In Europe, the Academic Profession in Europe—Responses to Societal Challenges (EUROAC) took place from 2009 to 2012, with scholars from six additional European countries (Austria, Croatia, Ireland, Poland, Romania, and Switzerland, with Finland and Germany) joining the studies on academic profession (Höhle & Teichler, 2013). In addition to conducting a survey, EUROAC also collected extensive interview data in eight countries. In Asia, the Academic Profession in Asia (APA, 2011) study was launched, with new teams joining the survey on the academic profession from Cambodia, Taiwan, and Vietnam.

These projects had significant achievements in the study of the academic profession. They provided a rich portrait of the profession and made it possible to compare academics' work situations, career, and attitudes on core tasks and management on a global scale. On a scholarly level, a large number of books and journal articles based on the survey data were published from a comparative perspective or focusing on individual countries; approximately 700 scholarly publications had emerged from these projects by 2018. Most importantly, the projects have united a broad community of scholars for nearly 10 years, with colleagues who participated in an active network of international collaboration on subsequent projects.

Academic Profession in the Knowledge-Based Society (APIKS): From 2014 to 2019

After the successful completion of the CAP survey, the scholars who led it took the initiative in 2014 to create a new comparative survey on the academic profession. With reflections on previous projects, the project leaders and active participants organised workshops and seminars to discuss the major directions of the project and the survey framework, design the survey, build strategies of survey implementation and data management, and share the preliminary findings. Table 4.1 summarises the workshops held from 2014 to 2019 in connection with the APIKS project. Dialogue among participating teams will continue in the years to come.

Planning Phase

At the very first stage of the project, ten teams (Brazil, Canada, Finland, Germany, Japan, South Korea, Mexico, Norway, Portugal, and the USA) from the previous CAP survey agreed to participate in the new survey. To plan the project in a more structured way, the members launched an organising consortium. With a goal of implementing the survey in 2017 (10 years after the CAP survey), the consortium emphasised maintaining a strong collaborative network, empowering an efficient decision-making body, and ensuring ongoing dialogue among team members. The first workshop discussed the changes that had taken place in the various higher education systems since 2007–2008. These changes were related to structural reforms, regulation, massification, and enlargement of higher education systems, for example. A mode of governance for the APIKS project was established, comprised of three bodies: core group, coordination group, and advisory group. The team leaders constituted the core group as a key decision-making body. The coordination group acted as the body responsible for membership and issues related to survey implementation; it was also in charge of providing a platform for participating teams with coordination decisions and managing the international data. The first co-ordinator group members for 2013–2017 were Timo Aarrevaara (chair), Elizabeth Balbashevsky, Leo Goedegebuure, and Jung Cheol Shin. The second group, from

Table 4.1 APIKS workshops from 2014 to 2019

Time	Location	Title	Main agenda
September 2014	Helsinki, Finland	Planning and designing the survey	Launch the consortium for a new survey.
			Plan upcoming workshops.
			Discuss strategies for ensuring a sustainable collaborative research network.
			Discuss project timeline .
April 2015	Campinas, Brazil	The academic profession in the knowledge-based society	Discuss the major theme of the survey.
			Define the survey framework .
			Decide on the target group for the survey .
			Discuss sample size, sampling procedure, and data storage procedures; draft survey themes .
			Discuss the possibility of launching two separate surveys .
September 2015	Aveiro, Portugal	The project conceptual and methodological definition	Confirm the major theme of the survey.
			Discuss the sample and construction of the instrument.
			Discuss the pros and cons of implementing separate surveys.
April 2016	Seoul, Korea	Academic profession in knowledge-based society	Determine the core survey areas.
			Develop the questionnaire, adding new questions.
			Finalise the conditions for consortium membership.
			Decide on the principle of two tracks in one survey .
March 2017	Hiroshima, Japan	Status of the survey	Finalise the questionnaire.
			Prepare survey implementation.
			Establish definitive guidelines for data management, data storage, and access to survey database.
March 2019	Hiroshima, Japan	Academics' teaching and research activities in the knowledge society: Main findings from national surveys	Update the progress of each team in the project.
			Share major findings focusing on teaching and research activities from the survey.

(continued)

Table 4.1 (continued)

Time	Location	Title	Main agenda
August 2019	Kassel, Germany	Analysis of engagement/ knowledge and technology transfer	Share major findings and explore potential collaborative work across higher education systems .
			Conduct onsite data analysis and discussion for collaborative publications.

2017 onwards, were Timo Aarrevaara and Monica Marquina. Senior scholars who participated in the first Carnegie survey and led the second CAP project—Akira Arimoto, William Cummings, and Ulrich Teichler—remained in the project as an advisory group chaired by Teichler, to provide ongoing support and share their valuable experience to ensure successful implementation of the APIKS survey.

The tasks of the methods group as a sub-committee were also important; its role was to assess data from individual teams to ensure that it met the criteria of the international dataset and to decide when it was necessary to reduce the number of datasets. This sub-committee controlled the minimum standards for comparative data and made recommendations about key result tables for use in analysis. Six other sub-committees were organised: questionnaire coordination, survey coordination, data coordination, conference coordination, ethical committee, and publication coordination.

Participating Teams

As the project evolved, the number of participating teams grew, with more than 20 joining the project, although the project status was slightly different between teams. For the coordinating group, it was important to manage the participating teams efficiently in terms of qualifications, quality of work, and active participation and meaningful contributions to the project. The consortium decided that team leaders should participate in at least one workshop as a prerequisite for participation in the consortium. This principle ensured that members would play a role in establishing the rules and adapting them during the implementation phase of the survey. In 2016, it was decided that new members should host a national workshop that would examine survey implementation and the consortium's rules in detail. The new teams would invite an expert nominated by the APIKS coordinating committee to monitor the survey process, with transparency required in that process and in all decision-making.

It was also necessary to keep the door open to those teams that were not able to participate in a workshop but still had strong potential to contribute to the project. Many scholars in higher education from different countries approached the project leaders and expressed their interest in joining the project, and new members were brought into the project until very recently. However, three teams unfortunately had to withdraw from participating in the project even though their contributions at the initial stages were significant. This was mainly due to difficulties in securing the research funding needed to carry out the project or changes in research project priorities at their institutions. By the end of 2019 there were 22 teams involved with the survey located in Europe, Africa, the Americas, and Asia. An additional four teams had been interested in completing the survey at a later stage. Seven teams participated in the planning phase but didn't make it to the survey stage.

Survey Framework: Theme and Target Group

As the project's first step, the major theme of the survey was discussed. Throughout the ongoing dialogue between team members in 2014 and 2015, it became clear that the core of the APIKS project would be about understanding how the emergence of new realities created by the knowledge society was affecting academics' work and values. Two features of the knowledge society were highlighted. First, innovation was deemed to be the main driver of today's economy, bringing with it a heavy emphasis on research and development across higher education systems. Second, large proportions of employment and gross national product are related to the knowledge activities of academics.

The new survey was formally named (the Academic Profession in the Knowledge-Based Society) and the survey framework was discussed. In the process of building the survey framework, there were intense discussions about determining the target group of the survey. In particular, there were several debates about whether the survey should target only academics from science, technology, engineering, and mathematics (STEM) fields or academics from across all fields. The starting point was a narrower and more easily implemented survey targeting only STEM sectors. The idea was to identify comparative data, policies, and programmes of STEM from the early 1990s (Freeman et al., 2015). Based on this, the aim was to carry out a flexible sample design through which each team could define the academic profession in the STEM disciplines according to the specifics of each university system. This approach was expected to allow teams to manage the survey with fewer resources.

The scope of STEM fields is understood differently in different national contexts. For example, some teams could include broader science- and technology-focused fields, like agrarian science and the health sciences, while others would exclude them. In addition, there were concerns of missing the voices of academics from non-STEM fields, so it was decided that the survey population should be extended to academics from across all fields, unless certain teams had a specific rationale for narrowing their survey target groups to focus only on STEM. This narrower option did not take place, because the teams that implemented the survey had a wider interest in knowledge of societies and the role of disciplines in knowledge production. Another important reason for the broader sample design was the interest in a comprehensive comparison of Carnegie, CAP, and APIKS surveys. Over time, teams were able to access the research funding needed for the implementation of a wider survey of all disciplines in higher education.

Emerged Theme: Two Tracks Under One Survey

While developing the survey framework, another theme emerged that focused on the academic career and its formative years. The career aspects of academic life were always an important issue in earlier projects on the academic profession. The results from CAP and its successor projects demonstrated a substantial gap in the working conditions between senior and junior academic staff across some higher education systems. This refers to a small core of senior academics with secure working conditions, on the one hand, and casual workers with an emphasis on heavy teaching duties, short-term projects, and low levels of institutional influence who were mostly early career and junior academics, on the other (Altbach, 2000; Höhle & Teichler, 2013; Santiago et al., 2015). Several team members expressed keen interest in conducting an extended APIKS survey called the formative years, with a greater focus on academics' career-related issues. The formative years were defined in the sample as final-year doctoral candidates and subsequent years as researchers or post-doctoral appointments.

It was expected that about half of the teams would conduct this extended formative years survey, primarily because they believed that the extended survey would include the broader range of academics among survey respondents, regardless of their formal employment status. In particular, some European teams were deeply interested in this extended survey because doctoral students are called 'researchers' or 'junior academics' in some European contexts and are actively involved in knowledge production functions; however, they were not included in previous surveys, where they were classified as students rather than academics.

There were ongoing discussions about whether to conduct two separate surveys or merge the two into one. Conducting a separate, extended survey with doctoral students would lead to results that were richer in describing academics' work at different career stages and in comparing higher education systems. However, resource limits meant that it was not realistic for many teams to implement two full-fledged surveys. The ideas were advanced and defined in 2015 and 2016, and the survey framework was clearly shaped with the idea of two tracks within one survey. Combining the knowledge society and formative years surveys made it possible to cover a wider range of respondents and offered individual teams the choice of whether to include both tracks. At that point APIKS was envisioned as dividing into two parts: the CAP II Knowledge Society (CAP-KS) and the CAP II Formative Years (CAP-FY) surveys.

These discussions raised the issue of balance between the level of standardisation and survey flexibility in the comparative project, as it was obvious that each team had a slightly different focus and interpretation of the survey as a whole. It was important to proceed with the survey only after all consortium members had a clear understanding of the target group, sampling strategy, and survey instrument. These ideas were actively discussed in workshops until the team members agreed to allow a certain level of flexibility for individual teams. For example, each team was permitted to include additional survey items as long as they kept the main part of the survey in a standardised format for comparative purposes. After the major theme was defined and target groups identified, in-depth discussions followed regarding sample size, sampling procedure, data storage procedures, and a draft questionnaire. The implementation of two separate surveys had its pros and cons as it would have produced inconsistent data because these data would not have been comparable to previous survey results. Thus, one APIKS survey was formed from the two surveys made.

Designing the Questionnaire

The questionnaire became more concrete after the third round of workshops in 2016. Seven areas of questions were identified: career and professional situation, general work situation and activities, management and governance, internationalisation, personal background and personal characteristics, academics in the knowledge society, and formative academics. To ensure effective survey design and implementation, team members were divided into seven groups, each with a coordinator, as Table 4.2 shows.

Through 2017, there were follow-up workshops and communication between team members to finalise the questionnaire. The external activities and formative years sections were new and had not been included in the CAP survey. In addition, each section included new questions. Although the questionnaire evolved significantly based on productive discussions among team members, it was premature to implement the survey in 2017 due to the length of the questionnaire and level of flexibility that would allow for each team to add its own questions. The coordinating group members agreed to shorten the questionnaire so that it would not take longer than 20 minutes and allowed each team to add higher education system-specific questions within that time limit. As the length of the survey form affects the response rate, and given the addition of new questions, some items also had to be left out. The APIKS questionnaire does not cover some topics as comprehensively as the CAP project, such as the respondents' income, residence, and support services, and some governance questions were asked in different ways.

Career and professional situation asked views on professionally active respondents' degrees, career paths, and current work situation. *General work situation and activities* included respondents' work hours according to several tasks and attitude-to-work conditions. *Teaching* refers to the current academic year or the previous one for those who had not taught during the current academic year. *Research* referred to the current academic year or the previous one if a respondent was active in research. External activities asked for views on how external activities to a respondent's institution contribute to society. *Governance and management* mapped the respondents'

Table 4.2 Survey areas

Survey areas	Coordinator	Participating members
Career and professional situation	Agneta Vabø (Norway)	Maria Yudichevich and Ilya Prakhov (Russia), Peter Bentley (Australia), Marek Kwiek (Poland), Robin Chen and Sophia Ho (Taiwan), Hui Guo (China)
General work situation and activities	Timo Aarrevaara (Finland)	Hong Shen (China), li-fang Zhang (Hong Kong SAR), Tsukasa Daizen (Japan)
Management/governance	Lynn Meek (Australia)	Maria Yudichevich and Ilya Prakhov (Russia), Hanying Li(China), Norzaini Azman (Malaysia)
Internationalisation	Futao Huang (Japan)	Laura Valkeasuo (Finland), Fatma Nevra Seggie (Turkey), Eric James Iversen (Norway), Li Yu (China)
Personal background and personal characteristics	Jung Cheol Shin (South Korea)	Glen Jones (Canada), Yan Zhang (China)
Academics in knowledge society	Christian Schneijderberg (Germany)	Baris Uslu and Fatma Nevra Seggie (Turkey), Lars Geschwind (Sweden)
Formative academics	Leo Goedegebuure (Australia)	Peter Bentley (Australia), Lars Geschwind (Sweden), Barbara Kehm (UK), Eric James Iversen (Norway), Maria Yudichevich and Ilya Prakhov (Russia), Norzaini Azman (Malaysia), Teresa Carvalho (Portugal), Juhani Saari (Finland), Yaging Lin and Jin Lin (China)

influence and attitudes to governance and management phenomena. *Academics in formative stages* were questions for junior respondents, excluding full professors, associate professors, or similar ranks.

Creating the International Dataset

During 2018 and 2019, most teams implemented the survey, with system-level data collected at the individual team level. Once most teams had completed data collection, it was essential to establish definitive guidelines for data management, data storage, and access to the international database. There were important questions to be answered, such as: (1) how long to store the data, (2) whether data would be available to the public, (3) the extent to which data management should be centralised and what level of flexibility should be given to individual teams for data correction, and (4) what specific steps would follow after data creation, sharing, and access.

In the planning phase of the project, an important decision was made to store the data securely for 12 years after the APIKS survey had been implemented. This approach ensures that there will be no problems with consent, fabrication, or falsification of data after team members publish their work individually or in collaborative efforts.

Whether the data should be available to the public was a sensitive issue. For some teams, open data was an essential condition of financial support from national funding agencies, while it was simply not possible for other teams to allow open data. As a principle, it was agreed that raw data would not be available to the public; however, there are plans to develop an online system that would enable the public to make statistical queries from the database under certain conditions and obtain the resulting information. Of course, access would apply only to the data from those teams that accepted the open access conditions. If some teams decide to take further steps and publish their data in an open-source format, they will be permitted to do so, provided that they do not share other teams' data without consent. It is also critical that the survey participants be notified in advance if their material is to be used in open data applications.

Another issue regarding data management was the extent to which data collection should be standardised and centralised. Although it was assumed that the implementation would be based on a highly standardised questionnaire and that data collection would follow centralised procedures, some teams revised some questions according to their context and added their own questions to the survey. The basic recommendation for each team was to store its data in accordance with the consortium guidelines, even if they did not need to submit the data from higher education system-specific questions to the international dataset. In addition, each team was advised to consult with the co-ordination group about the number of team-specific questions before survey implementation.

The core group of team leaders, with support from Ville Tenhunen as data coordinator, decided the specific step-by-step guidelines for data management, from collection to storage and sharing. This process included data storing at CSC, the IT Center for Science owned by Finnish higher education institutions. The system features four phases of operations. First, individual teams collected the data using their own tools. Each team uploaded its questionnaire results to the centralised repository, with due consideration for technical harmonisation and national regulations on data protection. Only the team leader and administrator had access to the data during this phase. Second, raw datasets were saved in the centralised database, which the team leader and administrators could examine, review, and clean when necessary. A centralised system offered an interface to the data and researchers so that they could use their preferred tools to clean and correct the data. Only those with access to the data were responsible for data correction and cleaning. Third, after data cleaning, the corrected versions of the datasets would be stored by team leaders as data for analysis. With these data, researchers can create final-version datasets, which are the basis for research and publications. The operations are run according to the ethical code of the consortium. Only team members have access to the data during all these phases. Each team is responsible for data manipulation. Fourth, a centralised system offers an interface for publishing datasets based on researcher consent, and the open data will demand metadata management techniques.

Data management and governance are particularly important in the changing environment of international standards regarding data regulation. Over the last 10 years, data regulations in most countries in which the APIKS survey was conducted have undergone significant changes, and the international transfer of data now requires a common understanding between all teams. In Europe, for example, the General Data Protection Regulations (GDPR) have come into force, while legislation in many other countries is even more complex. Many universities follow standards such as the FAIR principles and CC BY 4.0, and scholars use ORCID to validate trusted datasets. Data security requires that the consortium enforce strict rules and rely on a trust-based approach for data storage and usage practices.

It was necessary to find a common understanding of the principles for using the APIKS international dataset. Thus, approval of the memorandum of understanding was a prerequisite for data sharing, and a document was needed for the forthcoming publication phase. Each team received the rights to their own data, but restrictions apply to situations in which the material collected by other teams is involved. The eventual goal of the APIKS survey is to make available a dataset that can be credibly reported in a range of publication forms in the future; this aim was shared by all team members.

In short, there are three key principles to which each team had to commit. First, the memorandum of understanding confirmed the governance model adopted at the earlier core group meetings. Second, each team was provided with a clear understanding of the definitions of the matters covered by the memorandum of understanding, and transferring data from the international dataset to anyone other than APIKS partners that have signed that memorandum is not permitted. Third, the memorandum of understanding also introduced the FAIR principles for the APIKS international dataset, with the goal of ensuring findable, accessible, interoperable, and re-useable data.

APIKS: Looking at the 2020s

Despite the challenges that emerged as the project moved along, team members have retained a collegial atmosphere in dialogues to resolve issues and make productive adjustments to the rules. The APIKS international dataset represents a unique database for comparative studies. In particular, the data collected in the APIKS survey are based on a strong foundation, as the survey was implemented by knowledgeable and experienced team leaders who have produced widely distributed reports from previous surveys. The APIKS project has a voluntary, highly decentralised, loosely coordinated structure, and this is how it reflects the knowledge society as a new kind of structure for conducting comparative research.

Some teams will have the opportunity to produce time series studies dating back to the 1992 Carnegie survey and/or the 2008 CAP survey results, along with successor projects like EUROAC and APA. International publications in a range of languages will be produced to report on valuable research. The project will proceed in a comparative and collaborative way through forthcoming conferences, and the major findings from each team will be shared in scholarly reports, including journal articles and the Springer book series, *The Changing Academy—The Changing Academic Profession in International Comparative Perspective*.

As the first of the APIKS book series, this volume aims to provide the necessary information for the context of higher education systems in the countries participating in APIKS. In particular, the volume explores the knowledge society and academic profession in the context of each participating team. Subsequent volumes will discuss the concepts, methodology, and results of the APIKS survey and provide comparative results. Those themes will include universities and the knowledge society, the teaching-research nexus, research, external activities, career and professional situation, internationalisation, general work situation and activities, and academics in formative stages.

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Timo Aarrevaara is a Professor of Public Management at the University of Lapland, and Principal Investigator of the research team of Professions in Arctic Societies. He has professional experience in public administration as well as in research and teaching. He is chair of the APIKS coordinators group.

Martin Finkelstein is Professor of higher education at Seton Hall University, South Orange, New Jersey, USA. He is the author of *The American Academic Profession* (Ohio State, 1988) and co-author of The *New Academic Generation* (Johns Hopkins, 1998), *The American Faculty* (Johns Hopkins, 2006), Scholars in the Changing American Academy (Springer, 2011) and *The Faculty Factor* (Johns Hopkins, 2016). He is co-editor of *The Internationalization of the Academic Profession* (Springer, 2013), and *Professorial Pathways: Academic Careers in a Global Perspective* (Johns Hopkins, 2019).

Glen A. Jones is Professor of higher education and Dean of the Ontario Institute for Studies in Education, University of Toronto. His research focuses on higher education systems, governance, policy, and academic work. He is the author or editor of more than a dozen books and has published more than 100 papers. Recent books include *International Education as Public Policy in Canada* (with Merli Tamtik and Roopa Desai Trilokekar, McGill-Queen's University Press, 2020) and *Professional Pathways: Academic Careers in a Global Perspective* (with Martin Finkelstein, Johns Hopkins University Press, 2019).

Jisun Jung is Assistant Professor in the Faculty of Education at the University of Hong Kong. Her current research focuses on the academic profession, doctoral education, master's education and employment, and higher education research in Asia. Her recent co-edited books include: *The changing academic profession in Hong Kong* (with Gerard A. Postiglione, Spriner, 2017), and *Researching Higher Education in Asia: History, Development, and Future* (with Hugo Horta and Akiyoshi Yonezawa, Springer, 2017). She is a co-editor of *Higher Education Research & Development*.

Part II
Systems of Innovation and Higher Education

Chapter 5
Higher Education and the Knowledge Society Agenda in Uganda

Florence Ndibuuza, Patrício V. Langa, and Ronald Bisaso

Abstract This chapter examines the role of the higher education sector in the knowledge society agenda in Uganda. National policy documents on research, development, and innovation mandate higher education institutions to produce knowledge and human resource and foster innovation for the economy to rise to the development trends of the knowledge age. However, there are two dilemmas to this effect; the first is that national expectations coexist with the reality that Ugandan universities lack academic staff and major teaching and research infrastructure. The second is that the policy rhetoric at the national level demonstrates little commitment at the implementation level; hence, there is a big gap between policy and practice at the institutional level. Thus, an overview of the higher education sector in terms of origins, structure, and contemporary trends has shown that expectations for the sector are growing and evolving, depicting an academic community under pressure to deliver with the bare minimum. Uganda's higher education sector therefore appears tasked beyond its capacity to guide socio-economic transformation.

Keywords Higher education · Knowledge society · Research · Technology · Innovation

F. Ndibuuza
Institute for Post School Studies, University of the Western Cape, Cape Town, South Africa

P. V. Langa (✉)
Institute for Post School Studies, Faculty of Education, University of the Western Cape, Cape Town, South Africa

Eduardo Mondlane University, Maputo, Mozambique
e-mail: planga@uwc.ac.za

R. Bisaso
East African School of Higher Education Studies and Development, College of Education and External Studies, Makerere University, Kampala, Uganda

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Introduction

The twenty-first century has been marked by an expanded mandate for higher education to meet the socio-economic changes that will accompany the knowledge society (World Bank, 2017). The idea of a knowledge society suggests that knowledge is evolving into the key factor of production and a basic characteristic of social inclusivity for development (Snellman, 2015; Välimaa & Hoffman, 2008; World Bank, 2017). The centrality of knowledge in contemporary societies has therefore increased the awareness that higher education can play a key role if universities can produce, disseminate, and apply knowledge beyond the walls of academia. In response, nations around the world regardless of their current level of development are striving to create their own knowledge societies with higher education as the cornerstone (Snellman, 2015; World Bank, 2017), including Uganda.

In Uganda, the idea of the knowledge society is part of the policy rhetoric reflected in the Uganda Vision 2040, a 2007 initiative specifying that "Uganda will reorient itself to make science, technology, engineering, and innovation the main driver of economic growth and the key pillar of competitiveness" (National Planning Authority [NPA], 2007, p. 75). This commitment led to the formation of a science, technology, and innovations (STI) policy in 2009 to address socio-economic growth challenges in the quest for a knowledge-based economy (Ministry of Finance Planning and Economic Development [MoFPED], 2009). The national development plan further endorsed building research capacity to foster knowledge production and technology transfer (NPA, 2015). The idea of a knowledge society in Uganda is central to the policy environment, with all entities, including higher education, operating to fulfil national aspirations.

The first phase of the national development agenda identified higher education as a driver of Uganda's economy of the future given the role assigned to knowledge and human resource production (NPA, 2010). In the same vein, the second phase of the national development agenda identifies academia as a player entrusted with research and knowledge transfer (NPA, 2015). This may explain why Makerere University, the leading institution in the country, incorporated strategies to foster knowledge translation and human resource development into its recent strategic plan (Planning and Development Department [PDD], 2017); trends over the past decade reveal an increase in the number of publications and graduates from the university, a possible step toward meeting the goals of the national agenda. However, universities across Uganda are still making limited contribution to the national and global knowledge base although public institutions are doing better than private ones (National Council for Higher Education [NCHE], 2019; Uganda National Council for Science and Technology [UNCST], 2016).

Overall, national expectations coexist with the reality that Ugandan universities lack academic staff and major teaching and research infrastructure (Muriisa, 2014; Ochwa-Echel, 2016). Due to these constraints, this chapter focuses on describing emerging trends of the knowledge society agenda and their implications for Uganda's higher education system. It offers an overview of the national research, development, and innovations policy. The sections below describe Uganda's higher education system and its role in the national development and knowledge society agenda.

Overview of the National Research, Development, and Innovations Policy

Uganda is aiming to attain middle-income status by 2040, a goal that would be achieved by boosting STI to lay the foundation for the country's ultimate goal of building a knowledge society (UNCST, 2016). Thus, the formulation of the 2009 STI policy was a recognition by the government that the desired socio-economic transformation lay in committing to the blueprint of contemporary development trends (MoFPED, 2009). The Ministry of Finance, Planning and Economic Development specifically noted that the policy would serve as a platform for Uganda's transformation by prioritising knowledge as a factor of production. This policy is presented as a sum of 15 policy statements representing the strategic direction for national development with the following focus:

> Strengthening national capability to generate, transfer and apply scientific knowledge, skills and technologies that ensure sustainable utilisation of natural resources for the realisation of Uganda's development objectives. (MoFPED, 2009, p. 13)

Thus, underscored by knowledge utilisation, the success of the STI policy lies in nurturing and fostering Uganda's national STI systems (UNCST, 2016).

UNCST (2017) has made an effort to integrate science and technology into the national development process through technology transfer and commercialisation of innovations. There are two institutions that UNCST has identified as contributing to the STI development agenda. The first is Uganda's industrial research institute, which promotes applied industrial research and technology in a bid to create a sustainable industrial sector for the country. The second is the Ministry of Science, Technology and Innovation, which has not only recognised the role of STI in Uganda's socio-economic development but also sought to raise awareness of its importance. A combination of efforts is thus setting the pace for the implementation of the STI strategy (see Fig. 5.1).

The input level of the STI framework in Fig. 5.1 indicates that a combination of knowledge workers and an investment in research and development (R&D) will boost knowledge production, technology transfer, and innovation all of which will help fulfil the national development agenda. This suggests three consequences. The first is that the higher education sector must drive the national development agenda given that universities are still the main seat of research and innovation in most African countries including Uganda (Cloete et al., 2015). The second is that governmental commitment to R&D funding is bound to determine the success of the development path given that the research output depends heavily on the amount of funds a country dedicates to R&D (Wondwosen, 2019). The third is that researchers have

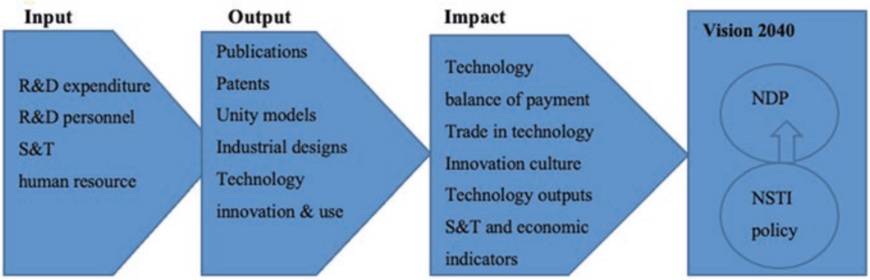

Fig. 5.1 STI framework of Uganda. NDP: National Development Plan; NSTI: National Science, Technology and Innovations Policy. (Source: UNCST, 2013)

to be readily available particularly in science and technology fields which are covered in the national requirement that universities produce a critical mass of skilled workers for all fields relevant to Uganda's national development (MoFPED, 2012). However, challenges specific to student enrolment, staffing, and the low funding for R&D are frustrating the STI agenda (MoFPED, 2012; Muvawala, 2017).

Research and Development Funding

Sustainable development goals suggest that the world will be in a better position by 2030 if a conducive environment is created for scientific and technological innovation through increased investment in R&D (Coalition for African Research and Innovation [CARI], 2018). Unfortunately, the existing distribution of funds is geographically unequal: in 2016, the United States was responsible for 28% of global investment in R&D, China 20%, the European Union 19%, Japan 10%, and the rest of the world including all of Africa 23% (UNESCO, 2016). That stark reality continues; in 2018, Africa's investment in R&D was just 1.3% of the global total (CARI, 2018) and 0.42% of the continent's gross domestic product [GDP] by 2019 (Wondwosen, 2019). It is important to note that trends are classified as improving across sub-Saharan Africa, although Uganda is not among countries like South Africa, Botswana, and Kenya that are investing over 0.7% of GDP in R&D (UNESCO Institute for Statistics [UIS], 2019).

At the start of the twenty-first century, Uganda emerged as one of the fastest growing economies in sub-Saharan Africa with a 7.8% annual growth rate (Brar et al., 2011). However, its low investment in R&D takes the shine off that statistic as Uganda's commitment to the national development agenda is compromised by committing less than the minimum 1% of GDP recommended by the recent STI strategy for Africa (African Union Commission [AUC], 2014). The largest investment the government has made so far is 0.476% in 2010, which dropped to 0.170% by 2014 (UIS, 2016). This continued underfunding is impairing Uganda's knowledge economy strategy, given the strong correlation between R&D investment and the quality and quantity of knowledge produced (Wondwosen, 2019).

Uganda like most sub-Saharan countries must deal with social challenges like HIV/AIDS, which demand resources that could otherwise be dedicated to R&D (Kariuki & Kay, 2017; NPA, 2015). In response, organisations like the Coalition for African Research and Innovation [CARI] are easing the burden on individual countries by offering funding for scientific breakthroughs (CARI, 2018). At the same time, government funding, for example, the 178 billion shillings (approximately 47 million USD) Uganda set aside for STI sector for the 2019/2020 financial year, is boosted with support from international organisations like the World Bank, local firms, and multinational companies that usually contribute over 50% of budgeted costs (MoFPED, 2019). Donor funding further bolsters the research component of Ugandan universities; Makerere University, the country's knowledge hub, depends mostly on grants (PDD, 2019). However, there are downsides to this approach: there are usually no long-term investment plans, and donors ignore national interests for their own development priorities which CARI (2018) notes as a challenge to R&D funding in Africa.

Challenges specific to poor research infrastructure and limited personnel have become manifestations of the dilemma of R&D investment (CARI, 2018; UNCST, 2016). This affects knowledge production and application for a country seeking to build a knowledge society, which is why Kunene (2013) advocates strengthening the research infrastructure in the higher education sector as a basis for nationwide development. The African Development Bank (AfDB) (2012) through its Higher Education, Science, and Technology project funded the rehabilitation of science and technology infrastructure, and projects that link science and technology to the productive sector in Uganda. However, such relief efforts only slightly boosted the desired infrastructure, so a home-grown plan for generous R&D funding would not only curb the fragmentation of resources consistent with donor funding but also create a systematic funding mechanism for long-term goals (CARI, 2018). The lack of research personnel poses a challenge that requires national attention as discussed in the next subsection.

The PhD Crisis in Uganda

Higher education systems in Africa are a product of a colonial legacy that disregarded graduate education, and the post-colonial events specific to neo-liberalism have further hamstrung the sector (Hayward & Ncayiyana, 2015). The neo-liberal period in Uganda was marked by structural adjustments directed by the World Bank, which forced the government to focus on lower levels of education at the expense of higher education (Bisaso, 2017). This laid the foundation for the introduction of universal education at the primary level in 1997 and the secondary level in 2007, which increased the number of students seeking higher education and emphasised teaching at the undergraduate level at the expense of graduate education and research

(Mamdani, 2008; NCHE, 2013). This partially explains the shortfalls in graduate education and consequently research output among all higher education institutions in Uganda (NCHE, 2019).

The trend in Uganda is consistent with the experience across Africa; the continent has 25 and 28 times fewer researchers per million people than the USA and UK, respectively (CARI, 2018). This may help explain why the continent contributes just 1% of global science despite having 16% of the world's population (Wondwosen, 2019). Kariuki and Kay (2017) suggested that Africa should produce at least one million PhDs to reach the world average, a target that remains extremely difficult to meet. The limited number of Ugandan PhD holders (UNCST, 2016) poses a challenge to R&D as a foundation to the STI framework that was intended to propel Uganda into becoming a knowledge society.

Higher education is currently at the centre of national and continental economic plans in Africa due to the growing need for researchers within and outside academia (Molla & Cuthbert, 2018). This is consistent with the economic value attached to a PhD, since that degree fosters the knowledge production and innovation essential to the knowledge age (Molla & Cuthbert, 2016, 2018). Universities in Uganda are expected to produce enough doctoral graduates to fulfil their mandate to produce human resources for all sectors of the economy (NPA, 2018). However, those universities are still focusing more on undergraduate educate than granting advanced degrees (NCHE, 2019). At the same time, an examination of data from Makerere University, which produces the greatest number of PhDs in the country, shows a mismatch between national optimism and output of graduates, as shown in Fig. 5.2.

The details in Fig. 5.2 reveal two important points. The first is how few people move on from a master's to a PhD, and the second is that the output of PhDs is still far too low to create the critical mass of researchers needed to boost knowledge

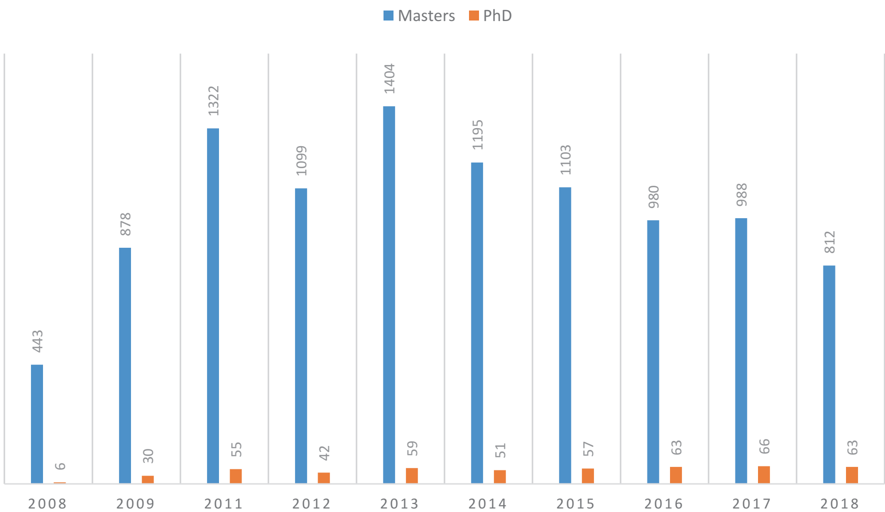

Fig. 5.2 Postgraduate degrees awarded by Makerere University, 2008–2018. (Source: PDD, 2019)

production and innovation in Uganda. Challenges like brain drain are further shrinking the research pool, as the country loses skilled workers with the capacity to contribute to its development agenda (Muriisa, 2014). This trend cuts across the continent; Africa loses over 20,000 professionals annually (Kariuki & Kay, 2017).

To counteract the PhD crisis in Uganda, the donor community is funding graduate programmes at several universities in the country and across the continent and beyond, including Makerere University (PDD, 2019). The University's annual report shows that bodies like the German Academic Exchange Service, the Carnegie Corporation, and the Consortium for Advanced Research Training in Africa offered over 300 scholarships in 2019 alone to increase the quality and quantity of PhDs at the university. This emerging avenue may boost the number of researchers needed to spearhead the construction of a knowledge society in Uganda.

Overview of Higher Education in Uganda

Higher education in Uganda traces its roots to the establishment of Makerere Technical College in 1922 to serve students from British East Africa (today's Uganda, Kenya, and Tanzania) (NCHE, 2013). Bisaso (2017) divides events from the early 1920s to the present day into three phases. In the colonial era, higher education focused on human resource development for the colonial government. In the second period, or "national phase", nationalism drove the agenda and sought to produce skilled labour for Uganda's post-independence economic growth. The key goal of higher education in that period was to create a critical mass of experts to cover the human resource gap left by the colonial experts and administrators who had left the region. In the third, neo-liberal period, structural adjustments required by the World Bank forced Uganda to focus first on funding lower levels of education, which changed the course of its higher education sector (Bisaso, 2017; Ochwa-Echel, 2016).

The aftermath of the neo-liberal era witnessed three developments in the higher education sector (Bisaso, 2017; Mamdani 2008; NCHE, 2013; Ochwa-Echel, 2016). The first was the introduction of cost sharing in higher education to cover reductions in funding and the second was that it led to the introduction of private universities in 1988, which was partly due to the lack of capacity at Makerere, then the only university in the country to meet the growing demand for higher education. The third was that free education at the lower levels increased the number of school graduates seeking higher education, with private institutions created to absorb the excess demand. The nature of higher education in Uganda today is thus a product of both internal and external forces driven by socio-economic constraints.

The National Council for Higher Education [NCHE] (2019) reports that the higher education sector in Uganda has two important aspects. The first is that the sector is made up of universities, other tertiary institutions (OTIs) like national teacher's colleges, colleges of commerce and technology, and other degree awarding institutions (ODAIs). The number of institutions has consistently increased over the years with a current total of 241 institutions (53 universities, 178 OTIs, and 10 ODAIs), which point to the growth of the sector in the country (NCHE, 2019) (see Fig. 5.3). The second is that institutions are either public or private, with the government controlling the former and the private sector controlling the latter. The private universities are further stratified into private for-profit-, private not-for-profit-, religious-, community-, and cultural-funded institutions that are controlled by individuals, non-governmental organisations, religious groups, communities, and cultural institutions. Most institutions are in the private sector, with the government controlling only 27.2%; only 17% of the universities considered at the peak of higher education in Uganda are under governmental control. This poses a challenge to the national development agenda, given that the private universities making up the majority of institutions contribute little to no research (NCHE, 2019).

The point of commonality in the higher education sector, whether public or private, is the shortage of academics, although the problem is more prevalent among private institutions. The highest numbers of academics with PhD and master's degrees are in public universities particularly Makerere (Bisaso, 2017); this leaves a large gap in all other tertiary institutions in the country. Nakayiwa (2016) observed that most universities are operating at less than 50% of full staff levels, a number of whom have reached retirement age. This poses a threat that could grind Uganda's higher education sector to a halt if it is ignored, especially for the 9 public universities that account for 49% of total university enrolment, the other 51% is spread across 44 private universities (NCHE, 2019). This staffing shortage creates high student-staff ratios that affect research output to the detriment of contemporary trends and goals in national development across Africa (Cloete et al., 2018), including Uganda.

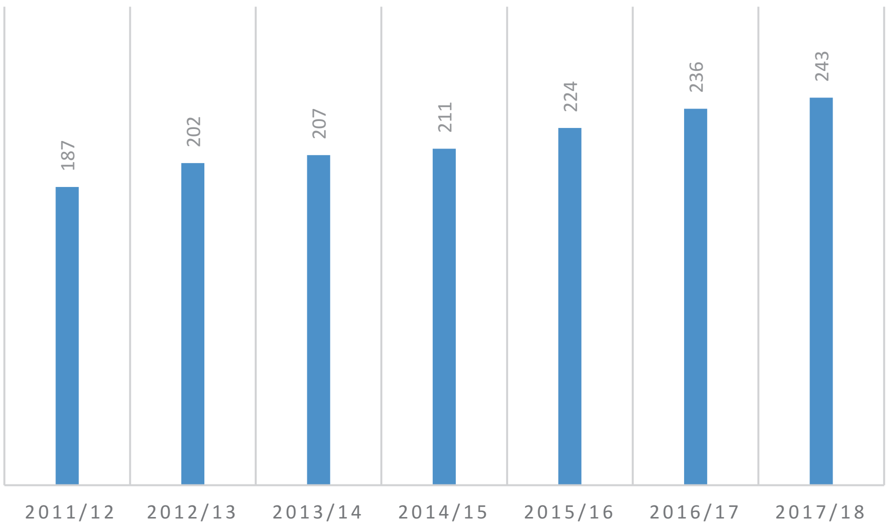

Fig. 5.3 Number of higher education institutions in Uganda, 2011–2018. (Source: NCHE, 2019)

Contemporary developments in Uganda's higher education sector pose a challenge to NCHE, an entity set up to promote and sustain the quality of higher education in the country (NCHE, 2017). As a regulatory body, the NCHE oversees the establishment of institutions; it accredits and ensures quality delivery of programmes across the higher education sector, yet enforcement has proven difficult due to limited resources (NCHE, 2017). However, the NCHE strategic plan for the 2017/2018–2019/2020 period promises accessible, equitable, relevant, and sustainable quality higher education, which may enable it to fulfil its mission. Higher education in Uganda is thus a growing and regulated but seriously challenged sector that is expected to meet stakeholder demands.

The Role of Higher Education in Uganda's National Development Agenda

Higher education in colonial and post-colonial Africa manifested in pioneer universities set up with the triple mission of teaching, research, and service, though from the early 1970s to the early 2000s, teaching was almost the sole mission of most universities (Andoh, 2017). However, in the last decade, research has become a key focus of most African universities, due partly to continental and national policy directives urging institutions to generate the scientific knowledge that is urgently required to achieve development in the contemporary world (Molla & Cuthbert, 2018). The events leading to the current situation relate to three phases that have shaped the higher education sector in Africa since independence. The first was the era of the "development university" during the 1960s and 1970s, when the universities were entrusted with human resource development for national development (Badsha & Cloete, 2011; Cloete et al., 2011). In essence, university education was a process of economic transformation across Africa, including Uganda.

The second phase relates to the onset of neo-liberalism in the 1980s; following the reduction in funding of higher education in Africa, market-driven universities emerged characterised by mass student entry, and commercialisation of knowledge. (Mamdani, 2008; Ochwa-Echel, 2013; van der Walt, 2017). The three studies cited in this context reveal a period during which universities had to seek alternative sources of funding for their financial survival, even though they intended to serve national interests. The third phase relates to the revitalisation of higher education specifically increasing the number of PhDs granted, publications, and innovations, along with developing intellectual capital as a strategy to respond to the agenda of constructing knowledge societies in Africa (Molla & Cuthbert, 2018). There are two aspects to note here; the first is that the three phases resonate with the post-independence expectations of higher education and consequently universities in Uganda, given the history of the sector in the last nine decades (Bisaso, 2017; Mamdani, 2008; Ochwa-Echel, 2016): the second is that universities in Uganda may not yet be at the revitalisation stage as current trends reflect the influence of all three phases of university transformation.

The key focus of most universities in Uganda is still teaching, as reflected in the rate at which both private and public universities are graduating students. Over 40,000 students graduate annually; this number is in excess of what the labour market can absorb (NCHE, 2019). It is important to note that most of these degrees are at the undergraduate level and in arts-related fields, which runs counter to the national target of creating a pool of scientists to boost knowledge production and innovation (NPA, 2018). This implies that "teaching universities" are a problem for the national development goals, and that problem is likely to persist, given that the government funds less than 30% of these institutions. Private institutions will still seek to survive by admitting large numbers of students, even to the detriment of national interests (Mamdani, 2008; Ochwa-Echel, 2013, 2016).

In the same vein, the higher education sector has a strong bearing on the quality and quantity of knowledge, technological advancement, and human capital required for the fulfilment of Uganda Vision 2040 (Muvawala, 2017; NPA, 2018). The National Human Resource Development Framework therefore raises two assumptions; the first is that universities will help narrow the gap between academia and society through active engagement with industry; the second is that universities especially public ones will respond to national interests in their accountability for public resources, since they have the highest concentration of researchers with the capacity not only to contribute to the research output but also to train the knowledge workers of tomorrow. When the STI policy was formulated in 2009, it acknowledged that Uganda's universities and other research institutions in the country were not properly equipped to handle the research necessary for innovation (MoFPED, 2009). The document further indicated that most of the research work was still at the basic level except for a modest amount carried out in the country's few medical and agricultural research institutes. The capacity of Uganda's higher education sector to meet national research expectations was still low.

The NCHE (2019) recognised three things about the practice of research in Uganda's higher education sector. The first is that universities, especially in the public sector, are improving their research output due to local, national, and international partnerships. The second is that research funding remains low, with public universities dedicating only 6.2% of their institutional budgets to research and private universities just 2.51%. The third is that the government commits little to research, so donors fund most research in universities; academic research may reflect donor rather than national development needs. These findings strongly suggest that the Ugandan government is contributing to the failure of the higher education sector to fulfil its mandate to help achieve same government's national development goals.

Academia and the Knowledge Society Agenda in Uganda

Research that addresses the knowledge society agenda in Uganda places many expectations on higher education. Brar et al. (2011) insisted that it is science and technology that will sustain Uganda's pursuit of a knowledge society. Najjingo (2016) called on universities in Uganda to focus on research to aid the creation of new knowledge and advance productivity. Meanwhile, Muvawala (2017) asked universities to focus on creating a workforce with knowledge and skills suitable for all sectors of the economy for Uganda to participate fruitfully in the knowledge age. In Uganda, research, technology, and human resource development are primarily driven by academics in universities (Muvawala, 2017), so these growing societal and governmental expectations call for vigilance in research in the university sector. It is within this context that universities particularly public ones like Makerere are committing to national development targets through academic research, teaching, and service (PDD, 2017).

Consequently, Ugandan universities have embarked on two initiatives to boost knowledge production and transfer: improving the quality of teaching and nurturing staff development (NCHE, 2019), both of which reveal the pressure on academia to deliver. University teaching is pertinent to the national development plan; of Uganda's young population, 78% are below 30 years and 52% are under 15 years (Uganda Bureau of Statistics, 2014). This implies that by 2040, the economy will still have a large young adult population that will need to survive in a world driven by knowledge-based societies. Therefore, universities are expected to equip the young generation with the globally competitive knowledge and innovation skills needed to survive in an advanced working environment (Muvawala, 2017). The review report on Makerere's strategic plan is an example of how academics have embraced the learner-centred approach to teaching, a teaching research nexus and disciplinary collaboration that is intended to produce graduates with a predisposition to lifelong learning (PDD, 2017). This points to a commitment that may make a substantial contribution to human resource development for a country seeking to play an active role in the knowledge age.

Staff development, on the other hand, is identified as an avenue through which higher education institutions can nurture high-quality sustainable faculty (NCHE, 2013). Universities across Africa are under pressure to raise the number and capacity of academics to boost research output, given that many of the continent's already limited number of seasoned researchers are aging (Teferra, 2016). Hence, the focus on staff development is a matter of survival and sustainability, an issue on which the NCHE (2019) noted two developments. The first is that commitment to staff development has improved slightly among higher education institutions, with an increase from 1823 academics in the 2016/2017 academic year to 1873 in 2017/2018. The second is that 60% of the relevant staff are from the university sector, with most of those pursuing a PhD. This may help explain the slow but steady increase in the number of academic staff with advanced degrees. Figure 5.4 presents the data from 2004 through 2018 in this regard.

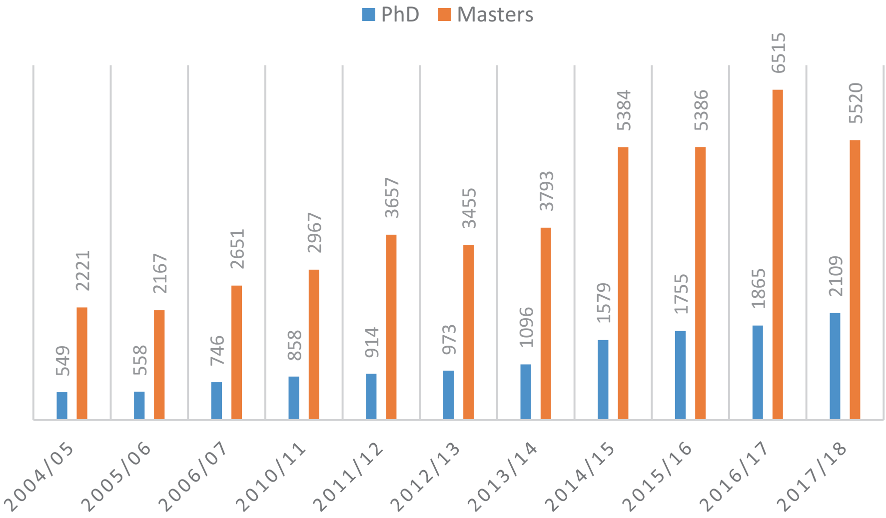

Fig. 5.4 Academic staff distribution at Ugandan universities, 2004–2018. (Source: NCHE, 2019)

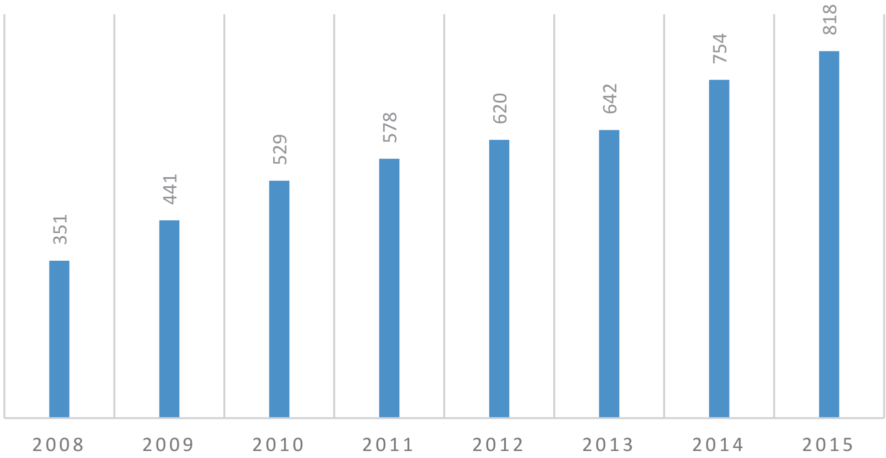

Fig. 5.5 Makerere University publications in Scopus, 2008–2015. (Source: PDD, 2017)

The assumption is that university faculty have the capacity to conduct research and transfer acquired knowledge beyond the walls of academia, and more PhDs will help ensure that capability (Molla & Cuthbert, 2016). An examination of available data on the research output of Makerere University, which has the highest concentration of PhDs among Ugandan universities, shows that the number of publications from the institution appearing in Scopus increased steadily from 2008 through 2015 (see Fig. 5.5 for details).

The trends in academic research therefore suggest that academic staff are committed to their mandate, given the increase in the quantity of knowledge they have produced. Figure 5.5 may show institutional progress but the output is still low by global standards. A recent assessment of flagship universities in Africa, including Makerere University, established that the level of knowledge production remains low (Cloete et al., 2018). Thus, the higher education sector may still not have the capacity needed to deal with Uganda's development targets given the country's leading institution in coming up short in this regard. UNCST (2016) recently identified a number of challenges that Ugandan academics face, including heavy teaching loads, poor information and communication technology facilities, and subpar remuneration. More recently, the NCHE (2019) identified labour mobility, retirement, death, and the lure of employment in other sectors as key challenges for the academic community. Unless such issues are soberly acknowledged and seriously addressed, Uganda's universities may not have the resources to play their role in meeting the country's national development agenda goals.

Conclusion

This chapter has focused on the role of higher education in Uganda's national development agenda to build a knowledge society. It describes the country's STI policy as a platform for fostering R&D while noting the serious challenges to achieving these national goals including low funding for R&D and insufficient human capital in the number of researchers working in Uganda. These deficiencies pose a challenge to the knowledge production, transfer, and the general human resource development required for Uganda to become a knowledge-based society. At the same time, an overview of the higher education sector in terms of origins, structure, and contemporary trends has shown that the expectations for the sector are growing in number and evolving in nature. The sector is under considerable pressure to deliver amidst limited financial and human resources, poor research infrastructure, and the issue of outside donor influence. At this point, Uganda's higher education sector appears tasked beyond its capacity to guide socio-economic transformation.

The chapter has further observed that academia is under considerable pressure to do its share in achieving national development targets amidst challenges of poor remuneration, heavy teaching loads, and limited staffing. The discussion in this chapter shows that existing challenges outweigh the current prospects for Uganda to attain its goals, making it crucial to address the concerns in higher education without delay, because academia can lead the way in overcoming national challenges. With proper funding, the sector has the capacity to enhance the quality and quantity of knowledge and human resources produced in all sectors, which will increase Uganda's chances to play an active role in the knowledge age (Muvawala, 2017). In addition, the higher education sector remains the primary seat of innovation (UNCST, 2016) and is Uganda's best option for fulfilling its development quest.

It is important to note that existing challenges suggest a gap between policy initiatives targeting Uganda's socio-economic transformation and implementation, which calls for policy makers, regulators, and implementers to identify, examine, and act upon emerging challenges to Uganda's interests. It is therefore imperative that national policy undertakings shift from rhetoric to practical strategies that will ensure the fulfilment of development goals. This points to renewed commitment to STI funding in universities and research institutions. The assumption is that universities will expand graduate intake and output, incentivise academic research and innovation, and enrol students mostly in the science-related fields at both graduate and undergraduate levels. This is bound to set Uganda on course to contemporary development trends, which dictate that the prosperity and competitiveness of a country depend on its level of adaptation to the rules of the knowledge age (Asongu & Tchamyou, 2020).

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Florence Ndibuuza is a PhD candidate at the Institute for Post School Education, Faculty of Education, University of the Western Cape, South Africa. Her research interests lie in the field of higher education studies, with the current focus on contemporary trends in the academic profession amidst the socio-economic developments of the twenty first century. Other areas of interest include technology enabled pedagogy, and policy and planning in higher education.

Patrício V. Langa is Associate Professor of Sociology and Comparative Higher Education, Policy and Innovation Studies at the Institute for Post-School Studies (IPSS), University of the Western Cape (UWC), South Africa, and at the Faculty of Education of the Eduardo Mondlane University (UEM) in Mozambique. He holds degrees in social sciences, sociology, and higher education studies (BA, BA Hons, Masters' and PhD, respectively) from the UEM, Mozambique, and the University of Cape Town (UCT), South Africa. His main research interests include: social theory, social studies of science, diaspora studies, higher education studies, higher education leadership and management, and public policy.

Ronald Bisaso is an Associate Professor and Dean of the East African School of Higher Education Studies and Development (EASHESD), College of Education and External Studies, Makerere University. His research interests include: leadership and management in higher education, higher education and social change, internationalization of higher education and capacity building in higher education organisations with a focus on sub-Saharan Africa. He is a member of the Steering Group of the Worldwide Universities Network (WUN) Global Challenge in Higher Education and Research (GHEAR).

Chapter 6
Higher Education and Investment in Knowledge: A Perspective from Talent Policies in Mainland China

Hong Shen and Jinwen Luo

Abstract China's "opening" policy brought her lasting economic growth over the last four decades and pushed her to become a major contributor to technology and science innovations. This chapter introduces China's effort in investing in knowledge through the channel of higher education institutions, through the perspective of China's talent policies. We found that higher education institutions can serve as human capital banks that create, store, and utilize talents for innovations in the knowledge economy. The active participation of other stakeholders steers the direction of research and teaching activities within higher education, which may sometimes lead to an overemphasis on short-term products and a segregated academic labor market at the cost of long-term academic productivity and total efficiency of knowledge generation. We suggest that China make more effort to build an open and sustainable academic environment, which would eventually boost the innovation-led economy via the talents that have been cultivated, recruited, and retained by higher education institutions.

Keywords Human capital · Talent policy · Academic profession · Higher education · China

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H. Shen (✉)
Center for Higher Education Research, Southern University of Science and Technology, Shenzhen, China
e-mail: shenh6@sustech.edu.cn

J. Luo
School of Education & Information Studies, University of California, Los Angeles, CA, USA
e-mail: jevanluo@g.ucla.edu

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Introduction

Over the last four decades, China has experienced unprecedented changes in terms of economic life. The average annual growth rate in gross domestic product (GDP) in the first two decades after China opened her doors to the global market in 1979 was 9.2%. This further increased to 13.6% over the subsequent two decades (World Bank, 2020). Many researchers consider the country's investment in human capital as a critical factor in explaining this dramatic economic growth (Barro & Lee, 2001; Hanushek & Kimko, 2000). These investments have underscored a dramatic expansion of higher education, the transition toward a knowledge economy that is increasingly dependent on highly skilled talent, and the emergence of a robust national knowledge and innovation system.

This chapter explores the relationship between higher education and the knowledge economy in China by investigating the country's investment in knowledge through the channel of higher education institutions, particularly from an aspect of talent policies. We begin by introducing the expansion and structural changes in China's research and development (R&D) activities and higher education in the last two decades. We then review China's talent policies and discuss the role that higher education institutions, especially research universities, play in human and innovation capital development.

The Knowledge Investment and Higher Education in China

China's Investment in Knowledge

Since opening up to the global market in the late 1970s, China has enjoyed a comparative advantage of inexpensive labor in global trade due to the large size of the population. A better-educated workforce gave China additional advantages in the competition associated with modern manufacturing. Seeking lower production costs, foreign direct investment introduced new technologies into China and provided a foundation for the development of local industrial knowledge through personnel turnover, demonstration effects, and knowledge spillovers (Hu & Jefferson, 2002; Wei et al., 2012; Wei & Liu, 2006).

The economic growth pushed the explosion of innovation and strong incentives for investing in R&D in the last two decades. China's intellectual property office filed only 50 thousand patents in 1999. The average annual growth rate for patents since then is 18.7%, resulting in 1500 thousand patents in 2018. The annual growth rate in the United States between 1999 and 2018 was 4.4% (World Bank, 2020). The R&D expenditure is an important indicator for investment in knowledge generation and application. As Table 6.1 indicates, R&D expenditure has been increasing faster than China's GDP, making new knowledge more important and profitable in the economy. However, one should note that the rapid growth rate is based on the

Table 6.1 R&D in China: 1999–2018

Year	FTE of R&D	R&D expenditure							
	Personnel[a] (in 1000)	Total (in billion CNY)	Annual growth rate	Basic research,%	Applied research,%	Application and development,%	Government,%	Industry,%	Of GDP, %
1999	822	67.9	30.6	5.0	22.4	72.8			0.81
2000	922	89.6	32.0	5.2	17.0	77.8			0.98
2001	957	104.3	16.4	5.0	16.9	78.0			1.03
2002	1035	128.8	23.5	5.7	19.2	75.1			1.19
2003	1095	154	19.6	5.7	20.2	74.1			1.3
2004	1153	196.6	27.7	6.0	20.4	73.7	26.7	65.7	1.23
2005	1365	245	24.6	5.3	17.7	76.9	26.3	67.1	1.34
2006	1502	300.3	22.6	5.2	16.3	78.5	24.7	69.1	1.4
2007	1736	371	23.5	4.7	13.3	82.0	24.6	70.4	1.34
2008	1965	461.6	24.4	4.8	12.5	82.8	23.6	71.8	1.38
2009	2291	580.2	25.7	4.7	12.6	82.7	23.4	71.8	1.63
2010	2554	706.3	21.7	4.6	12.7	82.7	24.0	71.7	1.68
2011	2883	868.7	23.0	4.7	11.8	83.4	21.7	73.9	1.65
2012	3247	1029.8	18.5	4.8	11.3	83.9	21.6	74.0	1.86
2013	3533	1184.7	15.0	4.7	10.7	84.6	21.1	74.6	2.0
2014	3711	1301.6	9.9	4.7	10.7	84.5	20.3	75.4	1.99
2015	3759	1417	8.9	5.1	10.8	84.2	21.3	74.7	2.04
2016	3878	1567.7	10.6	5.2	10.3	84.5	20.0	76.1	2.15
2017	4034	1760.6	12.3	5.5	10.5	84.0	19.8	76.5	2.12
2018	4381	1967.8	11.8	5.5	11.1	83.3	20.2	76.6	2.11

[a]The full-time equivalent (FTE) of R&D personnel is defined as the number of personnel after all part-time workers being converted into full time with a ratio of working time divided by reference full time

Source: National Bureau of Statistics of China (1999–2018) relatively low initial level of investment in R&D. For example, China's R&D expenditure in 1999 accounted for only 1.6% of global R&D expenditure that year, which increased to 12.8% in 2018. In comparison, the United States represented 31.4% and 27.6% of the total global R&D expenditure in 1999 and 2018, respectively, and Japan 15.8% and 10.9% (World Bank, 2020).

R&D groups within industry, higher education, and specialized research institutions are the three most important participants in R&D activities in China. As we can see in Fig. 6.1, industry has become an increasingly important participant in R&D activities. While total R&D personnel and expenditures rapidly grow, industry accounts for 78% of the full-time equivalent (FTE) R&D personnel and 76% of R&D expenditure (National Bureau of Statistics of China, 1999-2018). The R&D expenditure in industry contributed to new product innovation, productivity, and profitability (Jefferson et al., 2006). Many researchers have reported that the returns to R&D in China are at least three times the returns to physical capital investments (Jefferson et al., 2006; Yan et al., 2013). One should note that the state-owned and private enterprises play a different role in China's knowledge economy. Although state-owned enterprises have the highest R&D expenditure, private enterprises commit a higher share of their sales revenue into R&D and are more effective in using this investment, generating more patent applications per million yuan of R&D expenditure (Zhang et al., 2009).

R&D in higher education institutions (HEIs) and research institutes (RIs) have differentiated functions and with distinct orientations. HEIs invested more in basic research, while RIs predominantly invested in applied research and application. HEIs devoted 40% of their expenditure into basic research and another 40% to applied research in 2018. In RIs, however, more than half of their expenditure was distributed to applications and development (National Bureau of Statistics of China, 1999-2018).

As per the National Bureau of Statistics of China (1999–2018), RIs have greater funding from the government and higher expenditures. In 2018, for instance, 85% of the expenditure by RIs came from the government and just 4% from industry; however, 66.5% of HEI's R&D expenditure came from government and 26.5% from industry. RIs have been downsizing and specializing over the last two decades, while the R&D sector in HEIs expanded. While the size of R&D personnel decreased from 1999 to 2018, the FTE of the R&D personnel nearly doubled in RIs.

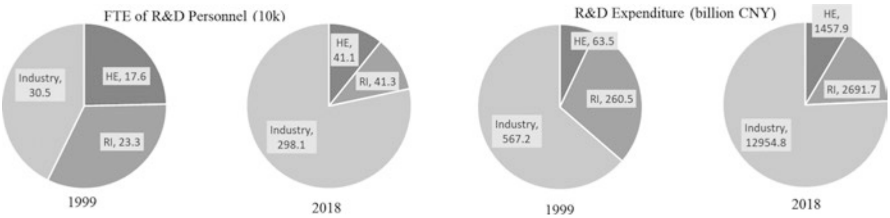

Fig. 6.1 Participation of R&D activities in 1999 and 2018. (Source: National Bureau of Statistics of China 1999–2018)

The investment in knowledge from different sectors has different foci and results. Government-sponsored R&D activities in state-owned enterprises, HEIs, and RIs are highly capital intensive and oriented to fundamental science and engineering breakthroughs. For example, both the high-speed rail and the Five-hundred-meter Aperture Spherical Telescope (FAST) involve national engagement in R&D; the former accelerated the transportation efficiency for the whole country, and the latter serves as an infrastructure for the global science community. Private enterprises, on the other hand, go for short-term returns, focusing innovation mainly on consumer products. The unmanned aerial vehicles created by DJI (a leading company in customer flying and camera stabilization systems) and mobile payment by Alibaba (the largest online shopping provider in China) are examples of such innovation. Despite the difference in orientation, all types of innovation are created by humans. The rise of the knowledge economy inevitably leads to higher demands for people who can use and create new knowledge.

China's Higher Education's Expansion, Reforms, and Finance: 1999–2018

The demand for highly skilled labor rocketed in the late 1990s due to increasing foreign direct investment and the expanding national innovation system for the government's goal of industrialization. The rising education returns also stimulated a demand for higher education from society (Dai et al., 2018). China has an undergraduate enrolment of 28.3 million in 2018, which is nearly seven times the 1999 enrollment. The gross enrollment ratio, expressed as a percentage of the official school-age population, has climbed from 10.5% in 1999 to 48.1% in 2018. Meanwhile, the number of higher education institutions has doubled.

The expansion served as a crucial stimulator that shaped today's Chinese higher education, and its consequences push Chinese HEIs further to reform their structure, curricula, and administration. Before the expansion, all the universities were serving as incubators for scientists and administrative specialists who can later work for the public sector. Massification, however, brought in new stakeholders, with different interests in higher education. An expanding system needs to seek diversified funding sources to cover the increasing expenditures, which would force the universities to reach out to industries and private sectors. However, the expansion of enrollment was not only a direct response from higher education but also a rather urgent request from the central government (Li et al., 2014; Wan, 2006; Wang & Liu, 2011) which initiated a series of policies, laws, and regulations that encouraged local government and private entities' participation. The reforms of China's administrative system emphasize streamlined administration and delegated power to bottom-level government. In higher education, the central government tries to strengthen the power of provincial government on higher education administration and encourage local governments to provide resources to support the local public

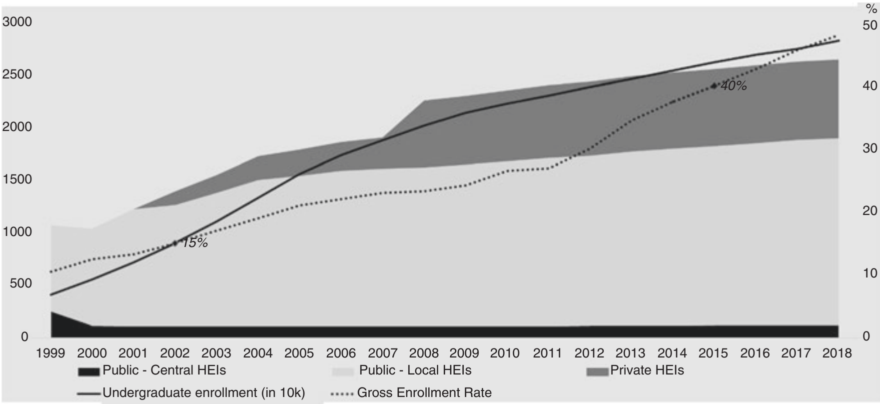

Fig. 6.2 Enrollment and institutions (In this chapter, all higher education institutions include 4-year universities and colleges (HEIs) offering degree programs and higher vocational colleges (HVCs) offering certifications. The HEIs offering degrees consist of research universities, teaching universities, and independent 4-year institutions (these are privates but must attach to one HEI). In 2018, for example, there are 2663 regular HEIs, of which 1418 are HVCs and 1245 are HEIs. Within the HEIs, 265 are the private independent colleges. Universities refer to 21.8% of HEIs that provide postgraduate programs. Research University refers to a list of 985 universities and Research-Teaching University is mostly about 211 universities; these two included 112 institutions in 2018. Undergraduates refers to students in a 4-year program toward a bachelor's degree and students in a 3-year program toward a higher vocational certification) in Mainland China, 1999–2018. (Source: National Bureau of Statistics of China Based 1999–2018)

institutions.[1] Meanwhile, the central government opens the door of the higher education system to the market, aiming at promoting social participation in increasing the supply of trained workforce.[2]

As Fig. 6.2 has shown, the increase in institutions and enrollment mainly came from the local and private sectors, while the number of institutions affiliated to central ministries (public-central) has decreased and/or stabilized. In 1998, there were 1022 HEIs in China, a quarter of which were administered under central ministries or agencies, and the rest affiliated with a provincial or city-level local government.

[1] See Opinions on Deepening the Reform of Higher Education System, MOE, 1995; Decisions of the Central Committee of the Communist Party of China on Deepening Education Reform and Promoting Quality Education, Central Committee of CPC & State Council, 1999; Province and Ministry Joint Construction Program, MOE, 2004; Decision of the Central Committee of the Communist Party of China on Some Major Issues Concerning Comprehensively Deepening the Reform, Central Committee of CPC, 2013.

[2] See Law on the Promotion of Non-public Schools of the People's Republic of China, National People's Congress of PRC, 2002; Opinions on Regulating and Strengthening Higher Education Institutions to Establish Independent Colleges on the Trial Basis with New Mechanism, MOE, 2003; Interim Measures for the Administration of Non-public Higher Education Fees, MOE, 2003; Provisions on the Administration of Non-public Colleges and Universities, MOE, 2007; Measures for the Establishment and Administration of Independent Colleges, MOE, 2008. Opinions of State Council on Encouraging and Guiding Healthy Development of Private Investment, State Council, 2016.

Over half of the HEIs were universities and colleges, of which there were only 58 comprehensive universities covering a relatively wide span of disciplines. Most institutions have a special disciplinary focus, such as education, engineering, finance, or medicine. In 2018, among the 2663 HEIs, there were only 119 affiliated with a central ministry, 1795 with provincial governments, and 749 with nongovernment institutions. Of the HEIs, 1245 were universities and colleges that offer bachelors' degrees, 580 of which provided postgraduate programs. More and more universities introduced new disciplines and switched to comprehensive missions, which accounted for about 25% of all universities.

Along with the expectation of decentralizing the higher education system, the central government resources have been targeted to a cluster of key universities and key disciplines with target funding programs (e.g., Project 211 and Project 985 and later Double First Class Initiative). The state-sponsored institutions enjoy the greater proportion of government appropriations, which consists of special national research project funding and other preferential treatment. Therefore, the state remains in control of the core of innovation in the higher education system, in the trend of decentralization, by creating a small group of elite research universities.

Guided by the *Reinvigorating China through Science and Education* national strategy and driven by economic growth, between 1999 and 2018 China's expenditure on education increased 14-fold and the expenditure on higher education increased 17-fold (Educational Finance Statistics Yearbook of China, 2000, 2019). HEIs strived to diversify their revenue models on the base of the central-local finance structure. The central government's share of the total expenditure on higher education dropped from 50% in 1999 to 30% in 2018. Government appropriation and tuition are two main financial sources for HEIs, and central institutions are more competitive in acquiring government support. The funding disparity creates a hierarchy of HEIs (Yaisawarng & Ng, 2014; Zong & Zhang, 2019), especially through research (Wu, 2015; Zhang et al., 2013). In 1999, 87% of the national research allocation in education expenditure went to central HEIs, and this number remained high at 62% in 2018 (Educational Finance Statistics Yearbook of China, 2019). These facts imply that Chinese HEIs are highly dependent on government support to survive and maintain financial wellbeing. With the history and finance model above in mind, we can perhaps generate a picture of Chinese HEIs: 70% of them are public and 5% of which are affiliated with central government—most likely research universities—and enjoy significant higher financial supports than their local peers.

Funding Innovations Through Universities and Its Research

Despite targeted funding programs such as Project 211 and Project 985 which created a club of elite research universities,[3] more specific funding and construction programs have been conducted to support the nation's ambition in science and technology advances. For example, the central government directs research through project-based funding like the National Key Technologies R&D Program of China and the National Natural Science Foundation of China (NSFC). For example, in 2018, the National Key R&D Program funded 1373 projects with 24 billion yuan, and the NSFC funded 701 key projects with 2 billion yuan. Besides the key projects, the NSFC also funded over 36 thousand general and youth projects with 15 billion yuan. The government funding inevitably steers the interests of researchers and encourages cooperation across campuses and disciplines. Research universities received the most benefit from these programs; in 2018, the top 10 highest-funded institutions from NSFC were all research universities in the former 985 project, whose 6701 research projects have been funded with 3.8 billion yuan. Target funding plans usually create advantages in the target supported research universities and institutions, which further develop into discipline specialization and even national research centers (e.g., Wuhan University as a research base of remote sensing technology). Such government-directed efforts have made tremendous progress in boosting science and technology development and providing substantial highly skilled talents in critical areas. Local government and industries also respond actively to such target funding program. One common response is to develop industrial parks around the supported universities focusing on the sponsored field of technology (e.g., Wuhan built an industrial park called Optic Valley around Huazhong University of Science and Technology when the university was funded as national research center in photoelectricity).

Some researchers argued that the state's role as a regulator has been strengthened rather than weakened during the decentralization reforms (Mok, 2001). Though the central government hopes to introduce market mechanisms to vitalize the higher education system, they are unlikely to relax the reins on their most important intelligence assets. As Mok (2000) pointed out, the strategy of marketization is intended to increase administrative efficiency and effectiveness, instead of fundamental shifting of value orientation. We can see that a strong government, such as mainland China's central government, has a wider range of policy tools and more effective and timely execution, especially when the goal is to create a new model of an economy driven by public goods such as knowledge. For example, targeted funding

[3] Project 211 was implemented in 1995 by the Ministry of Education with the aim of strengthening 112 (later increasing to 116) universities in key disciplinary areas as part of the national strategy, cultivating talents for socioeconomic development. It was succeeded by plan 111 (Talents program) in 2014. Project 985 was announced in 1998, aimed at founding world-class universities involving local and national government funding, creating new research centers and initiatives for international involvement; initially encompassing just 9 institutions, this was later expanded to 39 sponsored institutions in the mid-2000s. Project 985 was succeeded by Double First Class in 2017.

helped supported universities to make tremendous progress in research and teaching quality. However, as we will discuss with our example of talent flow, it also brings new challenges of ambiguous objectives and loss of efficiency.

Cultivating, Recruiting, and Retaining Talent in Chinese Higher Education Institutions

The higher education system is human capital intensive. Human capital is created and stored by HEIs and then discharged to society (Ahmed, 2017; Fleisher et al., 2010). China's current higher education institutions, within a stratified higher education system conditioned by a strong government, provide opportunities to observe the unique talent accumulation phenomenon around higher education. First, Chinese HEIs are heavily dependent on the government's financial and political support. Therefore, institutions have large incentives to stand tightly with government policies for an advantage in resource competitions. Second, the stratified system assigns different goals to different types of institutions. The expectations and requirements come with new resources, which produce further resource disparities that reinforce the institutes' function and position in the system. Third, globalization brings a new opportunity to Chinese HEIs to embrace the global market, but it can also reinforce the existing caste when the central government subsidizes already advantaged institutions to gain further, international advantage. With the picture of the structure of Chinese HEIs and its position in China's society, we will look closer into three major viable paths of talent management: cultivating domestic talent, recruiting talent from both the domestic and global markets, and retaining of skilled labor. For each path, we discuss the related policies and evaluations.

Cultivating: Supplies of Skilled Labor

Like HEIs in other countries, cultivating talents is a major function of Chinese HEIs. The focus of China's last three decades was economic growth, and science and technology advances. Indeed, Chinese higher education was driven to cultivate a skilled workforce and thereby create the corresponding economic reward. When the government attempts to mediate HEIs' responses to the labor market, there can be a mismatch between the demands of the market and the supply of talents, in terms of knowledge, profession, and capacity.

Enrollment Expansion Created a Larger Educated Graduate Population

From 1999 to 2018, Chinese HEIs supplied a total of 44.3 million bachelors and 6.6 million graduate students, including 0.78 million doctoral graduates. As we can see in Table 6.2, half of the graduates have a STEM degree.[4] Since the supply of degrees is controlled by the Ministry of Education (MOE) of China, the high ratio of STEM degrees represented an orientation toward technology innovation and application.

There Is an Education Quality Gap Within the Current Stratified Chinese Higher Education

The quality of higher education, or more specifically, the quality of graduates from HEIs, has been a major theme of the reforms within China's higher education system. Investing in higher-level talent is especially costly and risky compared to investments in other forms of capital. When a government has incentives to allocate

Table 6.2 Graduates of all levels (in 1000)

Degree awarded (in 1000)	Bachelor		Master's		Doctor	
Year	Total	% in stem	Total	% in stem	Graduates	% in stem
1999	441	65.8	44	69.6%	10	80.9
2000	496	64.2	48	66.9%	11	82.1
2001	568	60.5	55	59.5%	13	77.2
2002	656	60.1	66	35.0%	15	74.1
2003	930	58.2	92	61.5%	19	73.7
2004	1195	58.0	127	61.0%	23	73.6
2005	1466	55.4	162	61.8%	28	73.2
2006	1727	53.0	220	60.3%	36	72.8
2007	1996	51.5	270	60.4%	41	73.2
2008	2257	50.6	301	60.1%	44	73.0
2009	2455	50.0	323	57.6%	49	71.0
2010	2591	49.9	335	55.9%	49	71.0
2011	2796	49.5	380	57.4%	50	73.2
2012	3038	49.1	435	58.2%	52	73.2
2013	3200	48.7	460	57.1%	53	74.1
2014	3414	48.5	482	56.8%	54	75.3
2015	3586	48.0	498	57.4%	54	76.2
2016	3744	47.6	509	57.7%	55	76.9
2017	3842	47.7	520	56.6%	58	77.4
2018	3868	47.9	544	57.1%	61	78.3

Source: National Bureau of Statistics of China (1999–2018)

[4] STEM degrees here refer to degrees of science, engineering, agriculture, and medicine.

resources to higher education to seek better returns in human capital, it will invest the limited resources in assets with the highest expected returns. As we discussed earlier, China created an elite class of HEIs by introducing the Project 985 and Project 211 as part of the expansion in the late 1990s, which later evolved into Double First Class in 2015, aimed at creating top universities with national efforts (e.g., Tsinghua University and Peking University as the top 5 HEIs in Asia and the top 30 in the world). The elite group enjoys higher financial support from the central government and attracts the best high school graduates in terms of their performance on the national college entrance examination, and their graduates have premiums in employment rate and salary (Yue & Zhang, 2014).

Government Mediation Led to Mismatches Between the Higher Education Talent Supply and Market Demands for Skills and Capacity

As described earlier, China's government sponsors research activities through targeted funding programs. When government requests become prioritized tasks, short-term market demands can be overlooked by the higher education system. First, there is a high enrollment rate in postgraduate education and over-education in the labor market. Given that 21.6% of graduates were overqualified for their positions in 2015 (Yue, 2017), we still see postgraduate education enrollment rates increasing. In 2003, around 15.1% of undergraduates chose to seek a graduate diploma (domestic and overseas); this increased to 26.3% in 2017 (Yue & Zhou, 2017). The extension in education and overqualification in the labor market indicates an oversupply of highly skilled workers. Second, their specific knowledge does not match the market's demands. For example, in a representative national survey, Yue (2017) reported that 35.8% of graduates' placements are irrelevant to their college majors. Moreover, the training in relevant majors did not show a significant market return (Li & Ding, 2005). Third, graduates' abilities and skills fail to meet the market needs. Professions are created and die quickly in a developing knowledge society like China, which makes it harder for HEIs to meet increasingly diversified demands for skills. Instead of curricula aimed at providing specific knowledge, transferable skills are considered as a solution to the changing market. However, Shen and Zhang (2017) found Chinese HEIs underperformed in improving students' critical thinking skills, which was considered as the core of the necessary transferable skills.

Changing Academic Careers and Cultivating the Next-Generation Scholars and Researchers

Academic careers in mainland China have experienced shocks from the outside market and expansion within the system during the last two decades. There were nearly four times as many full-time faculty members in 2018 as they were in 1999; the numbers of full professors, associate professors, and assistant professors[5] increased 4.6 times, 3 times, and 3.2 times, respectively. The threshold for obtaining an academic position has increased. Only 40.7% of entry-level faculty held a doctoral- or master's-level degree in 1999; this number increased to 85.7% in 2018, which led to an increase in the number of doctoral degree holders in the population. Before the expansion, China had a large proportion of STEM faculty and student base; we can also see that there are now more female faculty and fewer faculty working in STEM disciplines in 2018. The average age of full professors has decreased, while that of associate and assistant professors has increased (Table 6.3).

China's HEIs emphasize publication in faculty evaluations, which is one major factor that drives faculty's devotion to research. Shen (2016) found that university and college faculty spent 48% of their working hours on research, and 30% on teaching, while reporting that they preferred investing more time in teaching. In terms of workload, 57% of the surveyed faculty reported that they were overloaded by research, and only 39% reported being overworked in teaching activity. Despite the intensive research pressure, 75% of the surveyed faculty reported that they would choose the academic career again, while 20% reported that they wanted to quit the academic profession. Along with the higher education reforms, attention to academic careers has been growing. Yan (2019) commented that the reforms to the academic appointment system aimed at increasing academic productivity

Table 6.3 Full-time faculty in HEIs in 1999 and 2018

	Year	Total	Full	Associate	Assistant
Total, in 1000	1999	426	39	126	156
	2018	1673	218	505	656
Doctoral degree, %	1999	5.4	16.1	8.3	3.4
	2018	25.9	57.3	32.0	19.4
Female, %	1999	37.3	15.1	30.1	41.8
	2018	50.3	31.1	47.1	55.4
Mean age	1999	37.6	54.1	41.4	35
	2018	40.4	51.2	45.3	37.6
STEM, %	1999	57.5	70.2	62.8	54.1
	2018	55.0	66.4	59.3	52.1

Source: National Bureau of Statistics of China (1999–2018)

[5]Refers to senior rank, sub-senior rank, and middle rank, respectively, in China's conventional professional rank system

encouraged the faculty's short-term research engagement but harmed their academic potential in the long run.

The expanding higher education system creates new opportunities in academic careers and attracts young talent. A government-mediated system can be inefficient in responding to market demands. One may wonder, however, if such a system works better in producing top talent of the next generation because young scholars with the greatest potential are expected to secure the highest funding from the government. HEIs have played an increasingly important role in cultivating future researchers. In 2018, over 95% of faculty who were able to supervise postgraduate-level studies worked in HEIs. Observing doctoral-level training will directly tell us how a country or an institute does in cultivating the best of their next-generation knowledge workers. We will investigate China's performance in doctoral training here and then evaluate the tension between domestic and global talent market in later sections.

Doctoral Students Have Spillover to Industries

The number of PhD holders has increased six-fold during the last two decades, and they have become increasingly attractive to employers from industry. In 1996, 77% of doctoral graduates chose academic and research professions, which decreased to 46% in 2006. Market-oriented disciplines, such as medicine, finance, and engineering, attract more doctoral graduates (He & Zhu, 2019; Gao & Shen, 2016).

Doctoral Training Programs Are More Research Oriented

A qualified doctoral graduate is expected to push forward human knowledge by innovative research. Doctoral students from elite institutions were more likely involved in research and have more publications in international journals, as well as higher PhD completion rates (Shen et al., 2016; Gao et al., 2020). However, the emphasis on short-term research outcomes may hurt doctoral students' long-term academic potential. Ma et al.'s (2019) study showed that students with a heavy research workload would have lower innovation capacity in future research.

Human Capital Accumulation by Learning from Others Is Becoming Less Efficient

Sending students to overseas advanced learning and research institutes is an important policy to accelerate domestic human capital accumulation. The MOE reported that China has become the largest source of international students. In total, 5.2 million Chinese students have studied abroad over the last 40 years, and 1.5 million students are currently enrolled in overseas higher education institutions (MOE of China, 2018). Developed countries and regions such as the United States and

Western Europe are the most popular destinations (MOE of China, 2018). Doctoral students with overseas research experience were more likely to obtain academic positions in elite universities, attain higher academic ranks, and secure administrative positions (Li et al., 2018a, b; Zhao, 2010). However, these young scholars are less likely to receive awards from home institutions and show no significant advantage in terms of quantity of patents, publications, and regional and national awards. There are high expectations for, and high investments in, returnees, but there is little evidence that they have advantages in short-term productivity, which may suggest their challenges in transitioning to the Chinese research environment.

Recruiting: Returnees

The term "overseas returnee" can be traced back to the late 1990s when many Chinese international students chose to return to China. Overseas returnees are usually referred to as an elite group who have studied or worked in a foreign country, are familiar with new technology, and are market oriented. Globalization requires a large number of experts who understand foreign rules and cultures. People with a background both in China and foreign countries are ideal to bridge between China and external markets (Yu, 2018). Therefore, global academic labor with Chinese roots is the most promising target for HEIs' talent plans.

Overemphasis on Overseas Experience May Distort the Academic Labor Market

Many researchers report that overseas experience has a positive impact on income. Compared to domestic graduates, overseas graduates enjoyed a 36% premium in their annual income and a 33% premium in their hourly pay (Sun et al., 2016). Yu and Shen (2017) observed the growing income gap (annual income of full-time academic faculty) between returnees with a foreign credential and those with a domestic diploma, between 2007 and 2014. However, overseas experience did not necessarily directly lead to higher academic productivity (Zhang et al., 2018). The overemphasis on overseas experience would inevitably create more "returnees" due to economic incentives, which encouraged the chase of the signal as a "returnee." Zhang et al. (2018) pointed out that faculty with lower academic potential tended to stay longer in their overseas academic visit at the cost of higher funding package from the institution and government.

Support for Returnees: Expected to Adapt to Domestic System

Compared to their domestic counterparts, overseas returnee faculty work in a system that has distinct differences from the system in which they have been trained, which caused adaptation issues that could impact their academic productivity. Returnee faculty were not satisfied with their research performance, especially in terms of obtaining domestic grants (Zhu & Wu, 2018). Overall career satisfaction for the first 3 years was low; it did not live up to their expectations, and there was decreasing satisfaction in autonomy, pressure, and sense of achievement despite an increase in financial satisfaction between 1997 and 2017 (Li & Zhu, 2020). However, many researchers agreed that after adapting to the Chinese context, the performance of returnee faculty would improve (Zhu & Wu, 2018), even though they faced many challenges including communicating with domestic peers and involvement in domestic academic networks.

Competition in High-Level Talent Market Is Active and Has Room for Progress

Concentrating resources to accomplish large undertakings is considered as one of the major advantages of a centralized system. China's central and local government initiated a variety of talent programs to attract scholars that exhibited high academic productivity (Li et al., 2018a, b). Compared to the entry-level talent market, the top-caliber talent market is more transparent. Candidates have to outperform their peers to earn a ticket to such programs. The open market makes it easier to identify appropriate candidates and less risky an intellectual investment. However, returnees were found to be less competitive than their counterparts staying overseas: they were more likely to be older but less likely to obtain a tenured position, and they had a similar number of publications, but their works were less influential (Sun et al., 2016; Yang & Marini, 2019). These observations suggest that investing money does not necessarily lead to innovation; a more welcoming and supportive academic atmosphere is needed to attract top-notch talent.

Retaining: Avoiding Brain Drain

From earlier analysis, we can see that China relied heavily on polices to encourage talent inflow. The late-developing premium in science and technology would sooner or later end, due to China's rapid growth in research. Sharma (2013) reported that Chinese PhD holders in science and technology were less likely to return home compared to Indian and Canadian PhD holders. China has made many attempts to resolve this brain drain.

Economic Incentive Is the Most Feasible Policy in Retaining Academics

Rigid evaluation systems, low levels of autonomy, pressure from short-term outcomes, and disappointing salaries were major factors that pushed Chinese faculty out of academia (Li & Shen, 2016). It is difficult to change organization goals in a top-down administrative system, which made increasing salaries the most feasible option to retain domestic scholars.

Therefore, institutions with better financial capacity can better retain talent. Elite institutions have both higher financial capacity and increased autonomy, which attracts the best talent in the market. The advantage reinforced by the government would thus be transformed into human capital in terms of highly productive faculty that reinforces institutional privileges, resulting in a stratified academic labor market that may further harm the vitality of the system (Liu & Shen, 2015).

Domestic Talent Competition Between Local Governments Can Lead to a Market Failure

If the talent policy aims at winning the global talent competition, there is limited incentive for the central government to interfere in the domestic talent market. Liu and Shen (2014) observed a decreasing domestic mobility rate between Chinese institutions from 1986 to 2007. Institutions saw talents as their assets in competition for reputation and resources, leading to domestic competition for talent. Besides national talent programs, local government and HEIs provided similar plans. What a plan can offer depends heavily on the local and institutional economic advantages. Therefore, regional-, provincial-, and city-level talent plans lured the academics to economically advantaged regions, such as eastern and south-eastern coast of mainland China (Kim & Allen, 2018; Zhu & Wang, 2019; Zhe & Sun, 2019). Moreover, scholars in the upper level of talent program were more likely to be recruited again in local program (Xu & Jia, 2019), which resulted in decreased efficiency in the usage of public funding. The central government is expected to fix the market failure to reach a higher national gross efficiency by investing in talents.

Conclusion

Emergence of the knowledge economy and globalization creates additional demands and expectations for higher education (Dale, 2005). As knowledge became the new driver of China's economy, adopting effective human capital investment strategies and building a stronger higher education system were crucial for China to transition to innovation-led growth (World Bank Group, Development Research Center of the

State Council, The People's Republic of China, 2019). Chinese HEIs were expected to serve as national innovation drivers and knowledge boosters, an increasingly important role, along with China's rise as a major contributor to science and technology (Xie et al., 2014). But how will Chinese HEIs make the expected contributions? What are the impacts of the new responsibility on HEIs? What lessons can we learn from the talent policy perspective about building a sustainable relationship between HEIs and the market?

Higher education institutions are intelligence intensive and human capital intensive; they use these primary resources to drive the knowledge economy. The increasing domestic demand for innovative technology and skilled labor pushed the government to first trigger enrollment expansion and then focus on quality improvement. Meanwhile, China's government directly sponsored HEIs to compete in the global academic market in response to globalization and the pressures to reverse brain drain. Chinese HEIs depended heavily on public funding; therefore, the requests from government were prioritized among other institutional goals. The interactions between higher education and government created new roles for HEIs as national human capital banks, which create, reserve, and utilize talents they have cultivated, recruited, and retained.

However, the pursuit of higher returns to innovation can be operationalized as a chasing of high-impact talents. On the one hand, the demands of knowledge and innovation opened up new academic opportunities. However, when the institutions prioritized pragmatic goals over academic goals, resources would be directed to institutions and disciplines with higher expected returns. This institution-level imbalance created a privilege that resulted in barriers to academic mobility and reduced knowledge production efficiency. Although the public sector decision-makers were concerned with long-term interests, the evaluation system pushed scholars to seek short-term work that contributed to the numbers of papers and patents and to win the international science competition.

Talents are assets in the knowledge economy because they generate new knowledge. Investing in talents, like any other investment, does not mean they will contribute to national economic growth. China should provide a more open environment and better financial support to all levels of academics to foster their capacity to innovate. The ongoing reforms in China's higher education system are trying to enlarge the autonomy of HEIs, to invigorate and mobilize the academic market through performance-based funding (Wang, 2019), and to utilize new evaluation models that include long-term indicators instead of overemphasizing short-term outcomes. HEIs have grown into vital channels for government and industries to sponsor and transform knowledge discovery and social innovations. Besides the reforms, we would suggest that China create an open academic market to encourage high-quality innovation in ideas, science, and technology.

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Hong Shen is a Chair Professor, the Director of the Center for Higher Education Research, SUSTech, China. She has been rewarded the Special Government Allowances of the State Council of China in 2004 and is an elected Vice President of National Association of Economics of Education. She has received her PhD in Management Engineering, Master in Higher Education, and Bachelor in Mechanical Engineering from Huazhong University of Science and Technology (HUST). She has been the China-PI of international projects of CAP and APIKS since 2004. She was a Fulbright Scholar in PSU (2002/2003) and a visiting scholar in SUNY-Buffalo (1996/97).

Jinwen Luo is a doctoral student studying advanced quantitative methods at the department of education, UCLA. Before UCLA, Jinwen worked with Prof. Hong Shen and received his MS in the economics of education at Huazhong University of Science and Technology (HUST) in China. He has broad interests in quantitative methods and their applications in the higher education context. Jinwen's recent research includes an evaluation of Chinese universities' impact on student's critical thinking skills.

Chapter 7
Recalibrating After Two Decades of Rapid Expansion: The Pursuit of Excellence Amid Declining Enrollment in Taiwan

Sophia Shi-Huei Ho and Robin Jung-Cheng Chen

Abstract This chapter documents the trends in Taiwan's science and technology (S&T) research and development (R&D) policies and metrics, by analyzing comparative data on R&D expenditures, performance, and the role of business versus higher education. It provides an analysis of the interaction between national research infrastructure, higher education institutions (HEIs), the academic profession, and the status of doctoral education. In our analysis of Taiwan's higher education system, several salient points have become clear. First, Taiwanese higher education system is in a period of change with a large number of HEIs tending to oversupply education to a shrinking student population. Second, diplomas have become inflated while the student population is steadily declining. Third, full-time faculty positions in Taiwanese HEIs are difficult for PhD graduates to obtain. In the light of national policies on S&T and R&D plans, both will inevitably affect the ways in which knowledge is generated. This generation of knowledge will influence the prosperity of the nation and impact the development of a competitive knowledge society. The biggest feature of the allocation of R&D funds in Taiwan's corporate sector is the high proportion of funds invested in technology development, while the investment in basic and applied research is relatively insufficient.

Keywords Education policy · Higher education · Research development · Science and Technology Policy · Taiwan

S. S.-H. Ho
Institute of Educational Administration and Evaluation, University of Taipei, Taipei, Taiwan
e-mail: shihuei@utaipei.edu.tw

R. J.-C. Chen (✉)
Department of Education, National Chengchi University, Taipei, Taiwan
e-mail: robin@nccu.edu.tw

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Introduction

This chapter tells the story of how Taiwan has sought to secure its competitive position in the global knowledge economy, building on the dominant role of business and industry, and both expanding and strengthening its higher education sector as a vehicle for cultivating human capital resources and promoting a healthier and environmentally sustainable society. While industry has historically played the dominant role in research and development (R&D) and technological advancement – as it has in Japan, Korea, and the USA – higher education, including a robust private sector, has grown explosively over the past two decades to the point of saturation of the labor market. Taiwan is now confronting the consequences of its own success as the labor market for PhD and scientific personnel becomes saturated, and imminent "brain drain" ensues.

In telling this story, this chapter documents the trends in Taiwan's science and technology (S&T) R&D policies and metrics by analyzing comparative data on R&D expenditures, the role of business vs. higher education, and R&D performance. We analyze the interactions in Taiwan between national research infrastructure, higher education institutions (HEIs), the academic profession, and the status of doctoral education. The potential effects and subsequent challenges of higher education, especially doctoral education, are also investigated in order to provide a narrative of how these developments have taken place in Taiwan.

Taiwan's Innovation and Technology Policy Context

In 1999, Taiwan's government enacted the "Fundamental Science and Technology Act" as an important legal basis for the development and promotion of S&T. According to Article 9 of the Fundamental Science and Technology Act, the government should fulfill several responsibilities, including casting a vision every 2 years for technological development and compiling a "White Paper on Science and Technology for the Republic of China" and holding a National Science and Technology Conference every 4 years to draft the national S&T development plan, so that these two documents are separated by 2 years to adjust and elevate Taiwan's S&T sustainable development. After the S&T policies are formed, the relevant ministries will draw up policy guidelines and budget estimates and promote the development direction and importance of each project individually.

Within the context of the 1999 law, the Taiwanese Ministry of Science and Technology (MOST) issued in 2016 the White Paper on Science and Technology (The White Paper) which became the blueprint for the promotion of S&T R&D for 2015 to 2018.[1] In order to accomplish the stipulations of the Fundamental Science

[1] It provided a vision and shifted policy for related government agencies, HEIs, research institutes, and industries to achieve four major goals, as follows: (1) transform research innovations, (2) build

and Technology Act, the Executive Yuan in Taiwan held the 10th National Science and Technology Conference in December 2016. The conclusions reached at this conference are hereby translated into the National Science and Technology Development Plan (2017–2020) which became the basis in promoting Taiwan's major policies for S&T R&D (Ministry of Science and Technology (Taiwan), 2017). This plan was comprised of references to approaches adopted by Japan and Singapore, and compared with the 2013–2016 version, its overall goals, strategies, and resource planning were more centralized and followed global trends. For instance, the goals were focused on R&D infrastructural development and boundary-spanning collaboration among HEIs, industries, and government in order to undergo a transformation process in terms of redistributing governmental R&D resources, promoting the industries' autonomous R&D through S&T policies, and facilitating exchanges between professionals and academics.

Development and Implementation of Government Policy on R&D

The Taiwanese R&D system can be divided into three major subdivisions: promotion, implementation, and evaluation. The promotional organization is a scientific and technological administrative system which includes the National Science Council of the Executive Yuan funded in 1959 which was reorganized into the MOST in 2014, and the Board of Science and Technology (BOST) which was created in 2012 to review and coordinate the overall development of national S&T policy. The executive body is responsible for all aspects of the implementation of basic research into applied research and, subsequently, into technological development.

The implementing agencies can be divided into government agencies, HEIs, research institutes, consortium corporations, and business communities. In the category of government agencies, the MOST, the Ministry of Education (MOE), and the Central Research Institute (CRI) are mainly responsible for the implementation of basic research. Other ministries such as the Ministry of Economic Affairs (MOEA), Council of Agriculture (COA), and the Environmental Protection Agency (EPA) work to implement the results obtained at the basic research stage to move

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a sustainable green energy environment, (3) generate value added for industrial technology, and (4) establish a thriving and diverse society. This last goal was to be accomplished by implementing the following eight strategies: (a) focus on cutting-edge S&T fields, (b) bridge the gap between the supply and demand for skilled human resources and advance the S&T entrepreneurial environment, (c) establish Taiwan as a global leader in green technology, (d) implement effective sustainable development mechanisms and make economic growth compatible with environmental enhancement, (e) establish S&T intellectual property portfolios to strengthen momentum for industry innovation, (f) accelerate intelligent industrial upgrading, (g) build a vibrant society by providing safety and security, and (h) build a diverse and inclusive society (Ministry of Science and Technology (Taiwan), 2016, p. iii).

them from theory to practice, to begin to apply research at the second stage, and to develop new technology in the final stage.

The National Development Council is currently responsible for the monitoring and management of major national projects, while the MOST investigates individual projects. The relevant departments are in charge of formulating the priorities of the country's future S&T development in light of budgetary restrictions, as well as completing scientific and technological R&D in various implementing units.

National Investment in Research and Development

R&D Expenditure to Gross Domestic Product in Taiwan

Due to the different sizes of countries' economies, R&D expenditure as a percentage of gross domestic product (GDP) – rather than gross R&D expenditure – is one of the most common indicators used when comparing various countries' R&D input. Japan's and South Korea's R&D expenditure exceeded 3% of the GDP in 2002 and 2007, respectively. Yet in 2009, South Korea surpassed Japan to become the second highest country in terms of R&D expenditure as a percentage of GDP; in 2012 its expenditure grew rapidly at a rate 3.3 times higher than that of its GDP growth, and its proportion even climbed to 4.3% by 2014.

The ratio of R&D expenditure to the GDP in Taiwan was 3.3% in 2017, which increased by 0.14% from the previous year and increased by 0.28% compared with 2013 (Fig. 7.1). The changes show that, except for the decrease in the year 2014, the ratio has increased annually. Due to the decline in capital expenditure by the National Biotechnology Research Park and the completion of experimental hardware facilities by large research institutions in 2017, the R&D expenditure was declined to −1.7%.

Sector Performance and Expenditure Sources

Following OECD classification, Taiwan defines its four major R&D sectors as business enterprise (BE), government (GOV), higher education (HE), and private non-profit (PNP). In the 1990s, the United States (USA) had the highest relative R&D expenditure by BE sector (74.2%), followed by Korea (71.4%) and Japan (70.1%). However, 17 years later, Japan rushed to catch up and became the country with the highest relative R&D expenditure by BE sector, accounting for 78.8% of its overall R&D expenditure in 2016. South Korea came in second place with 77.7%, followed by Taiwan with 77.5%. In 2018, Taiwan's BE sector accounted for 80.3% of the national R&D expenditure (Ministry of Science and Technology (Taiwan), 2019b).

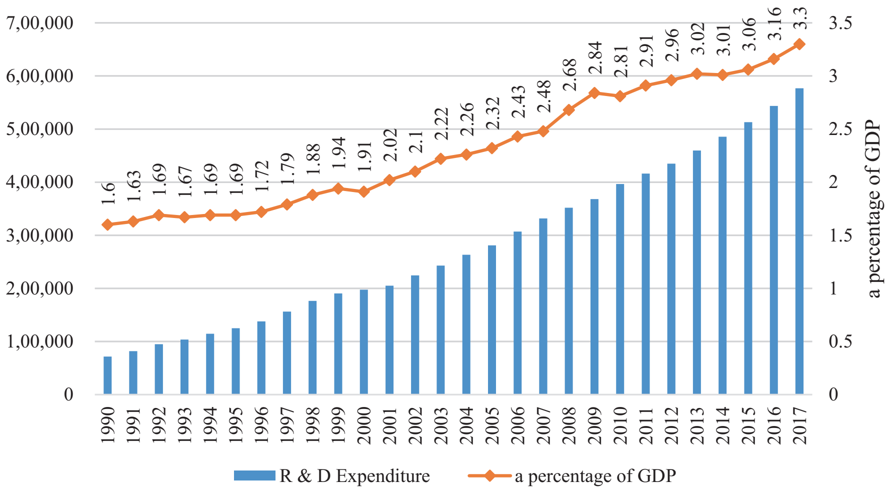

Fig. 7.1 1990–2017 ratio of R&D expenditure to GDP in Taiwan. (Source: Ministry of Science and Technology (Taiwan), 2018a)

The growth of Taiwan's R&D expenditure is closely related to the BE R&D expenditure. In 2017 the BE sector grew by 8.1% which is a new peak in recent years, a growth mainly promoted by the information and technology industries. According to the MOST (2019a), the biggest feature of the allocation of R&D funds in Taiwan's corporate sector is the high proportion of funds invested in technology development; however, the investment in basic research and applied research is relatively insufficient. Regarding the development of BE, Taiwan's government has played a key role in promoting R&D policies, especially the farsighted infrastructure construction planned in recent years, such as the water environment constructions in response to climate change, the promotion of environmentally sustainable green energy constructions, and the creation of industry parks, leading many industries to invest and uphold sustainable development. Especially considering that the growth of R&D expenditure was mainly due to the contribution of manufacturers in Taiwan's Science Park in Xinzhu, a high-tech S&T site was designed to expand the size of private economy and creative vitality.

With regard to the source of R&D expenditure among the three sectors of GOV, HE, and PNP, government resources were key in supporting R&D. In the GOV sector more than 95% of R&D funding came from the government; this funding is directly impacted by the increase or decrease in government R&D budget. In the HE sector, approximately 80% was from the government, and under the government's recent active promotion of industry-academia collaboration, R&D expenditure from enterprises has increased annually. In the PNP sector, government-sourced funding has been around 50% of the overall funding, over the years.

In addition to government funds, R&D funding from foreign resources was key to maintaining growth. Comparing the R&D expenditure of government and the private sectors (including the BE sector, the HE sector, the PNP sector, and overseas sectors), in terms of R&D funding growth rate, in 2018 the private sector R&D expenditure increased by 8.5% compared to 2017, and government-sourced R&D funding increased only by 1.9%. In terms of the proportion of R&D expenditures by government and the private sectors, since the growth of the private sector is faster than that of government sector, the R&D expenditure from the private sector in 2018 accounted for 81.2%, an increase of 3.1% over 2014, while the government sector accounted for 18.8% in 2018, a decrease of 3.1% over 2014 (Ministry of Science and Technology (Taiwan), 2019b).

The Types and Issues of R&D Expenditure and Researchers

Taiwan's government fund is the most important key to supporting R&D. In 2017, Taiwan's government invested only 20% of R&D funds, lower than the 25.1% average of OECD countries, showing an inefficiency in the government's preparations for scientific and technological research, causing a decline in national competitiveness and brain drain in the long run (Ministry of Science and Technology (Taiwan), 2018b). On the other hand, the government's investment in basic research funds was also severely insufficient, accounting for only 7.8% of the country's overall R&D funds, far lower than Switzerland (41.7%), the Netherlands (26.5%), Singapore (23.8), and countries like South Korea (14.5%) and Japan (13.1%) which have similar scales. Therefore, the Taiwanese government has annexed an additional 140 million USD for research funding in 2020, hoping that the proportion of basic research funding can increase to 8.3%.

Although basic research is mainly in the HE and GOV sectors, the HE sector had tried to narrow the gap between industry and academia in recent years and is actively linking with industry, so that HE R&D is utilized in the BE sector. As a result, the HE sector has devoted more expenditure to applied research and technological development than to basic research (Ministry of Science and Technology (Taiwan), 2019a, b). In 2018, R&D expenditure in the HE sector was 1.83 billion USD, up 6.2% from the previous year. The share of HE R&D as a proportion of national R&D expenditure has gradually fallen. In 2018 it was 8.9%, a decrease of 1.5% from 2014 (Ministry of Science and Technology (Taiwan), 2019b).

The BE sector still employs the most researchers across various sectors in Taiwan, rising from 97,019 person-years in 2014 to 109,276 person-years in 2018, a growth rate of 3.0%. The shift in R&D personnel in the BE sector is usually attributed to organizational restructuring, reform, or regulation of new R&D products. The increasing number of researchers being employed are government researchers, with an average growth of 2.5% from 14,229 person-years in 2014 to 15,688 person-years in 2018. Researchers in the HE sector decreased gradually from 30,621 person-years in 2014 to 28,767 person-years in 2018, an average reduction of 1.5%. The main reason for the decline in university researchers is the schools' response to declining birth rates, position elimination once it is vacant, or researchers exiting once cases are completed. In the PNP sector, there was also a negative growth rate over the past 5 years, a decline of 17.9%; this drastic reduction of researcher numbers is probably caused by the OECD classification adjustment, whereby some large-scale organizations had been shifted to be listed under other sector categories (Ministry of Science and Technology (Taiwan), 2019b).

Trends in National Investment in Higher Education

The proportion of total education expenditure to the GDP is used to measure the extent of government investment in educational institutions. The total educational expenditures grew from 16,811 million USD in 1995 (the percentage of educational expenditures to GDP is 6.55) to 29,902 million USD in 2019 (the percentage of educational expenditures to GDP is 4.76). Even so, Taiwan's investment in educational expenditure has displayed a significant growth trend in self-help funds and private sector in the last 20 years; expenditure grew from 160 million USD self-help funds and 3100 million USD private sector in 1995 to 2536 million USD self-help funds and 7325 million USD private sector in 2019 (Ministry of Education (Taiwan), 2020a). In summary, regarding the process of education development, Taiwan's government has played an active role in funding; nonetheless, private education institutions and corporate investment have also become important sources of funding in recent years, creating human capital, enhancing technological development, and promoting national competitiveness.

The OECD data (Fig. 7.2) shows that in recent years, the expenditure of tertiary education on educational institutions as a percentage of GDP in most countries has been declining; this has been seen most clearly in South Korea, declining from 2.6% in 2011 to 1.7% in 2016. Taiwan's higher education expenditure in the 2014–2016 GDP average is between 1.54% and 1.4%, showing great room for improvement. In 2018 the Ministry of Education's total budget was 7926 million USD, of which the total subsidies for public and private HEIs amounted to 3070.9 million USD; *1/3 was for private HEIs* and was allocated in four areas: (1) shortening the gap between what is learned and applied and fostering high-level talents; (2) creating a learning environment that combines industry, teaching, and research, promoting local economic growth; (3) promoting flexibility in higher education policy, in addition to assisting HEIs to develop distinct features and also guiding the transformation or exit of some; and (4) strengthening the layout of the New Southbound Policy, developing multiple admission strategies and internship abroad policies (Ministry of Education (Taiwan), 2019a, b).

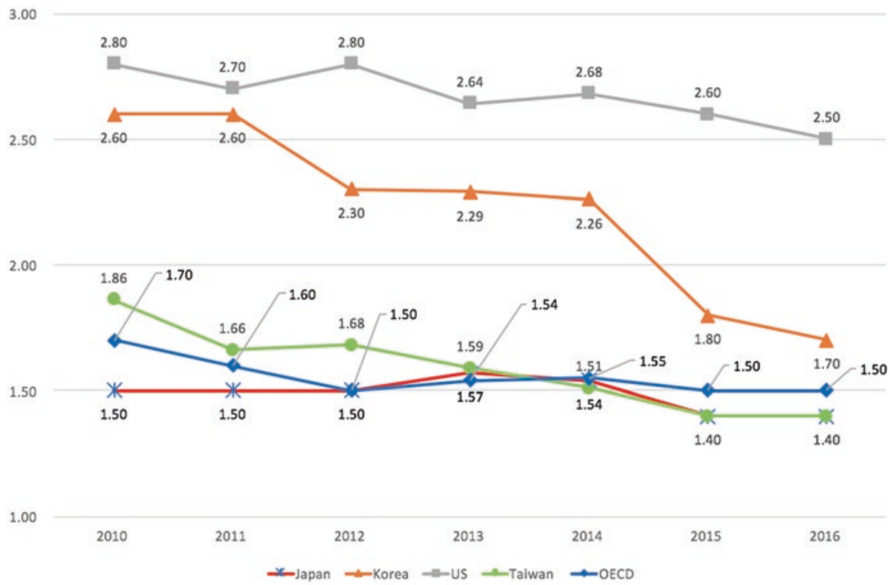

Fig. 7.2 2010–2016 expenditure on educational institutions as a percentage of GDP in tertiary education. (Source: Education at Glance: OECD Indicators (OECD, 2013–2018); Ministry of Education (Taiwan) (2014, 2015, 2016, 2017, 2018))

A Focus on Competitive Excellence

In the twenty-first century, higher education is influenced by the realities of globalization, the emergence of the knowledge society, as well as development in information and communications technology. In response to this environment, new competition patterns have arisen. These include the promotion of free competition in the higher education market, international development in education, the linkage of education with industry, as well as the increasing importance of international rankings of educational institutions (Chen, 2019). Various countries have also done their utmost to pursue university excellence and enhance competitiveness so that their top universities are able to stand out on the international stage. These outstanding universities seek to make their teaching, research, and service the same quality as internationally renowned ones. Neighboring East Asian countries such as Korea (Brain Korea of 21st Century, BK21), Japan (21st Century CEO Program), and China (Project 985) have adopted similar strategies to select and focus on high-quality universities.

Taiwan entered the period of higher education expansion in 1994, changing from a system of education for the elite to the popularization of education (Chen, 2019). In 2000, while the number of HEIs in Taiwan increased, funding remained the same which potentially threatened the overall quality of higher education. In an effort to avoid the dilution of quality amid resource constraints, the Ministry of Education

Table 7.1 2000–2022 higher education competition projects in Taiwan

Project name	Duration	Total funding (USD)	# of receiving institutions
Program for Promoting Academic Excellence of Universities	2000–2005	433 million	8
The Top University Development Plan (Stage I)	2006–2010	1667 million	17
The Top University Development Plan (Stage II)	2011–2016	1667 million	12
Teaching Excellence Program (Stage I)	2005–2008	480,716 million	2005: 11 2006–2008: 58–60
Teaching Excellence Program (Stage II)	2009–2012	486,725 million	63–65
Teaching Excellence Program (Stage III)	2013–2016	540,451 million	65
Competitive Funding Bridging Project	2017	389 million	Over 85
Higher Education Sprout Project	2018–2022	2,511,741 million	153

Source: Ministry of Education (Taiwan) (2020b)

has considered the practices of Europe and the United States as well as neighboring advanced countries and has since then adopted policy guidance changes. The strategies have been to use competition to target resources to initiatives that promise the greatest return. To that end, the Ministry has successively conducted five large-scale higher education competition projects (Table 7.1).

In the "Program for Promoting Academic Excellence of Universities" from 2000 to 2005 and the three-phased "The Top University Development Plan," the Ministry of Education has provided a total of 3767 million USD, selecting and subsidizing universities to pursue world-class campuses and establish research centers in more particular fields to spread Taiwan's academic influence and R&D force. At the same time, in order to encourage universities to develop excellence in teaching models and enhance students' employment based on competitive positioning, the Ministry of Education invested 1,507,892 million USD in the Teaching Excellence Program between 2005 and 2016, hoping that through the competitive, inter-university reward system, subsidized schools can shape a high-quality teaching atmosphere. Research shows (Executive Yuan (Taiwan), 2011) that this strategy notably improves the teaching quality of university teachers and integrates cross-disciplinary courses.

In order to promote the sustainable development of universities, continuously improve the quality of teaching, and enhance the effectiveness of student learning, taking into consideration that different HEIs have diverse missions and tasks, the Ministry of Education proposed the "Higher Education Sprout Project" for 2018–2022, reaching up to 2,511,741 million USD; the dynamic of "selecting the best to subsidize" shifted to comprehensively addressing the development of individual HEIs. In other words, through the integration of resources, all universities can receive subsidies, but the amount of funds approved must be allocated according to the school's individual positioning and features. Its purpose is to (1) assist research universities in pursuing world-class status and develop Research Centers of Excellence; (2) promote Global Taiwan, leading universities to establish Taiwan's international academic reputation and status on a highly competitive global platform; (3) support teaching universities to improve student learning effectiveness as the main body of the program, focusing on the key foundation of students' competence and employability; and (4) encourage universities to step out of the ivory tower and play a key role as local think tanks in the process of regional innovation and development, striving for university social responsibility.

There has been a substantial growth in funding (Table 7.1) which may be related to Taiwanese government beginning to invest in higher education competitive projects. Facing the competitive pressure of the globalized higher education market, the competitive plan has indeed allowed Taiwan's HEIs, under educative resource constraints, to highly value performance responsibility, and performance-oriented competitive funding has also become one of the ways to guide universities to improve their competitiveness. Using National Taiwan University (NTU) as an example, under the funding of "The Program for Promoting Academic Excellence of Universities" and "The Top University Development Plan," according to Science and Technology Policy Research and Information Center (STPI) (2019), in 2013–2017 the number of papers published by NTU was the highest among all universities in Taiwan; however, the trend of paper numbers in that same period showed a year-on-year decline, with 5309 papers published in 2013 and only 4656 papers in 2017. In terms of relative influence in the field, NTU has the most outstanding performance, showing a year-on-year increase from 2013 to 2015, with an increasing influence in the fields of computer science, engineering, materials science, and physical sciences.

The research outcomes from HEIs which received government grants also provide helpful information with regard to research performance in Taiwan. In recent years, the number of papers from these top 12 universities has accounted for more than half of the journal articles published. Although the Ministry of Education has been criticized for allocating a disproportionate amount of money to these universities, it is clear that the strategy of centralized subsidies for top universities has been effective in creating and disseminating research and has built a strong foundation for the pursuit of world universities. With the support of competitive funding, research universities in Taiwan have also provided a context for domestic R&D to gradually develop on cumulative infrastructure, talent cultivation, and continuity of research outcomes (STPI, 2019).

Promoting University Social Responsibility and Industry-Academy Collaboration

Universities are the congregation of public resources and knowledge communities for top professionals, not only leading research in specialized disciplines but also shouldering the mission of cultivating future industrial talents and social leaders.

Due to the expectations from all sectors of society on performance responsibilities for higher education, university teachers and students are generally expected to care for public issues and provide professional feedback to society while using social resources, thereby improving the gap between academic use.

Therefore, in order to encourage universities to step out of the ivory tower, be attentive to social issues and industrial development needs, play the role of local think tanks, and ultimately become the promoter of local community and industrial development, the Ministry of Education launched the "Higher Education Sprout Project" in 2018. Forty million USD is integrated every year to promote the "University Social Responsibility (USR) Plan." In 2018, 114 HEIs and 220 projects received subsidies; all proposed plans need to meet national policy development, focusing on (1) local care and support, (2) industrial linkage, (3) sustainable environment, (4) food safety and long-term care, and (5) cultural continuity and others, in the interest of stimulating the involvement and creativity of university teachers and students on local and public issues while working with local residents and businesses to promote community and industrial development. The 2020 USR Plan fully incorporates the Sustainable Development Goals (SDGs), internationally relevant social responsibility practice topics. In addition to providing professional practice fields for learning and application, students are encouraged to develop their ability to solve problems in the course of learning by doing and cultivating talents for local communities and industries that meet actual development needs.

At the same time, technical and vocational education has always played an important role in Taiwan's economic development. In order to combine technical and vocational education with industrial practice to raise the level of professional and technical personnel cultivation, the Ministry of Education has promoted the "Academia-Industry Collaboration Project" since 2006. Through the flexible planning of vocational and specialized colleges and universities, technical personnel is cultivated by combining practice-oriented technology development, keeping in mind students' potential economic and learning disadvantages, and building talent for specific and traditional industrial needs to supply the lacking industry workforce. Concrete results include the planning of Industry College in response to the industry's need for human resources and jointly developed interdisciplinary courses by academia and industry to assist students' incorporation to the industry. In 2019, 29 university implementation plans were approved, with 1378 students participating.

In addition, to help universities enhance their doctoral talent's pragmatic R&D capabilities, the Ministry of Education has invested 12 million USD annually since 2017 to promote the "Talent Development through Collaboration of Academia-Industry Plan," providing 6600 USD annual scholarships for each doctoral student, having universities and industries guide the thesis research collectively. The research topics must be relevant with the industry to cultivate R&D capabilities of doctoral students. In 2019, 464 doctoral students from 26 universities were approved to participate. In short, Taiwan has promoted a series of competitive initiatives since 2000, encouraging HEIs to rethink individual positioning and improve school quality and student learning effectiveness. Taking the 2005–2016 "Teaching Excellence

Program" as an example, each HEI has established a Center for Teaching and Learning, teaching evaluations and curriculum reform mechanism, indeed changing university teachers' past perception of valuing research and despising teaching, therefore enhancing HEIs' overall teaching quality and curriculum essence.

Changing Scope and Profile of Higher Education in Taiwan

Taiwan is pursuing this targeted focus on academic excellence and research distinction concomitantly with an accelerated drive for massification. The system has expanded three-fold over the past 20 years. HEIs are now places for the entire population to receive education. This has changed the nature of higher education to become universal in its scope. With this new change, the modern HEIs needed to be able to fulfill the multiple demands of teaching, research, and service (Wu, 2009). In 1994, the total number of students in the 130 HEIs was just 720,180. By 2012, the number of HEIs had increased to 162, and the number of students reached a record high of 1,355,290 (Fig. 7.3), around double the number prior to the broadening of Taiwan's HEIs in 1994. Due to declining birthrates, the number of HEIs decreased to 153 in 2018, and the number of students also dropped to 1,244,822. These numbers will continue to decrease meaning a major concern for Taiwan's higher education.

Between 1994 and 2000, the number of HEIs increased from 130 to 150. However, between 2000 and 2010, only 13 HEIs were added. In 2019, there were a total of 152 HEIs in Taiwan (Fig. 7.4) with 126 comprehensive universities (including 44 public, 1 municipal and 81 private), 14 colleges (including 1 public and 13 private), and 12 junior colleges (including 2 public and 10 private). Compared with 1994, the number of public and private comprehensive universities has increased by 103, colleges have decreased by 21, and junior colleges have decreased by 60. The increased number of universities is a result of the restructuring of the colleges and junior colleges. In addition, the ratio of public to private HEIs in Taiwan in the past 10 years is near 1:2. Taking 2019 as an example, the number of public HEIs (including 33 comprehensive universities, 13 science and technology universities and colleges, and 2 junior colleges) is 48, and the number of private HEIs (including 37 comprehensive universities, 57 science and technology universities and colleges, and 10 junior colleges) is 104 (Ministry of Education (Taiwan), 2019c).

The Emerging Disconnect Between Education Supply and Demand

Taiwan's dramatic expansion of higher education in scale, both publicly and privately, has created pressure on the availability of national resources. The percentage of the population above the age of 15 holding an undergraduate degree has dramatically increased from 16% in 1997 to 44.6% in 2017, an increase of 279% (Ministry

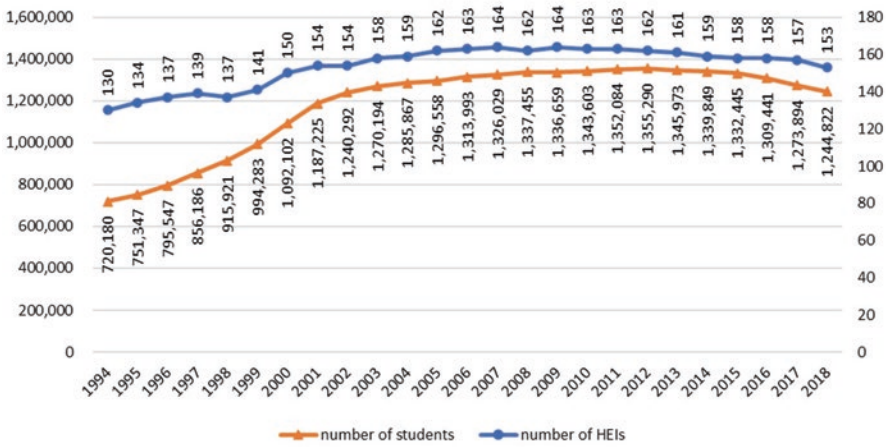

Fig. 7.3 1994–2018 number of HEIs and students. (Source: Ministry of Education (Taiwan), 2019c)

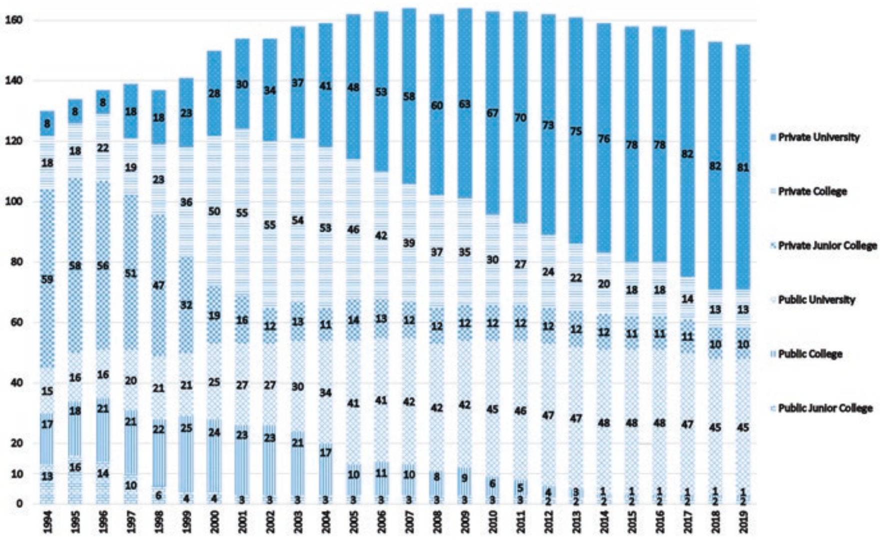

Fig. 7.4 1994–2019 number of HEIs by institution type. (Source: Ministry of Education (Taiwan), 2019c)

of Education (Taiwan), 2018). The increased number of higher education degree holders has plunged the higher education system into a severe imbalance of supply vs. demand for educated manpower. In the past decade, bridging the gap between talent supply and employment demand has become a fundamental issue in Taiwan's higher education system. The report shows that employers are increasingly requiring a bachelor's degree for positions that did not require baccalaureate education in the past (Burning Glass Technologies, 2014). In other words, a university degree is becoming the new high school diploma, the minimum credential required to get even the most basic, entry-level job. A wide range of jobs, such as in management, administration, and sales, are undergoing "un-credentialing" or degree inflation. As an example, just 25% of people employed as insurance clerks have a Bachelor of Arts, but twice that percentage of insurance-clerk job advertisements require one. Among executive secretaries and executive assistants, 19% of job holders have degrees, but 65% of job postings require them for employment (Burning Glass Technologies, 2014).

Another crisis Taiwan's higher education faces is declining birth rates. The number of newborn children was 260,354 in 2001, which declined to 205,854 in 2005, and this number reduced even further to 166,886 by 2010. Between 2000 and 2010, the birth rate decreased from 14.42 per thousand people to 8.3, with Taiwan having among the lowest birth rates in the world. This means that the population of Taiwan is aging and is expected to show negative growth in the future. The Council for Economic Planning and Development speculates that the effects of the population's negative growth will begin to impact society in 2022 (Chen, 2010). Setting 18 years old as the age that a student begins to attend HEI, for people born in 1995 approximately 329,581 will enter HEI in 2013. In 2016, the number is predicted to decline to 271,450, and in 2028, the number will continue to plummet to 166,866 (Department of Household Registration (Taiwan), 2011). The impact of this low birth rate on Taiwanese higher education will be more serious in the next decade if there are no outside sources of students to replenish the system.

With the low birth rate trend in Taiwan, HEIs are confronted with the issue of low enrollment. When the supply of positions for students exceeds the demand, this results in the waste of resources, the reduction of programs, and ultimately, the closure of schools from the market. Therefore, in addition to expanding student resources, the Ministry of Education also promoted a total quantity control policy in 2011. When the enrollment rate does not reach 70% for three consecutive semesters, the Ministry of Education will reduce the enrollment quota for the class to avoid further deterioration of the enrollment gap and waste of resources. The impact of the low birth rate on private HEIs is much greater than the impact on public HEIs; the registration rate of public HEIs shows a steady trend of enrollment.

National Retirement Policy and Influence on Higher Education

Under the premise of national financial difficulties, Taiwan carried out a teacher annuity reform plan in 2017 and revised the National Retirement Policy. The three important items of this policy are extension of retirement age, reduction of monthly retirement pension, and additional retirement expenses. The impact of this retirement policy on university professors includes the following: (1) previously, with 25 years of service and 50 years of age, one could retire and enjoy the benefits of receiving monthly pensions. Now public university professors need to complete 15 years of duties and be at least 58 years of age before they can request pensions. For full pension, one must serve until the age of 65. (2) Previously, public university professors who were 50 years of age could apply for "voluntary retirement," transfer to high-quality private universities to service, and receive both salaries from private universities and pension plans. Now professors in public universities delay retirement, leading to the trend of aging among university professors. (3) The pension reform has caused many senior professors to feel reluctance toward retirement, making it difficult for young doctors to have the opportunity to serve in public universities; additionally, private universities, affected by declining birthrates, have relatively reduced teaching positions.

Taiwan's public opinion on the transfer of retired public university professors to private institutions is relatively negative. Chou (2012) and *United Daily News* (2012) pointed out that as of 2012, the number of teachers retiring from public universities to serve in private universities was 2547. These double-income professors have prevented many PhD graduates from obtaining formal teaching positions. These transferred senior professors only serve as part-time teachers or contract-based instructors due to a reluctance to take up administrative work; junior faculty must bear heavy administrative services, which may affect their research performance and teaching quality in the long run. Furthermore, the difficulty for young scholars to find teaching positions in HEIs will also lead to the continued reduction in the number of candidates for doctoral classes in the future, and even affect the subsequent willingness to devote oneself into the university professor's workplace, which is seriously hindering the academic conditions of Taiwan's higher education and national talent cultivation policies.

The Changing Profile of the Academic Profession

The number of full-time university faculty has been decreasing every year since 2011 (Fig. 7.5) which mirrors enrollment declines. In 2019, there were 45,945 full-time faculty members in Taiwan, 1.8% lower than in the previous year (Ministry of Education (Taiwan), 2020a). In order to cope with this impact, some HEIs have reduced their hiring of new faculty, which decreases the employment opportunities for novice faculty. The decrease in the number of teachers in private HEIs has been the most significant; in 2017 there were 25,072 full-time faculty in private HEIs, but only 23,675 in 2019, which reflects that private schools are seriously affected by the shortage of students and the pressure of personnel costs. Consequently, some HEIs imposed a recruitment freeze; they no longer hire full-time teachers and replace them with part-time ones. The number of part-time teachers in public and private HEIs in 2019 was 42,088 in total, with the 64.3% *of them coming from the private HEIs*. According to the Ministry of Education (Taiwan) (2020a), 49.2% of faculty members in public HEIs were over 50 years of age, compared with private institutions where 45.2% of faculty members were over 50, indicating that Taiwan's full-time faculty body is rapidly aging.

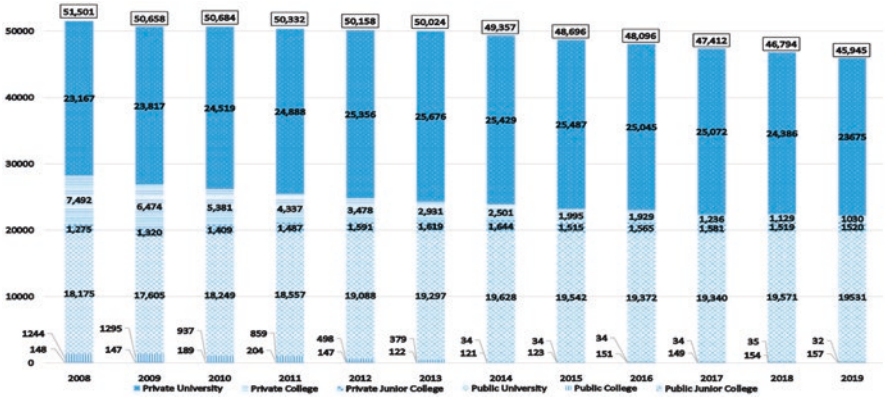

Fig. 7.5 2008–2019 number of full-time faculty. (Source: Ministry of Education (Taiwan), 2020a)

Since the private sector of higher education has mushroomed over the past two decades, the institutional mission of these HEIs is to undertake more teaching tasks and student counseling. Even so, according to *Global Views Monthly* (2019), among the top 50 HEIs, in 2016, 21 of them came from the private sector; however, this number had reached 27 by 2019, with medical universities performing best. The reason is probably that these private HEIs have more crisis awareness, so as to actively strive for competitive funds and emphasize industry-academia cooperation and innovative teaching.

Doctoral Education and Employment

It becomes clear that Taiwan's higher education system is currently facing the phenomenon of oversupply and academic qualification expansion. However, despite the fact that the proportion of those being educated has increased, there have been difficulties in the cultivation of high-level talent in Taiwan. The number of doctoral students enrolled in Taiwanese schools has decreased in the last 10 years, and the unemployment rate of graduate students has risen steadily. The number of doctoral students dropped from 34,178 in 2010 to 28,510 in 2019 (Fig. 7.6), which resulted in the cutting of about 200 departments over the decade. Even at the top universities in Taiwan, the enrollment rate for doctoral classes was on average 60–70% of capacity in 2018; there are still some doctoral programs with inadequate numbers of students in their departments (Ministry of Education (Taiwan), 2019c). The numbers of PhD graduates have steadily fallen, from a high point of 4241 in 2012 to 3306 in 2018.

Regarding the practice and overall employment situation, Executive Yuan (Taiwan) (2018) pointed out that the average number of years of schooling for PhDs

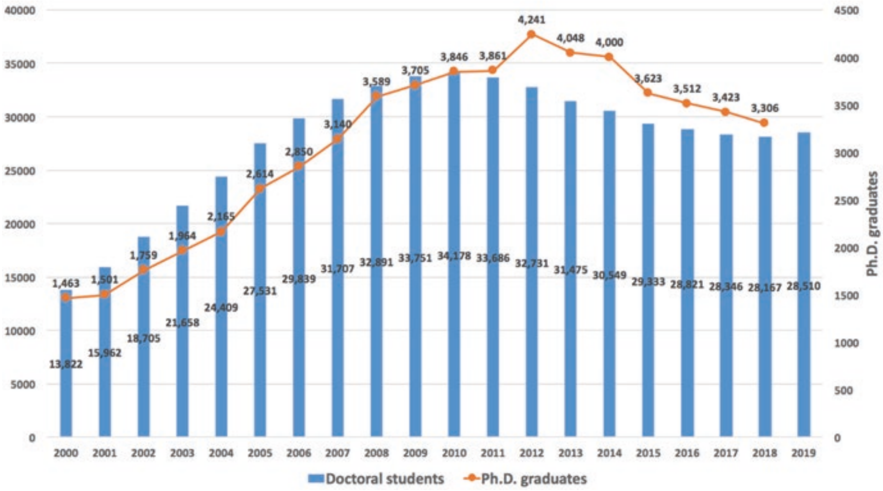

Fig. 7.6 2000–2019 number of doctoral students and graduates. (Source: Ministry of Education (Taiwan), 2020a)

in all types of schools in Taiwan is more than 5 years, which is higher than that of doctoral graduates from foreign schools. If it is divided by field, doctoral education takes longer in the field of humanities (5.84 years), while a PhD in the field of engineering takes the shortest amount of time (5.12 years). According to the Ministry of the Interior (Taiwan) (2018), the domestic research population (including master's degree and doctoral degree) in 2017 is as high as 1,420,000 degree holders, ranking fourth highest in the world. However, the unemployment rate of graduate degree holders is higher than that of the bachelor's degree holders, by 0.05% (Executive Yuan (Taiwan), 2018), showing that a higher level of education does not equal a higher employment rate in Taiwan.

In light of the serious situation the domestic higher education environment is currently experiencing, the employment of PhD graduates will soon be at a crisis stage. Many doctoral students feel helpless about spending more time studying and having a high degree of education, but not having more competitive advantage in employment than others. This highlights that Taiwan's higher education does not fully meet the needs of the industry, and there is a disconnect between industry and academia, which is worthy of consideration by the government and HEIs. Further observation by age range shows that the ratio of young PhD graduates under 45 years of age going into the education sector has decreased by nearly 20% in 10 years. In 2017, only 61.7% of PhD graduates entered the field of education. However, the number of people serving in the government sector continued to rise, reaching 20.1%, nearly 10% higher than a decade earlier.

Concluding Thoughts

In our analysis of Taiwan's higher education system, several salient points have become clear. The first is that the Taiwanese higher education system is in a period of change with a large number of HEIs tending to oversupply education to an increasingly shrinking student population. The second is that diplomas have become inflated while the student population is steadily declining. The third is that full-time faculty positions in Taiwanese institutions are difficult for PhD graduates to obtain as faculty continue to hold onto jobs until much later than were held in the past. With these, we have discovered that it usually takes slightly longer to graduate from a PhD program in Taiwan than in foreign nations, with fewer jobs being available upon graduation, and therefore, fewer people are interested in pursuing a PhD degree. This has resulted in fewer PhD graduates, and those who do obtain a PhD degree increasingly show interest in working abroad if they are under the age of 45, although most of these people do plan on returning to Taiwan at some point in the future.

In addition, Taiwan's S&T policy and changing trends, including an international comparison of R&D and S&T, as well as an overview of Taiwan's R&D policy have been considered. It is abundantly clear that investment and policy in Taiwan's higher education and talent cultivation have a significant impact on the creation of knowledge. The national policies on S&T and its R&D plans will inevitably affect the ways in which knowledge is generated. This generation of knowledge will, in turn, influence the prosperity of the nation, as well as impact the development of a competitive knowledge society.

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Sophia Shi-Huei Ho is Professor and Director of Institute of Educational Administration and Policy, University of Taipei. Her areas of expertise include higher education, education evaluation, and teacher education. She also serves as the General Secretary of the Taiwan Association for Institute Research.

Robin Jung-Cheng Chen is Professor and Associate Dean of the College of Education, National Chengchi University, Taiwan. His research interests are mainly in comparative education, education policy sociology, and rural education. He also served as the consultant with UNESCO for the teacher task force.

Chapter 8
Changing Policies of Research, Development, and Innovation and the Characteristics of Academics in Japan

Akira Arimoto, Tsukasa Daizen, and Futao Huang

Abstract The purpose of this chapter is to explore the changes that have occurred in Japan's research, development, and innovation policies and among Japanese academics since the early 1990s. The chapter argues that, despite a certain continuity and coherence between these policies, they also contain dramatic changes. It is fair to say that some of these policies and strategies led to successful outcomes, while others have so far ended in failure. Further, the chapter points out that there are many daunting problems to be solved, which the national government has not paid sufficient attention to since the 1990s. For example, firstly, Japan should reconsider its modest investments in R&D and the Japanese government's weakness in investing public funds in higher education, especially as to academic productivity in universities. Secondly, Japan needs to make more efforts to promote the R-T-S nexus, strengthening not only research universities but also teaching-oriented universities, and ensure that business makes its fair share of investments in research productivity by encouraging collaborations between industry, business, and academia.

Keywords Academic Profession · Research productivity · Teaching-research nexus · Science technology · Japan

A. Arimoto (✉)
Hiroshima University, Higashihiroshima, Japan

Research Institute for Higher Education, Hyogo University, Kakogawa, Japan

T. Daizen · F. Huang
Research Institute for Higher Education, Hiroshima University, Higashihiroshima, Japan
e-mail: tdaizen@hiroshima-u.ac.jp; futao@hiroshima-u.ac

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Introduction

Since the 1990s, having been impacted by both global and domestic factors, enormous changes have occurred in Japanese polices of research, development, and innovation. In this rapidly evolving context, Japanese academics have undergone a significant transformation that involves not only their demographic and employment situations but also concerning their views of academic activities and other issues. Based on an analysis of national policies, statistics, and other materials, the purpose of this chapter is to explore the changes that have occurred in Japan's research, development, and innovation policies and among Japanese academics since the early 1990s.

The chapter begins with a basic overview of national research, development, and innovation policy and changing trends, including comparative data from the Organisation for Economic Co-operation and Development (OECD) on research and development (R&D) expenditures and the attainment of national innovation goals. It argues for the basic intersection between national research and innovation infrastructure, and higher education and changes since 1990. The final part summarizes the chapter's key findings.

Changing National Research, Development, and Innovation Policies

Like other countries, Japan's science and technology policies have influenced its national policies for, and reforms of, its higher education system. Although significant changes have occurred in Japan's economic situation, science and technology development, and academic productivity—especially research productivity—in the past decade, there are still many similarities that can be identified in contemporary Japan (Arimoto, 2010).

The sweeping changes in Japan's national policies on research, development, and innovation can be summarized as follows. First, national policies relating to science and technology development have been reviewed every 5 years since 1995, when the Science and Technology Basic Plan was initiated (MEXT, 2016). The first stage of the basic plan presented a detailed blueprint and the expected science and technology outcomes, from 1996 to 2000. Based on substantial past development, Japan's National Institute of Science and Technology Policy (NISTEP) has begun to design the next 5-year plan, their sixth plan which will cover the 2021–2025 period. Unlike previous plans, the next stage will be named the Science and Technology Innovation Basic Plan instead of the Science and Technology Basic Plan. Further, it will include not only natural sciences and technology but also new fields in the humanities and social sciences that were not part of the basic plans of the previous 25 years (NISTEP, 2019).

According to Ueyama (2020), the key features in the basic plans since 1996 have been as follows: the first-stage basic plan stressed investment; the second-stage plan clarified focal areas; the third stage plan emphasized innovation; the fourth-stage plan concentrated on the integration between science and technology policy and innovation policy; and the fifth-stage plan envisioned a future called Society 5.0 (Ueyama, 2020).

Second, the national government introduced the Selection and Concentration Policy in 2004, which aimed to promote academic productivity, including research productivity, teaching productivity, and social service productivity at national universities, especially national research universities. The policy dedicated more resources to research universities while reducing funding for non-research or teaching-oriented universities. This policy has increasingly shaped the hierarchical structure of Japan's university system.

Third, the 2004 policy changed how public funds were allocated to all higher education institutions (HEIs) from a block grant approach (*ikkatsu haibun)* that was based on the number of faculty members and students, to a competitive allocation (*kyoso haibun*) method based on academic productivity, including research productivity. Under this new method, both scale merit and field merit are supposed to work well by being meritocratic; it is a doctrine of haves and have-nots. Larger HEIs are stronger in terms of university-industry linkage because of scale merit; fields in science, technology, engineering, and mathematics (STEM) and medicine enjoy greater prestige than disciplines in the humanities and social sciences. Humanities and social sciences used to be segregated; a former Minister of the Ministry of Education, Culture, Sports, Science and Technology (MEXT) said that they were not necessarily included in academia. In this context, it is a landmark in the history of the science and technology basic plans that the next plan will explicitly include the humanities and social sciences in addition to STEM and medicine. In the prevailing Darwinian evolutionary theory, the weak becomes the victim of the strong (Takahashi, 2015). Of course, this phrase should not be applied to academia. That is, the weak fields of humanities and social sciences shouldn't become the victim of the strong natural sciences, although it has happened in years past.

Fourth, contrary to the policy of the competitive allocation of funds, MEXT introduced a policy of decreasing national management grants to the national university sector in 2004, when all national universities become national university corporations. The amount of decrease for the sector as a whole was 1% per year, with the 14% over the past 14 years reaching ¥140 billion. Research universities, which make up around 5% of all Japanese universities, could receive additional funds and other resources by undertaking collaborations with industry and business, while non-research universities (95% of Japan's universities) had virtually no avenue to obtain additional funds or other resources. Therefore, research universities with high status could survive easily, owing to their prestige and scale merit. By contrast, non-research universities and those with a lower status in the system could barely survive.

The universities with a higher status in the social stratification found it easy to maintain academic productivity, while those with a lower status could not realistically achieve high academic productivity. This has resulted in an overall decline in the academic productivity, especially the research productivity of Japanese HEIs in the last decade. A sort of reverse policy of leveling up the weaker side of institutions by investing enough funds for them to survive unfortunately failed to nurture academic productivity in all universities, especially at the lower level of non-research institutions. It is necessary for the national government to create a new policy to support these institutions in crisis, at least by increasing the amount of national management grants in the near future (Arimoto, 2015b; Toyota, 2019).

Fifth, certain policies of differentiating between the research and non-research university sectors were institutionalized, in a series of stages, into the social stratification of all universities. For example, a chair system was institutionalized in Japan's former imperial universities beginning in 1893 (Terasaki, 1973). The first true research university in Japan arose in the late nineteenth century by importing the chair system from German universities, even though the national government created the official name of Research University in 1956. The German chair system was characterized by an apprenticeship approach, in which students deferred to, and obeyed, their teachers (the chair holders) to the extent that it led to academic inbreeding. A closed organization developed in Japanese academia, especially in elite institutions like the former imperial universities, before and after World War II (Shinbori, 1965; Yamanoi, 2007). Moreover, research universities and non-research universities were separated by the presence or absence of the chair system respectively in a 1956 law, when the national government established research universities under the *koza* system (chair system) and the non-research or teaching-oriented university under the *gakkamoku* (department subject) system. The differentiation between the two systems has increased gradually since then in terms of both funding and prestige (Tokyo Daigaku, 1986, pp. 118–119).

Sixth, in addition to the declining national management grants to national universities, the national government's investment of public funds in the higher education sector was the lowest among OECD countries several years ago, though it has improved a little, as we discuss in greater detail below. This is also one of the most important reasons for the decline in Japan's research productivity.

Seventh, the national government introduced a doctrine of selection and concentration to universities across the country. With the priority given to global competition for research productivity since the 1990s, national policies worldwide are likely to become more homogeneous in terms of selection and concentration of institutions (Altbach & Umakoshi, 2004). Japan has been moving in this direction, especially since 2004, when the national government introduced the twenty-first Century Center of Excellence (COE) Program. In this context, Japan's philosophy was intensively focused on science and technology development and the following viewpoints. First, it intended to spur significant economic growth by investing substantial funds to enhance research development rather than academic development in universities. Second, it intended to trace both research orientation and science orientations from an international perspective to realize higher research productivity. As a consequence, these policies have improved efficiency rather than the quality of research because they take a short-sighted view that leads to different outcomes than in other countries, especially the United States (USA), whose long-term outlook began over half a century ago (Arimoto, 2016, 2020b).

Finally, the intended purpose of promoting increased research productivity to the level of a top 100 ranking among research universities has not yet been successful. Further, this approach was likely to support only the upper-class institutions of the research university sector while giving short shrift to the non-research sector and decreasing their research productivity.

National Higher Education Reforms After 1990

Meanwhile, important academic reforms relating to research innovation have been launched by the Japanese government since the 1990s (Huang, 2014).

In the first phase that started in 1993, major reforms of the standards for university establishment resulted in declining outcomes for liberal or general education and declining research productivity. The primary reasons were related to decreases in the creativity and originality needed for academics' research productivity. Academics who lost the chance to study in general education programs at college and university were thought to lose the creativity and originality vital to research productivity. For example, the number of Nobel Laureates in the United States (USA) that had liberal education (equivalent to general education) program prewar time is larger than the counterpart in Japan that did not have general education prewar time, because the former could enjoy liberal education in the undergraduate course required as institutional obligation and the latter could not enjoy it without the same institutional obligation (Arimoto, 2020c).

In addition, a policy of deregulating the standards for establishing universities has resulted in the emergence of many small, private institutions that will be closed by 2030 due to an ongoing decrease in their student enrollments. According to a MEXT estimate in 2018, after the policy was implemented in 1993, the number of universities and colleges increased to almost 800; it is expected to decline to around 150 by 2030 (CCE, 2018).

In the second phase that began in 1997, a contract-based employment system was introduced to academia, combined with firm expectations for enhanced academic productivity. The system was adopted for all academics, from assistants to professors, at certain universities (Kazawa, 2015, pp. 245–261); however, this system only applied to young academics holding the post of assistant professor who were between about 30 and 40 years old, rather than senior academics. As a result, those who were recruited based on this system are expected to intensively conduct research and publish their findings for 2–3 years. Accordingly, they were forced to focus in research work for the short term without being hired with lifelong tenure. Without publication in short time, they are to be fired without reappointment in the same institution hired. Probably they could not find out next position in any academia without low publications, losing stable income enough for keeping academic

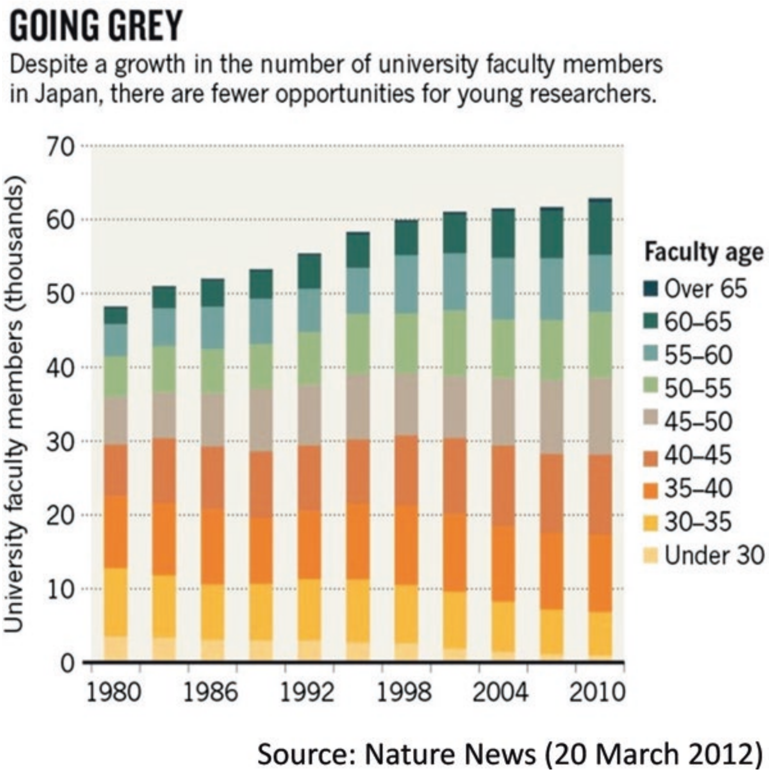

Fig. 8.1 Numbers of young scientists declining in Japan (Nature News, 2012, March 20)

career. Given their short and unstable terms of employment, many young academics and post-doctoral students have left the academic world, which has led to a decline in the number of young academics in Japan. As pointed out in *Nature News* (20 March 2012), "despite a growth in the numbers of university faculty members in Japan, there are fewer opportunities for young researchers" (Fig. 8.1).

Further, junior researchers (those under 35 years old) are confronted with job placement difficulties, which leads to losing opportunities for research. Junior academics are a declining proportion of academics and are losing vital time that is necessary for the research productivity that is demanded of them because they are expected to carry out a variety of administrative, teaching, and service tasks. They have little time for research and cannot realistically demonstrate academic productivity.

Many young academics are also post-doctoral students who are rarely recruited by HEIs throughout Japan. This also makes it difficult for them to contribute to the enhancement of Japan's academic productivity, especially research productivity. Despite high demand for expanding graduate education, because MEXT could arrive at effective measures to prevent decreasing student enrolments, it is extremely difficult for Japan to increase the number of doctoral degree holders and improve its academics' research productivity. As mentioned earlier, it appears that no fundamental changes have occurred in Japan for the last decade:

> The existence of the "opened structure" testifies to the fact of considerably high academic productivity, and on the other hand the existence of the "closed structure" reflects some problems as follows: aging of academic staff population; high proportion of full professorship; unemployment problem of post-doctors; compulsory mobility; gender problem; worsening work environment; younger academics' strong complaint, stress, and desire to go to other institutions. (Arimoto, 2016)

In the third phase, which began in 2004, the corporatization of national universities revealed how futile management's plans were because of their inherent defect of depending on MEXT's management grant without allowing for the university corporation's independence. A continual decline in the number of national management grants has resulted in declining research productivity.

In contrast to the corporatization policy, the national government implemented the COE program in 2004, together with a series of programs such as Good Practice (GP), Global 30 (G30), and Center of Community (COC). The main purpose of these programs was to boost the international ranking of selected universities in Japan. However, it is fair to say that a plan to improve the position of Japanese research universities in world university rankings has not been successful thus far; only two institutions were ranked in the top 100 on the Times Higher Education 2020 list (Arimoto, 2020c).

With the fourth phase that began in 2015, governance reforms based on the revised 2015 School Education Law have dramatically strengthened university presidents' leadership as a substitute for faculty governance; universities have shifted from being based on an academic guild structure with a bureaucracy and corporation to an enterprise model. On the other hand, the law has decreased academic freedom and academics' autonomy to the extent that it has impeded the development of academics' originality and creativity, which are the essence of academic productivity (Arimoto, 2015a). There is concern that the current situation, which hampers the enhancement of academics' originality and creativity, will lead to a decline in the number of Japanese Nobel Prize laureates in the future.

In the fifth phase that began in 2018, the Central Council of Education (CCE) Report *Grand Design for Higher Education Toward 2040* was issued. It estimated that approximately 160 private institutions would close by 2030 (CCE, 2018), a much higher number than had been expected.

For research productivity to increase, mutual interaction is necessary among all institutions situated in the upper, middle, and lower strata of the hierarchical structure. The possible closure of universities, particularly at the middle and lower levels, will lead to declining research productivity at upper-level institutions because they are supported by the middle and lower levels through academic mobility. The stagnation of research productivity by research universities can easily be connected to the overall decline in Japan's research productivity, given that universities are primarily responsible for promoting research productivity in Japan. Recently, the NISTEP team analyzed the production of scientific publications in Japanese universities by using long-term input and output data, as described in the following abstract:

> As a result, it was found that the stagnation of the number of scientific publications in Japan since the mid-2000s was caused by a combination of the following factors: (1) a decrease in the number of faculty members taking into account the time allocated to research (mid-2000s to around 2010); (2) a decrease in the number of doctoral course students (after around 2010); and (3) a decrease in expenses directly related to research implementation, such as raw material costs (after around 2010). (Igami et al., 2020)

According to this analysis, we can understand that there are three important factors behind the stagnation in the number of scientific publications produced by Japan. Among the four factors of researchers, materials, funding, and information, it is notable that the first two are related to researchers and the third to money. It goes without saying that funding is important, but the researcher factor is the most important, if research productivity is to be enhanced. In this context, the Japanese government should have paid much more attention to researchers, or training researchers, the emphasis being on the individual academic above all (Arimoto, 1994).

Comparison of R&D Between Japan and Other OECD Countries

As noted in the introduction, the amount of research funding in Japan was previously the lowest among OECD countries in terms of the national government's public expenditures on higher education, though it has improved. The OECD defines spending on tertiary education as follows: "the total expenditure on the highest level of education, covering private expenditure on schools, universities, and other private institutions delivering or supporting educational services. The measure is a percentage of total education spending" (OECD, 2019).

As Fig. 8.2 shows, Japan's expenditures on higher education in 2016 were the second highest, behind only the United Kingdom. This means that Japan is a leader among OECD member countries in tertiary or higher education spending. However, there exists a vast gap between private (~70%) and public (~30%) expenditure. Japan is spending a great deal on tertiary education, but its expenditures are small compared to developed nations around the world.

It is apparent that increasing public investments for higher education leads to greater research productivity. Not only has the United States enjoyed great success in the past thanks to phenomenal growth in its gross domestic product (GDP), but countries like China, India, and South Korea are also making great progress today, due to their growing GDP.

Of course, there is a mutual interaction between GDP and research productivity. National economic growth as shown by GDP is likely to encourage significant investment in research universities to increase research productivity. Conversely, growing research productivity will encourage national governments to invest much

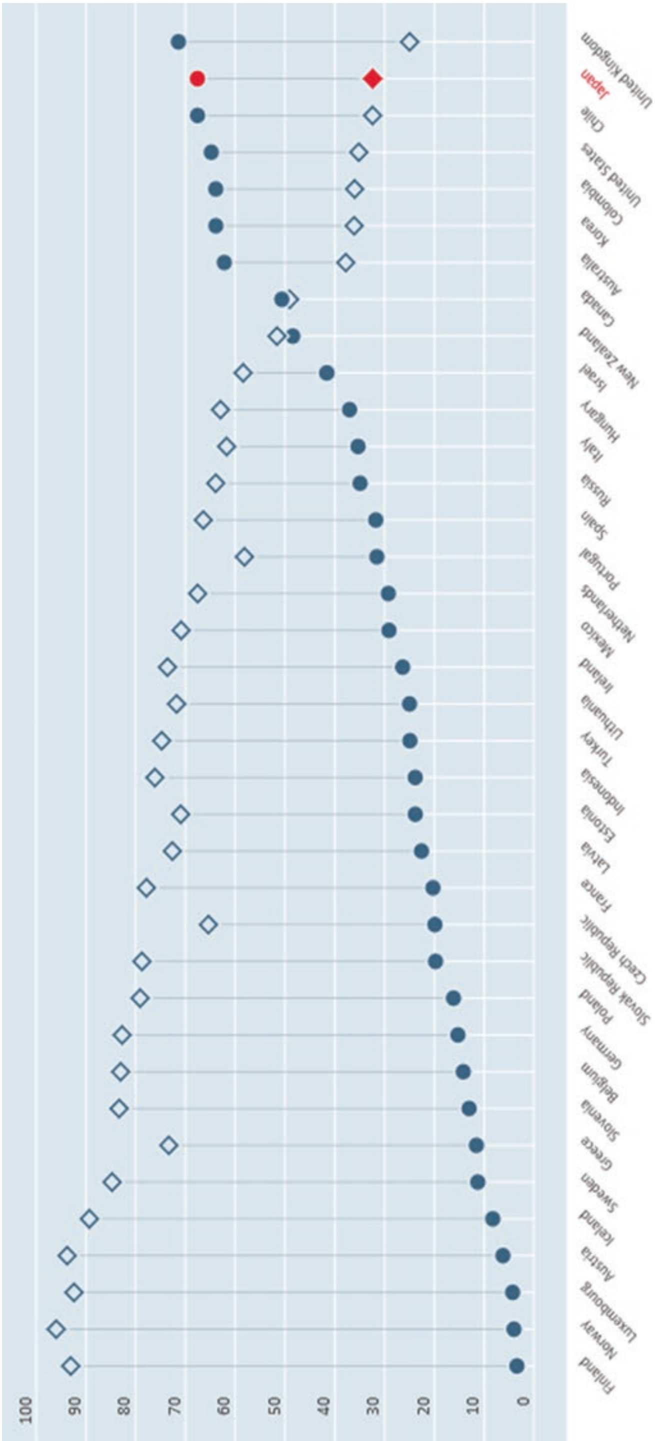

Fig. 8.2 Spending on tertiary education private/public, percent of education spending, 2016 or latest available. (Source: OECD, 2019)

more heavily in the research university sector to maintain that high productivity. This kind of mechanism was actually maintaining high research productivity in advanced COE countries like France, the United Kingdom, and Germany.

Purpose of National Innovation in Japan

As a country lacking in natural resources, Japan has made great efforts since the late nineteenth century to build a strong nation in terms of science, technology, and education. As a result, two ideal types of R-T-S nexus—with the abbreviation standing for slightly different things—are expected to be successfully achieved. The first ideal R-T-S nexus is related to the nexus of research, teaching, and social services, initially proposed by James Perkins (1968), while the second ideal R-T-S nexus is related to the nexus of research, teaching, and study, which Wilhelm von Humboldt was the first to put forward (Humboldt, 1910).

However, academics in Japanese universities and colleges have scarcely met either ideal, particularly the second, according to international surveys of the academic profession: the Carnegie survey in 1992 and the Changing Academic Profession (CAP) survey in 2008, (Altbach, 1996; Arimoto et al., 2015; Arimoto & Ehara, 1996; Shin et al., 2014; Teichler et al., 2013). The trends of delayed response to the modern ideals of competitive research and teaching revealed in the surveys are due to the Japanese government's research-focused orientation since before World War II, which it adopted to catch up with more advanced countries (Arimoto, 2020a, 2020b).

Before that war, the Japanese government decided to convert the former imperial universities (*Teikoku Daigaku*) into universities for training senior bureaucrats rather than promoting Centers of Learning (COLs; Okubo, 1943 [1981]). It was reasonable to follow this approach during an elite-driven era of higher education development, with many students from a socially and economically homogeneous upper class who were expected to become senior bureaucrats who would help create a strong and modern nation. However, it should have evolved during the universalization stage of higher education in which students are much more diverse, with many being the first in their families to enroll in university or college.

Today, the national policy of higher education should be transformed from a state orientation to a student orientation. For more than a century, universities were structured to conform with the national government doctrine of making a strong state first, with encouraging student initiative a far lower priority, if it was considered at all. The strong state doctrine measured students' abilities by *hensachi* (deviation scores) as a result of following a traditional teaching model where teaching was more important than learning or studying.

If we enhance the second type of R-T-S nexus (research-teaching-study) in the prevailing circumstances in Japan's higher education tradition, transformation can be achieved by moving from strengthening the research university sector to

Table 8.1 The ranking of universities in Japan

2019 rank	2018 rank	Institution	Overall score
1	=1	Kyoto University	82.0
2	=1	University of Tokyo	81.9
3	3	Tohoku University	80.2
4	5	Kyushu University	79.5
=5	6	Hokkaido University	79.3
=5	7	Nagoya University	79.3
7	4	Tokyo Institute of Technology	79.0
8	8	Osaka University	77.9
9	9	University of Tsukuba	77.5
10	12	Akita International University	76.7

Source: THE World University Rankings (2019)

strengthening the teaching university sector. Recently, Times Higher Education ranked universities in Japan on the basis of this new policy. According to the report (Table 8.1), it is notable that new universities, such as Akita International University (*Kokusai Kyoyo Daigaku*) which was not ranked highly in the traditional Times Higher Education world university ranking, were the leading institutions with a teaching orientation in Japan, while the University of Tokyo—which is usually ranked highest among Japanese institutions in world university rankings—was in second place behind Kyoto University (THE World University Rankings, 2019). In 2020, the picture was almost the same, except the University of Tokyo had dropped to third, after Tohoku University and Kyoto University (Asahi Shinbun, 2020).

In addition, the Times Higher Education Japan University Rankings for 2019, which included results from a student survey for the first time, also placed Kyoto University on top. It is notable that Kyoto University not only led the rankings but also was ahead of the University of Tokyo. Previously, almost all institutions ranked in the top level were former imperial universities and relevant research universities such as Tokyo, Kyoto, Tohoku, Kyushu, Hokkaido, and so on; Akita International University's ranking in the top 10 is thus exceptional. The latest Times Higher Education ranking signaled a transformation, from ranking based on research orientation to ranking based on teaching orientation.

A Growing Knowledge-Based Society in an Uncertain World

Given the increasingly uncertain future that faces us in the knowledge society, educational innovation is inevitable if we are to shift from old policies to a new outlook that emphasizes teaching and evaluates universities from that point of view. Indeed, the change in its evaluation of universities by Times Higher Education, to focus more on teaching, is likely a harbinger of similar trends in higher education policy.

Interaction Between National Research Orientation and Industry Research Orientation Since the 1990s

National research development has long taken place in the higher education sector, especially research universities with graduate schools; it appears in other sectors like industry, government, and research-intensive organizations, though the national university research sector has long played a leadership role in Japan.

Cooperation Between Industrial Enterprises and Universities

Corporate investment in research in Japan is not as large as in its peers around the world. Consequently, total research productivity in all Japanese enterprises has been lower than that in all universities, especially all national universities, in Japan. The first reason is that the national government's investment has been allocated to certain universities, especially in the national research sector, in order to promote research productivity. During the era of rapid economic growth, this policy was successful to a considerable degree, but during economic downturns this approach failed to such an extent that even the research university sector's productivity showed a rapid decline (Arimoto, 2015b; Toyota, 2019).

As discussed earlier, the national government's investment of funds in the national university sector has declined since 2004. As a result, many national universities have been forced to decrease academics' time for research, with an inevitable effect on research productivity (Urata, 2020). Academics have also lost both the energy and capacity to maintain their research productivity, although those working at certain research universities have been able to continue their research because of the government's policy of selection and concentration on small areas of elite institutions.

Under these circumstances, the national government is expecting the corporate sector to replace national universities with respect to research productivity. However, enterprises are discouraged from investing funds in research due to a persistent economic downturn. The current situation of business funding for universities' R&D is similar to the US context in 2017, when it ranked 15th and Japan ranked 19th out of 19 countries in the level of business funding for universities' R&D, as a share of GDP. Both the United States and Japan continue to fall further behind world leaders in funding for university research. To reverse course, Japan should increase support by $45 billion per year and provide stronger incentives for businesses to increase their own investments in research:

> While businesses in the United States invested the equivalent of 0.019 percent of GDP on R&D at universities, businesses in Germany, for example, invested 0.070 percent, more than 3.5 times as much—and Germany ranks second behind Switzerland, where companies invest more than 4.5 times as much as the United States. East Asian countries, including China, Korea, Singapore, and Taiwan, all outrank the United States with the sole exception

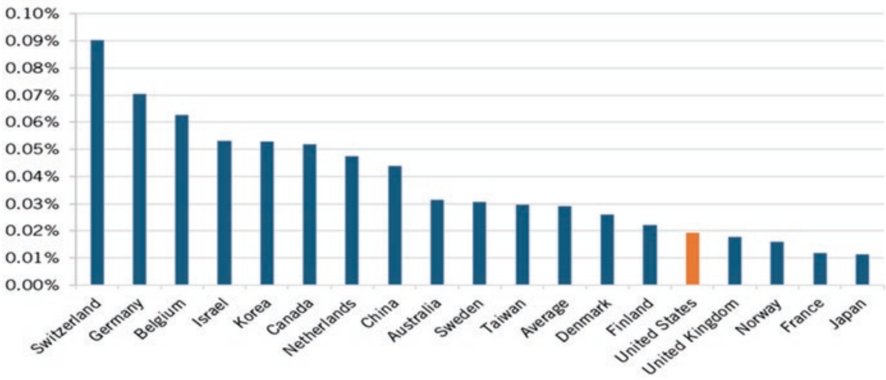

Fig. 8.3 Business funding for university R&D as a share of GDP, 2017. (Source: Atkinson and Foote, 2019)

> of Japan, with 5th-ranked Korea receiving 0.053 percent of GDP from businesses, and 8th-ranked China receiving 0.044 percent, each more than double the level of funding in the United States. (Atkinson & Foot, 2019; see Figure 8.3)

The second reason for the low level of business investment in research may be due to the choice made by enterprises, especially smaller firms, to prioritize profits over basic research, though larger enterprises have been involved in pursuing basic research to a considerable degree. In a down economy, even larger enterprises are driven to lose interest in, and capacity for, making large investments in not only basic research but also applied and development research.

Japanese Companies' Investment in R&D from an International Perspective

As Table 8.2 shows, the top 10 spenders are now spending a great deal of money on artificial intelligence (AI), robotics, and other new technologies; Japanese large companies such as Toyota, Honda, Nissan, Denso, Sony, etc. are now spending to these top areas (Oikawa, 2019). As Table 8.3 shows**,** Amazon spent the largest amount of money on R&D in 2018, about US $22.6 billion. Alphabet (the parent of Google), Volkswagen, Samsung, and Intel rounded out the top five companies with the highest R&D spending. No Japanese company was ranked in the top 10, though Toyota was ranked 13th and Honda was ranked 21st. Toyota's expenditure (US $10.02 billion) and Honda's expenditure (US $7.079 billion) are each less than half of what Amazon spent. Counting the number of "Top 100" companies in R&D spending by country reveals the following list: the United States (38), Japan (14), Germany (12), China (8), South Korea (4), France (3), Netherlands, (3), Switzerland (3), Taiwan (3), the United Kingdom (2), Sweden (2), Italy (2), Ireland (2), Finland

Table 8.2 Top spenders on AI, robotics, and other new technologies

Rank *(last year)*	Company	Priority fields	R&D spending *(in billions of yen and year-on-year change)*
1 *(1)*	Toyota	Robotics, AI, new materials, environment, energy	1100 *(4.8%)*
2 *(2)*	Honda	AI, autonomous driving, electrification	860 *(4.8%)*
3 *(3)*	Nissan	Autonomous driving, electrification, connected cars	550 *(5.1%)*
4 *(4)*	Denso	Connected cars, autonomous driving, electrification	520 *(4.5%)*
5 *(6)*	Sony	Image sensors, AI, next-gen game console	500 *(3.9%)*
6 *(7)*	Takeda pharmaceutical	Cancer, digestive disorders, rare diseases	491 *(33.3%)*
7 *(5)*	Panasonic	IoT, AI, robotics, energy	480 *(−1.7%)*
8 *(8)*	Hitachi	AI, robotics, security	335 *(3.6%)*
9 *(9)*	Canon	Health care, network cameras	312 *(−1%)*
10 *(14)*	Daiichi Sankyo	Psychoneurosis, cancer, circulatory diseases, kidney disease	225 *(10.4%)*

Source: Companies & Oikawa (2019)

(1), Denmark (1), Israel (1), and India (1). It is understandable that the United States is so strong, and that Japan and Germany are still holding onto second and third place, respectively. However, China and South Korea are rising rapidly; it is notable that of the 17 Asian countries in the top 100, 5 are classified as emerging economies.

Environmental Changes and Attribute Changes Among University Faculty

This section will clarify how the characteristics of university faculty have changed since 1990, with radical changes having occurred in the environment surrounding Japanese universities. The data used for this analysis comes largely from Carnegie survey data[1] from 1992 and APIKS survey data[2] from 2017. In some cases, the government data created by MEXT was also used.

[1] See Altbach (1996, p. 150) for information on how to collect data.

[2] The Japanese version of this questionnaire consists of 16 pages with 61 questions. Exactly 8807 questionnaires were mailed to 34 universities (5 research universities and 29 non-research universities). The number of faculty members responding to the survey was 2124 (710 from the 5 research universities, 1404 from the 29 non-research universities, and 10 respondents' affiliations are not clear). The valid rate of response is 24.1 percent.

Table 8.3 Top 25 R&D spenders in the world

Rank	Company	R&D spending (in billion US dollars)
1	Amazon.com	22.62
2	Alphabet	16.225
3	Volkswagen	15.772
4	Samsung	15.311
5	Microsoft	14.735
6	Huawei	13.601
7	Intel	13.098
8	Apple	11.581
9	Roche	10.804
10	Johnson & Johnson	10.554
11	Daimler	10.396
12	Merck US	10.208
13	Toyota Motor	10.02
14	Novartis	8.51
15	Ford Motor	8
16	Facebook	7.754
17	Pfizer	7.657
18	BMW	7.33
19	General Motors	7.3
20	Robert Bosch	7.121
21	Honda Motor	7.079
22	Sanofi	6.571
23	Bayer	6.194
24	Siemens	6.103
25	Oracle	6.091

Source: Statista (2018)

Expansion and Diversification

Table 8.4 shows the quantitative and qualitative changes in the Japanese university system since 1960. For example, between 1954 and 1970, the average economic growth was 9.1%. The growth of the economy enriched household budgets and encouraged growth in the number of both high school and college students. The two oil shocks of the 1970s led to global economic stagnation; however, Japan survived this crisis with energy-saving technology and maintained an average economic growth of 4.2%. In 1976, the Ministry of Education implemented a higher education plan focused primarily on controlling university capacity. As a result, the rate of university entrances remained at 25% of high school graduates until 1992.

After fiscal year 1992, though the number of 18-year-olds year on year was in decline due to the general declining birth rate, many private junior colleges were upgraded to 4-year universities to meet the increasing demand for human resources with higher academic degrees from the labor market. As a result, the rate of female

Table 8.4 Universities and junior colleges in Japan (1960–2019)

			1960	1970	1980	1990	2000	2010	2019
High school student graduates (thousands)		A	934	1403	1399	1767	1329	1069	1051
University entrance rate (%)		C=B÷4÷A	16.8	25.1	32.8	30.2	51.5	67.5	69.4
Students (thousands)	Universities	B	626	1406	1835	2133	2740	2887	2919
	Junior Colleges		83	263	371	479	328	155	113
Schools	Universities		245	382	446	507	649	778	786
	Junior Colleges		280	479	517	593	572	395	326
Faculty (thousands)	Universities		44	76	102	124	151	174	188
	Junior Colleges		6	15	16	20	17	10	7

students going to university increased, and, by fiscal year 2015, the rate of students going to university exceeded half (50.1%) of the age cohort.

The number of university faculty increased with the rise in the number of students. Between 1960 and 1990, the number of students increased by three and a half times, and the number of university faculty tripled. In addition, from 1990 to 2019, the number of students increased by 1.4 times, and the number of university faculty increased by 1.5 times.

Age Structure

When we look at the structure of university faculty by age (Table 8.5), the percentage of young faculty aged 44 or under has declined, and the ratio of senior faculty aged 45 and older has increased. The average age was 46.4 years in 1992 and 49.1 years in 2016, an increase of 2.7 years. The rise in the number of university faculty since the 1990s is likely due to a reduction in the employment of young faculty in addition to the re-hiring of senior faculty in anticipation of the future decline in the population of 18-year-olds.

Changes in the Social Environment and Attribute Changes in Faculty

Since the 1990s, the environment surrounding Japanese faculty has become more complicated for several reasons: the advancement of the knowledge-based society and an aging society, expanded employment of female faculty, increased employment of foreign faculty, a decrease in the 18-year-old population, and changing university management styles.

Table 8.5 Changes in faculty by age

	1992 total academic population	2004 total academic population	2016 total academic population
Below 34	18.7%	13.5%	10.3%
35–44	30.7%	29.1%	28.5%
45–54	25.4%	26.3%	28.7%
55–64	19.4%	25.2%	25.6%
65 or above	5.8%	5.9%	7.0%
Average age	46.4	48.1	49.1

Source: MEXT (1994a, 2006a, 2018a)

The Knowledge-Based Society and an Aging Society

It is essential for a country to produce enough knowledge to thrive in a knowledge-based society and to train its students to live in that kind of world. In addition, the key to leading a knowledge-based society and the developing Society 5.0 (a knowledge-intensive or super-smart society) is deploying human resources so that people will discover and create leaps and technologies that are the source of technological innovation and value creation, along with cultural achievements and social issues, and to create new businesses, including platforms (Minister's Meeting on Human Resource Development for Society 5.0, 2018). In particular, it has been emphasized that systemization is essential for the realization of a super-smart society, with the possibility that the rapid development of the Internet of things, AI, robotics, and other technologies could revolutionize both society and the economy. In this context, MEXT announced a policy in June 2015 for national universities to reduce the number of faculty in humanities and social sciences and emphasize the importance of studying STEM fields.

Table 8.6 reveals that though the number of faculty in the health and social sciences has increased, the number of faculty in natural sciences, engineering, and agricultural fields has decreased slightly, and the rest have decreased by varying amounts. Expanding the number of faculty in the health and medical sciences could help Japan address the issues resulting from its aging population.

Employment of Female Faculty Members

With the massification of Japan's higher education system and the realization of universal higher education, the rate of female students going to HEIs, including graduate schools, has been rising. For example, MEXT data shows that the percentage of female faculty increased from 9.2% in 1992 to 16% in 2004, and then again to 23.7% in 2016. Further, the Japanese government and professional associations have set specific objectives to expand the number of female faculty and institutional

Table 8.6 Changes in the structure of faculty by discipline

	1992 total academic population	2004 total academic population	2016 total academic population
Humanities	15.9%	14.7%	12.5%
Social sciences	17.4%	13.6%	19.5%
Natural sciences	11.0%	9.1%	8.5%
Engineering	16.2%	16.7%	14.0%
Agriculture	4.8%	4.0%	3.8%
Health/medical sciences	30.6.%	30.8%	35.6%
Others	4.1%	1.6%	6.1%

Source: MEXT (1994b, 2006b, 2018b)

leaders in the future; that 20% of faculty should be female by 2010 (National University Association, 2000), 30% of leadership positions should be held by women by 2020 (Second Gender Equality Basic Plan, 2005), and 30% of professors should be female by 2020 (Third Gender Equality Basic Plan, 2010). As these numerical targets have been established to promote gender equality at universities, the number of female faculty, including institutional leaders, should be substantially increased at Japanese HEIs.

Employment of Foreign Faculty

Another important policy issued by the Japanese government is to promote the employment of foreign faculty as a response to the internationalization of universities. With the introduction of the US concept of general education to Japanese HEIs after World War II, many foreign faculty were hired at those institutions, mainly in language programs. By the early 1980s, a large number of these teachers came from English-speaking countries. However, the implementation of the Special Measures Act for the Appointment of Foreign Staff at National and Public Universities by the Japanese government in 1982 significantly changed both the numbers and characteristics of foreign faculty at Japanese HEIs; it has not only led to rapid growth in the numbers of foreign faculty but also made it possible for them to become tenured professors in both the national and local public sectors. Since the early 1990s, the Japanese government has carried out a series of national-level projects to enhance the international competitiveness of its higher education system. A strong demand for foreign faculty has also emerged (Huang, 2018). In September 2008, the Central Council for Education (2008) announced the need to hire more foreign faculty to improve universities' international competitiveness, increase the mobility of international students and faculty within Asia, and introduce a more international perspective to Japanese HEIs. All these initiatives have led to a rapid rise in the number of foreign faculty in Japan. For example, in 1980, foreign teachers comprised approximately 1.1% of total university faculty members, with many employed as foreign language teachers. The proportion of foreign faculty increased from 1.8% in 1990 to 4.7% two decades later in 2019.

Concluding Remarks

The Japanese national government has introduced numerous policies to reform universities since the 1990s. Despite a certain continuity and coherence between these policies, they also contain dramatic changes. As discussed above, the Japanese national government emphasized science and technology development, introducing a science and technology basic law in 1995. It developed the selection and concentration policy related to science and technology policy in 2004, aiming to have least 10 Japanese institutions ranked in the top 100 in global university rankings. It is fair to say that some of these moves led to successful outcomes, while others have so far ended in failure. For example, a policy of promoting research productivity by introducing competitive funds to all universities, especially all national universities, instead of block funds has encouraged the development of research universities; however, it has had negative impacts on the development of teaching-oriented universities. In addition, cutting the national government management grant to national universities by 1% every year has led to many negative consequences for those institutions, especially in terms of research productivity.

As to university reforms, the national government has introduced many policies, including the grand policy in 1993, the term employment system for recruitment in 1997, the corporatization of national universities in 2004, the revised school education law in 2015, the prediction of university selection in 2018, and so on. As noted above, these policies have not necessarily turned out well in terms of academic productivity in many universities, although they have proven to be effective to research productivity in the research university sector.

In a knowledge-based society, a renewed commitment to science and technology, economic growth, and university reforms are probably the most important triangle for Japan's survival. For the country to succeed over the long term, it is essential to conduct reforms from an international perspective while seriously considering both the strong and weak points of previous policies. Given the statistics reported by the OECD, Japan should reconsider its modest investments in R&D and the Japanese government's weakness in investing public funds in higher education, especially as to academic productivity in universities.

Finally, at a time of universalization of higher education, there are many daunting problems to be solved, which the national government has not paid sufficient attention to since the 1990s. They include realizing the R-T-S nexus, strengthening not only research universities but also teaching-oriented universities, and ensuring that business makes its fair share of investments in research productivity by encouraging collaborations between industry, business, and academia.

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Akira Arimoto is the Advisor to President at Hyogo University and Director and Professor of RIHE, Professor Emeritus of Hiroshima University and Kurashiki Sakuyo University, President of the National Association of RIHE, and Representative of HERA. Dr. Arimoto was UNESCO's Global Scientific Committee Member and Chair in Asian and Pacific Region, Springer's editorial board member of the Changing Academy (series editor), President at KSU, Director and Professor at RIHE of Hiroshima University, Associate Member of the Japan Council of Science, and President of JAHER and JSSES. His recent book is *International Comparison of Academic Profession* (In Japanese, Toshindo Pub.Co., 2020).

Tsukasa Daizen is Vice-Director and Professor in the Research Institute for Higher Education, Hiroshima University, Japan. His specialty is sociology of education, especially focusing on the academic profession, academic productivity, and faculty development. His recent publications include: Research activities of Japanese Academic Profession (chapter, Toshindo, 2019); The Internationalization of Educational and Research Activities of Japanese University Academic Staff (chapter, RIHE, 2015); and Education and Research Activities of the Academic Profession in Japan (chapter, RIHE, 2013).

Futao Huang is professor at the Research Institute for Higher Education, Hiroshima University, Japan. He earned his BA, MA, and PhD at Chinese universities. His major research fields are concerned with university curricular development, internationalization of higher education, academic profession, and higher education in East Asia. Since the late 1990s, he has published widely in Chinese, English, and Japanese languages in many international peer-reviewed journals. His main publications include: Huang, F., Finkelstein, M. J., & Rostan, M. (Eds.). (2014). *The Internationalisation of the Academy: Changes, Realities and Prospects*; and Huang, R. & Welch, A. R. (Eds.) (2021). *International Faculty in Asia: In Comparative Global Perspective*.

Chapter 9
Higher Education in the National Research System in South Korea

Soo Jeung Lee and Hyejoo Jung

Abstract South Korea has accomplished remarkable economic growth and advances in scientific technology over the past few decades. The driving force of economic and scientific growth is Korea's national research system that has evolved alongside economic development under government-driven policies. The top-down national research system promoted close collaboration between government, industry, and the academic community, and this approach enabled the efficient use of limited resources. With increasing research capabilities, labor-intensive Korean industries rapidly transformed into heavy-chemical industries and technology-based industries in a short period of time. In this chapter, we provide an overview of Korean research and development (R&D) policies, strategies, and expenditures as well as Science Citation Index (SCI) publications in Korea. Then, we review how higher education has expanded in Korea and discuss the higher education sector's role in the national research system.

Keywords Higher education · National research system · Knowledge society · South Korea

S. J. Lee (✉)
Sejong University, Seoul, South Korea
e-mail: soojlee@sejong.ac.kr

H. Jung
Seoul National University, Seoul, South Korea
e-mail: nofluke@snu.ac.kr

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Introduction

South Korea was one of the poorest countries in the world for more than a decade after the 1950–1953 Korean War. Over the past few decades, however, Korea has accomplished remarkable economic growth and scientific development. Some have called this the "Miracle on the Han River" (Korea.net, n.d.). Korea has produced the 11th largest economy in the world today and ranked 12th in terms of Science Citation Index (SCI) publications in 2018 (KISTEP & KAIST, 2019). The British science journal *Nature* on May 27 in 2020 highlighted "How South Korea made itself a global innovation leader" (Dayton, 2020). Dayton (2020) pointed out that "systemic reform backed by strong investment has brought rapid and long-lasting results in South Korea." To be specific, the driving force behind Korea's remarkable development despite its poor resources and difficult conditions was the government-led national research system. The top-down innovation system fostered close collaboration between government, industry, and the academic community, and this approach enabled the efficient use of limited resources (Shin & Lee, 2015). With increasing research capabilities, labor-intensive Korean industries rapidly transformed into heavy-chemical industries and technology-based industries in a short period of time (Shin, 2012; Shin & Lee, 2015).

Education has also played a core role in this tremendous growth (Adams & Gottlieb, 1993; Lee et al., 2012). Given scarce natural resources, the main source of economic development in Korea is its talented human resources (Adams, 2010; Kim & Cho, 2014). Korea boasts a globally high level of opportunities in higher education, with a rate of college attendance exceeding 60%. Student enrollment in higher education rapidly increased during the 1980s and 1990s. Korea has also accomplished many achievements in terms of education and research quality. In recent years, the Korean government has invested heavily in research and development (R&D) through university-based research funding projects, leading to rapid growth in the research productivity of Korean academics (Shin & Jang, 2013; Shin & Lee, 2015). One of these projects is the Brain Korea 21 (BK21) Project, which aimed to enhance the international competitiveness of Korean graduate schools. BK21 is a long-term project which has been successfully maintained since its initiation in 1999 as a comprehensive master plan to restructure Korean universities (Shin, 2009). University research in South Korea has developed under the government-driven policy initiatives. As a result, the research activities in Korean universities are closely related to economic development, and university research is mainly focused on applied research, development research, entrepreneurial activities (e.g., patents), and so on.

The national research system in Korea has evolved alongside economic development under government-driven policies (Shin & Lee, 2015); examining this system will expand our understanding of the interactions between the government, private enterprises, and universities in a national research system. In this chapter, we examine the development of the Korean national research system and the role of the higher education sector in this system. This chapter consists of four sections. First, we provide an overview of R&D policies and strategies to examine how the national research system has evolved in Korea. Second, we examine R&D expenditures and SCI publications in Korea. Third, we review how higher education has expanded in Korea. Fourth, we discuss the role of the higher education sector in the Korean national research system.

Development of the National Research System in South Korea

Evolution of the National Research System

The Korean government designed a national research system to enhance national economic development (Ministry of Science and Technology, 2008). There are three major social entities within this national research system: research institutes, universities, and private enterprises. These three entities coexist in a nationwide research system, each complementing the other (Shin & Lee, 2015). The national research system is expected to function as a vehicle for knowledge transfer to aid local, regional, and global development. As a result, Korean research activities are closely related to economic development and are mainly focused on applied research and development research (Kim, 1997).

The main actor among these three entities has changed from national research institutes to private enterprises and universities according to developments in their research capacities. This process has evolved over four decades, a relatively short period compared to other developed countries (Shin & Lee, 2015). The main characteristics of the evolution of this national research system are presented in Table 9.1.

Table 9.1 Evolution of the national research system in South Korea

	Incubating period (1960s–1970s)	Transformational period (1980s–1994)	Institutionalization period (1995–present)
Main actors	National research institutes	National research institutes and private enterprises	Private enterprises and universities
Industrial development	Labor-intensive and heavy-chemical industries	Technology-based industries Mid-level technology	High-level technology
Technological development	Technology transfer	Technology diffusion	Technology innovation
Educational development	Middle school education	Higher education	Graduate school education

Source: Shin and Lee (2015, p. 189); amended by authors

Incubating Period (1960s–1970s)

In the initial stage, national research institutes played a major role in supporting national economic development (Kim, 1997; Oh, 2006). The Korean government established a 5-year economic development plan in 1962, and government-funded research institutes were established to support science and technologies that would promote industrialization. The Korea Institute of Science and Technology (KIST) was established as the first government-funded research institute in Korea in 1966 (Ministry of Science and Technology, 1967), and it has played a central role in economic development by driving national science and technology research over the past five decades. In the 1970s, five major government-funded research institutes were established: the Korea Atomic Energy Research Institute (1973), the Korea Research Institute of Standards and Science (1975), the Korea Institute of Machinery and Materials (1976), the Korea Research Institute of Chemical Technology (1976), and the Electronics and Telecommunications Research Institute (1976). The Korean government also continued to push ahead with specific research development projects. For example, the Daeduk Research Complex was initiated in 1973, began construction the following year, and was completed in 1992. The Daeduk Research Complex is a science and technology hub that combines research and education encompassing research, production, and commercialization.

In the 1960s and 1970s, these government-funded research institutes played a core role in importing new technologies from abroad and transferring new technologies into private enterprises (Kim, 1997; Shin & Lee, 2015). The government served as the control tower for industrial development and R&D. Korea established the foundation for an industrialized country through economic development plans and export-driven development strategies in the 1960s and heavy-chemical industrialization policies in the 1970s.

Transformational Period (1980s–1994)

In the late 1970s, Korea's continuous development began to slow down (Ministry of Science and ICT, 2017). The Korean economy experienced extreme inflation, and its excessive dependence on foreign countries made it vulnerable to changes in the global trade environment. In order to overcome this crisis, the Korean government implemented economic stabilization policies in the early 1980s and switched to another economic operating system under the initiative of the private sector (Ministry of Science and ICT, 2017). As the government actively pursued technology-driving policies, opportunities for private enterprises and universities to participate in government R&D projects were greatly expanded. The number of corporate subsidiary research institutes (which stood at only 53 in 1981) showed rapid growth, surpassing 183 in 1985, 604 in 1988, and 1000 in 1991 (Ministry of Science and ICT, 2017). The number of researchers also increased from 2086 in 1981 to 31,186 in 1990 (Ministry of Science and ICT, 2017). Large private enterprises began to establish their own research centers to develop high-level technologies (e.g., LG in 1984 and Samsung in 1987). Thus, Korea shifted to an economy based on technologies (e.g., automobiles and semiconductors) in the 1980s.

The role of universities has become increasingly important in the field of basic science, and support for university research activities has begun to strengthen. In 1986, the Ministry of Education established the Academic Promotion Foundation to support university research. In the late 1980s, industry–academic cooperation centered on government-funded research institutes was promoted mainly by universities, such as the Korea Advanced Institute of Science and Technology (KAIST) and Pohang University of Science and Technology (POSTECH).

Institutionalization Period (1995–Present)

Since the 1990s, support for university research has been implemented in conjunction with the objectives of technical and industrial policies, such as enhancing university research, to foster excellent research hubs, develop small and medium enterprises, and promote regional development (Lee, 1997). In 1990, the Korea Science Foundation carried out a project to promote excellent research groups, such as the Science Research Center (SRC) and the Engineering Research Center (ERC). The Regional Cooperation Research Center (RRC) was established in 1995 as part of an effort to link outstanding R&D resources from local universities to industrial technology development based on regional characteristics. In order to enhance university research, the BK21 Project was established in 1999. The BK21 Project aims to foster graduate schools that cultivate excellent specialized human resources and secure research performance and international competitiveness. The BK21 Project is one of the longest and most successful projects to have improved the global competitiveness of Korean universities. Furthermore, this project had a significant impact on the research landscape of Korean universities (Shin, 2009). The first phase of the BK21 Project was conducted from 1999 to 2005, followed by a second phase from 2006 to 2012. The third phase of the BK21 Plus Project, which merged with the World-Class University Project (2008–2012), has been in progress from 2013 to 2020. The fourth phase of the BK21 Project is soon to begin. A grant of 1.3 trillion won was obtained in the first phase, a grant of 1.8 trillion won was obtained in the second phase, and a grant of 1.9 trillion won was obtained in the third phase. For support, 438 project groups were selected from 72 universities in the first phase, 568 project groups were selected from 74 universities in the second phase, and 522 project groups were selected from 65 universities in the third phase (MOE, 2019a).

The Technopark is a complex established by the Korean government to integrate R&D resources. After the Technopark plan was established in 1995, the construction project began in December 1997; by 2001, six Technoparks had been created, to combine industry–academic-related technical resources. As of 2020, 19 Technoparks have been created across the country in locations such as Seoul, Incheon, Gyeonggi, Gangwon, Sejong, Daejeon, and Daegu. In addition, the government established the Technology Business Incubator (TBI) to support start-ups and commercialization. The Technological Innovation Center (TIC), which became the Regional Innovation Center (RIC) in 2006, was established to enhance regional technological innovation by setting up centers around universities to promote industrialization in the strategic and university-specific areas of the regions of these universities.

Korea has secured international competitiveness in many major industries (e.g., the semiconductor, display, mobile phone, steel, shipbuilding, and automobile industries) by adopting the strategies of more advanced countries. However, the structural vulnerability of Korean industries was revealed amidst the financial crisis that hit the country in the late 1990s (Ministry of Science and ICT, 2017). As the limits of Korea's development strategy were revealed, it was necessary to strengthen the core capabilities of its industries and change its economic constitution through the development and connection of new technologies, including information technology (IT), biotechnology (BT), and nanotechnology (NT). In the 2000s, global R&D efforts were strengthened amidst globalization and widespread market opening (Korea Industrial Technology Association, 2006).

In the 2000s, policies were pursued to strengthen industry–academic cooperation and facilitate the transfer and spread of technology (Suh, 2010). In 2000, the Technology Transfer Promotion Act was enacted to promote commercialization by transferring technologies developed by public research institutes to the private sector. In 2003, the Industrial Education Promotion Act was amended to the Promotion of Industrial Education and Industry-Academic Cooperation Act to form a stronger legal foundation for industrial–academic cooperation. The Industry-Academic Cooperation-Oriented University Development Project and the New University for Regional Innovation (NURI) Project were launched in 2004. The goal of the NURI Project was to strengthen the competitiveness of local universities through specialization and foster professional human resources for regional development by establishing a close cooperation system with industries, research institutes, and local governments.

The Technology Transfer Promotion Act was revised to the Act on the Promotion of Technology Transfer and Commercialization in 2006. Another revision in April 2009 stipulated the allocation of royalties to researchers at public universities and government-funded research institutes to facilitate the transfer of technology through the distribution of profits (Suh, 2010). The Leaders in Industry-University Cooperation (LINC) Project was launched in 2012 by integrating and reorganizing previous projects aimed at promoting industry–university cooperation. The purpose of this project was to expand industry–academic cooperation beyond engineering colleges and enhance the sustainability and diversity of industry–academic cooperation. Fifty-one universities were selected and supported with a budget of 170 billion between 2012 and 2016. The LINC Project was expanded to the LINC+ Project in 2017, and a total of 104 universities were selected and supported with a budget of 327 billion between 2017 and 2021.

R&D Expenditure and the Science Citation Index Publication in Korea

Korea has produced the 11th largest economy in the world. The success of the Korean economy may be due to its sociocultural context combined with Confucianism and capitalism. The bureaucracy and patriarchal system of Korean society allow for top-down management to work efficiently and for knowledge and skills to be acquired quickly (Kim, 1997). Strong government initiatives support the economy and research development with large investments in research science. Korea's gross domestic expenditure on R&D (GERD) had increased to $98,451 (PPP) by 2018, up $8065 (PPP; 8.9%) from 2017. According to the 2018 Main Science and Technology Indicators, GERD as a percentage of GDP is 4.53 in Korea. This figure is relatively very high compared to the Organisation for Economic Co-operation and Development (OECD) average of 2.38% and the European Union (28 countries) average of 2.03%.

As shown in Fig. 9.2, most R&D expenditures in 2018 were financed by the business enterprise sector (76.64%) or the government (20.53%). The higher education sector and other sectors had little funding for R&D expenditure (0.89% and 1.94%). The share of government and public funds in Korea was lower than those of other major OECD countries (e.g., the USA 62.37%, the UK 54.80%, and Germany

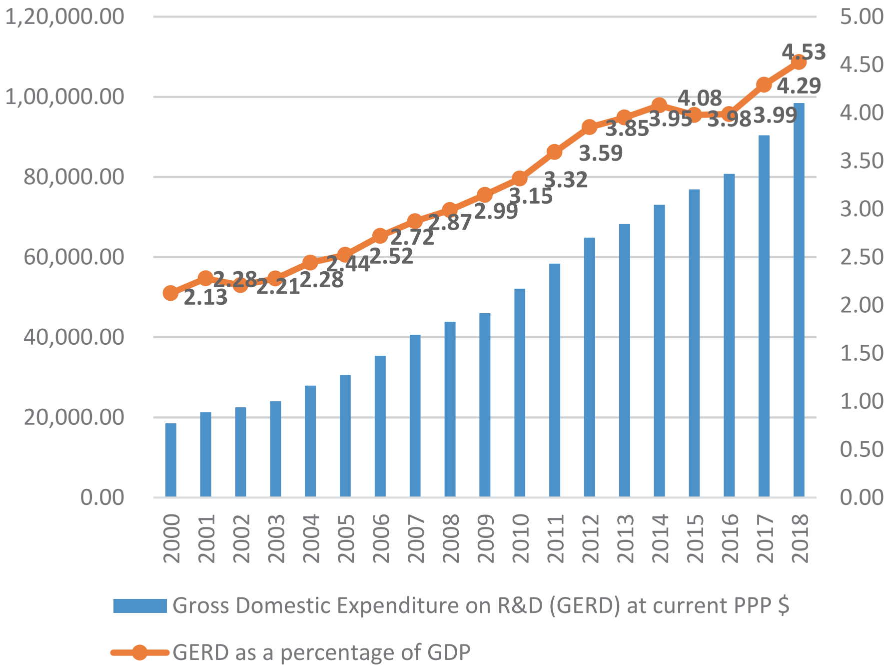

Fig. 9.1 R&D expenditure in PPP $ and as a percentage of GDP. (Source: Data taken from OECD. Stat Database, 2019)

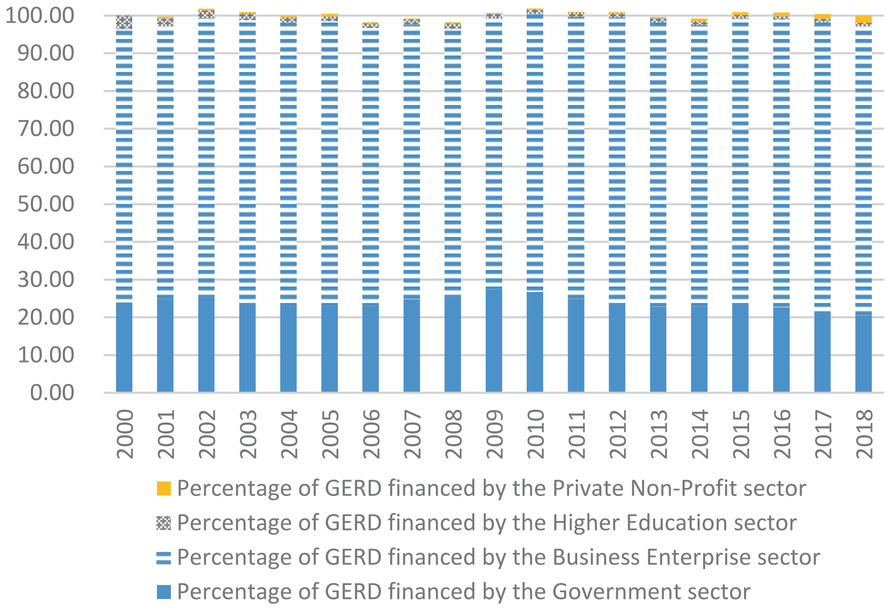

Fig. 9.2 Percentage of GERD financed by the government, the business enterprise sector, the higher education sector, and other sectors. (Source: Data taken from OECD.Stat Database, 2019)

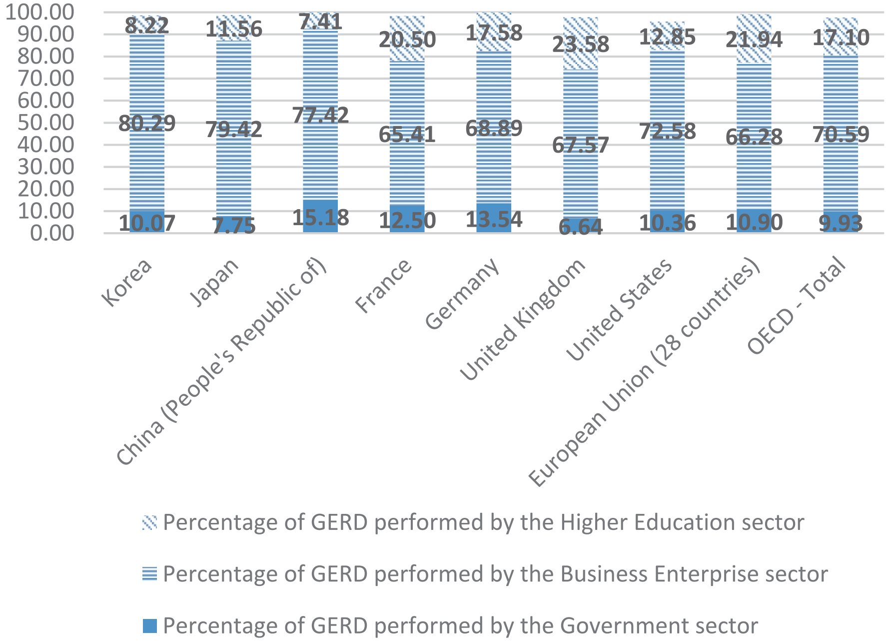

Fig. 9.3 Percentage of GERD performed by the government, the business enterprise sector, and the higher education sector. (Source: Data taken from OECD.Stat Database, 2019)

66.01%) except for Japan (14.56%) and China (20.22%), as Korean R&D expenditure is highly dependent on the business enterprise sector. Although government funding continued to foster R&D expenditure, the weight of major investment in R&D shifted to the business enterprise sector, supported by R&D tax incentives.

Figure 9.3 shows the percentage of GERD performed by the government, the business enterprise sector, and the higher education sector. In terms of R&D expenditure in South Korea, 80.29% of GERD was performed by the business enterprise sector, 10.07% was performed by the government, and 8.22% was performed by the

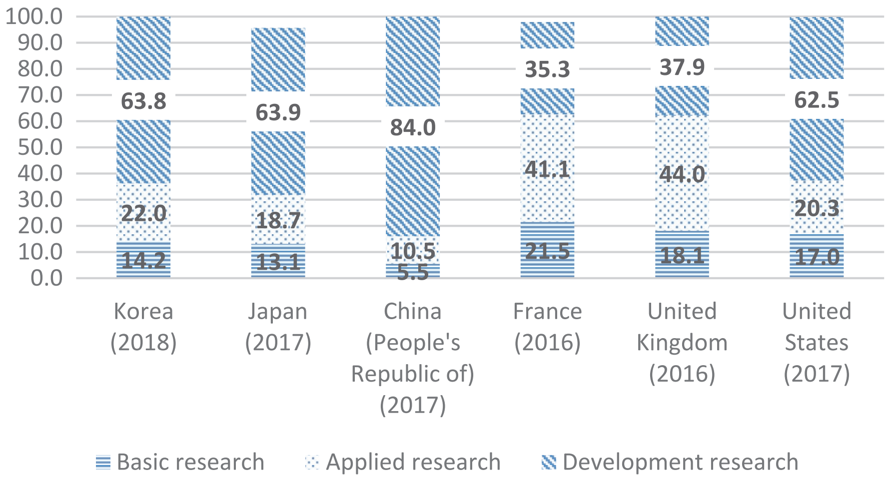

Fig. 9.4 Percentage of GERD by type of R&D. (Source: Data taken from OECD.Stat Database, 2019)

Table 9.2 The top 10 countries in terms of SCI publications and Korea's SCI publication trend (2017–2018)

Rank	Country	No. of SCI in 2017 (A)	No. of SCI in 2018 (B)	Growth rate (%)	Global share of SCI (%)
1	USA	460,899	450,352	−2.29	17.82
2	China	348,022	397,717	14.28	15.73
3	UK	145,209	141,426	−2.61	5.59
4	Germany	122,249	121,119	−0.92	4.79
5	Japan	84,762	84,689	−0.09	3.35
6	France	82,541	80,453	−2.53	3.18
7	Canada	78,130	77,903	−0.29	3.08
8	Italy	76,524	77,451	1.21	3.06
9	India	73,880	77,146	4.42	3.05
10	Australia	74,533	75,218	0.92	2.98
12	Korea	61,172	63,311	3.50	2.50

Source: KISTEP and KAIST (2019)
Note: SCI growth rate = {(B − A)/A}*100

higher education sector. The share of R&D expenditure used by businesses in Korea was higher than those in major countries, such as the USA (72.58%) and the European Union (28 countries; 66.28%). On the other hand, the proportion of R&D expenditure used by universities in Korea was 8.22%, which was lower than those of major countries except for China (7.41%).

As shown in Fig. 9.4, Korea, Japan, China, and the USA produce high proportions of development research, while France and the UK produce high proportions of basic and applied research.

Table 9.2 shows the top 10 countries in terms of SCI publications as well as Korea's SCI publication trend. Korea has published 63,311 SCI publications as of 2018 (a 3.5% increase from 2017), maintaining its previous year's ranking of 12th place. Four of the top 10 countries (China, Italy, India, and Australia) saw their SCI publication numbers increase year on year, while the remaining six countries (the USA, the UK, Germany, Japan, France, and Canada) saw their numbers decline. In particular, the number of SCI publications in China increased significantly (14.3%).

Table 9.3 Total number of higher education institutions in Korea (1980–2019)

Year	Total	University	Graduate school		Junior college	Others
			Type A	Type B		
1980	237	85	–	121	128	24
1990	265	107	–	298	117	41
1995	327	131	–	421	145	51
2000	372	161	17	812	158	36
2005	419	173	34	1017	158	54
2010	411	179	40	1098	145	47
2011	432	183	41	1126	147	61
2012	430	189	43	1134	142	56
2013	431	188	43	1157	140	60
2014	431	189	44	1165	139	59
2015	431	189	47	1150	138	57
2016	430	189	46	1149	138	57
2017	430	189	46	1153	138	57
2018	430	191	45	1153	137	57
2019	430	191	45	1138	137	57

Source: MOE and KESS (2019)

Note: (1) Type A graduate schools are higher education institutions that only operate graduate programs independently. Type B graduate schools are affiliated with universities; (2) Type B graduate schools were not included in the total numbers of higher education institutions

Higher Education in the National Research System

Expansion of Higher Education in South Korea

Over the past 40 years, the scale of higher education in Korea has expanded quantitatively. For both universities and graduate schools, the period from the 1990s to the present day has been regarded as a period of quantitative expansion fostering high-quality professionals. The number of universities expanded following the Kim Young-Sam administration's 5.31 Education Reform in 1995, more than doubling from just 85 in 1980 to 179 in 2000. As of 2019, the number of universities in Korea was 191, including 35 national and public universities and 156 private universities. The number of graduate schools in Korea was just 121 in 1980; however, this number rapidly increased until 2010 and then began to decrease in 2014; as of 2019, the total number of graduate schools was 1183 (MOE & KESS, 2019) (Table 9.3).

In 2019, national and public universities accounted for 18.3% of all universities; 81.7% of universities were private (MOE & KESS, 2019). Such a high proportion of private universities is a major characteristic of higher education in Korea. This is because the people's educational needs have historically relied heavily on private schools due to the poorness of the national budget, which resulted from the liberation of Japanese colonial rule from 1910 to 1945 and the 1950 to 1953 Korean War. Kim (1989) claimed that this can be explained by two factors: (1) the practice of paying the costs of education to parents under the *benefit principle* and (2) a private school promotion policy that entrusts the private sector with the costs of establishing and managing schools. It would be no exaggeration to say that the expansion of

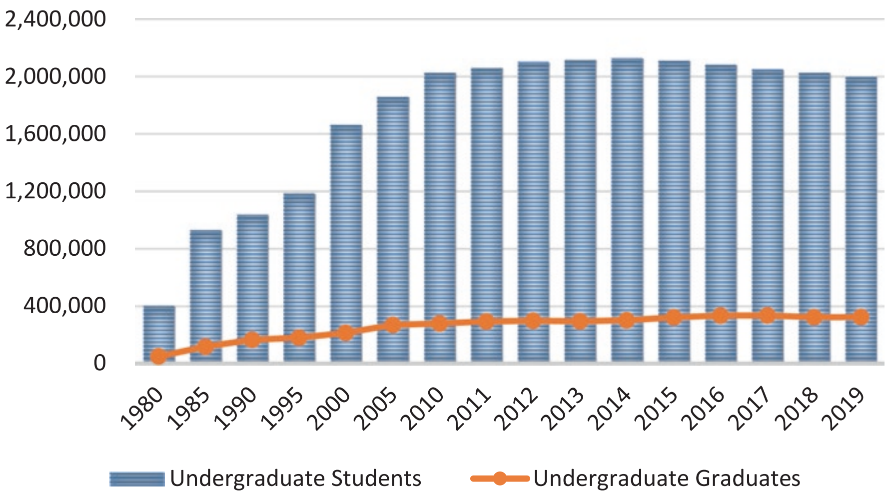

Fig. 9.5 Increase in the numbers of undergraduate students and graduates (1980–2019). (Source: MOE & KESS, 2019)

higher education in Korea was led by private universities. However, the establishment and operation of universities was thoroughly managed by the government, and private universities were operated like semi-public universities until the 1990s.

Compared to 40 years ago, higher education in Korea has become more focused on building a foundation to facilitate college enrollment; this has fostered and contributed to the expansion of human capital, which will allow for higher education institutions to improve national development and competitiveness. The number of students in bachelor's programs, which was only 402,979 in 1980, exceeded one million in 1990 and two million in 2010. The largest number of bachelor's students was 2,130,046 in 2014; this figure gradually decreased to 2,001,643 students in 2019. In 2019, the total number of university students was 461,937 at national and public universities and 1,539,706 at private universities; thus, private universities accounted for 76.9% of all university education in Korea.

The number of students in Korea increased between 1980 and 2005, but this growth began to slow due to the government's strengthening regulations on universities and a decrease in the school-age population. The number of undergraduate graduates rose from 49,735 in 1980 to 214,498 in 2000 (exceeding 200,000); since 2014, this number has remained over 300,000 (Fig. 9.5).

Similarly, the number of graduate students changed as the number of graduate schools increased. The rapid increase in the total number of graduate students between 1995 and 2005 can be attributed to the increasing demand for high-quality human resources as well as the popularization and generalization of higher education that occurred as a knowledge-based society began to develop after the 2000s.

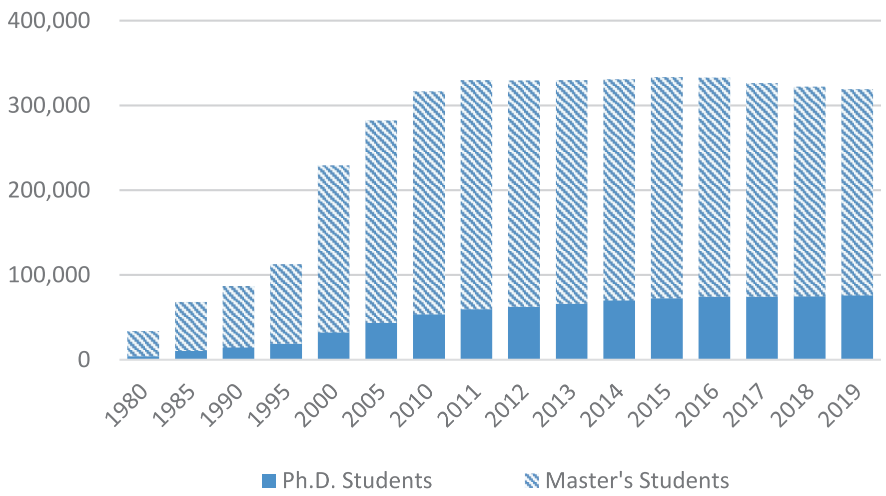

Fig. 9.6 Increase in the numbers of doctoral and master's students (1980–2019). (Source: MOE & KESS, 2019)

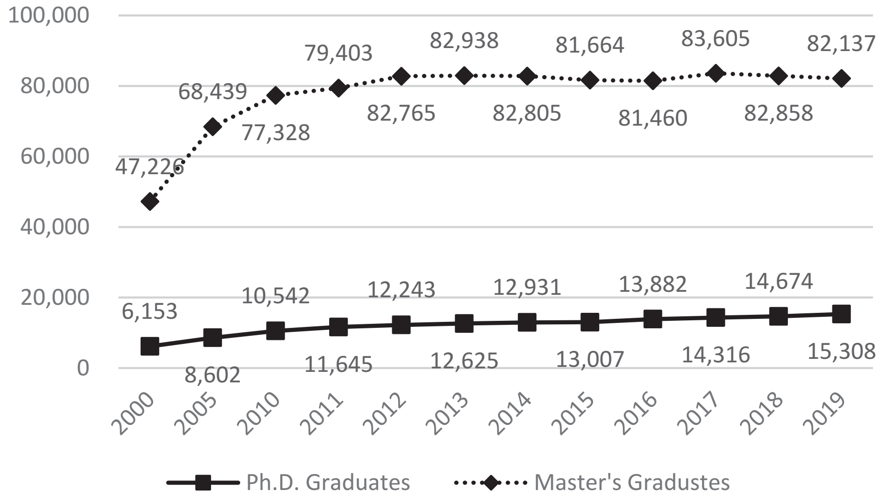

Fig. 9.7 Increase in the numbers of doctoral and master's degree holders (2000–2019). (Source: MOE & KESS, 2019)

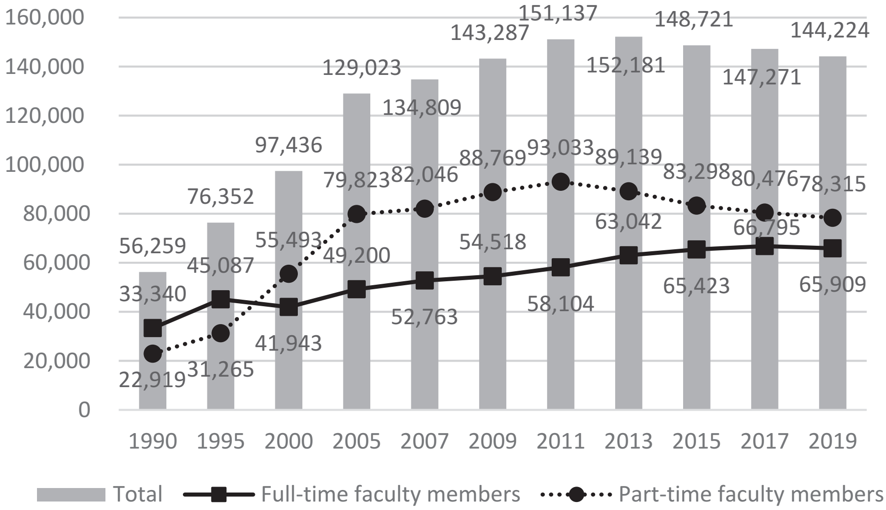

Fig. 9.8 Change in the numbers of faculty members (1990–2019). (Source: MOE & KEDI, 2019)

The Korean government has begun to expand investment in graduate school education to improve the research competitiveness and productivity of universities. Over the past 50 years, the number of graduate students in Korea has increased nearly 50 times over (from 6640 in 1970 to 319,240 in 2019). As a result, Korea has the largest number of graduate students per 1000 population members, among the major developed countries (Korea 5.3 persons, the USA 3.8 persons, France 2.5 persons, and Japan 1.6 persons; Lim & Shin, 2018).

The number of students in Korean master's degree programs began to steadily increase after 1980 but has decreased since 2011; as of 2019, this figure was 243,298. The number of students in Korean doctoral degree programs has increased steadily from 4038 in 1980 to 75,942 in 2019 (nearly 19 times over). Furthermore, the admission rate for doctoral programs in Korea was 3.4% in 2019, which is higher than the OECD average (2.3%; OECD, 2019) (Fig. 9.6).

As of 2019, of all graduate degree holders in Korea, 82,137 had master's degrees and 15,308 had doctoral degrees. Of the master's degree holders, 31,580 (38.4%) earned their master's degrees at general graduate schools and 50,557 (61.6%) earned their master's degrees at professional graduate schools. Of the doctoral degree holders, 14,028 earned their doctoral degrees at general graduate schools, accounting for 91.6% of all doctorate holders (Fig. 9.7).

As shown in Fig. 9.8, the total number of Korean university faculty members gradually increased from 76,352 in 1995 to a high point of 152,181 in 2013 (nearly doubled). Then, this value began to decline, decreasing to 144,224 in 2019. The number of full-time faculty members doubled from 33,340 in 1990 to 66,863 in 2018, but reduced to 65,909 in 2019, down 954 (1.4%) on the previous year. On the other hand, the number of part-time faculty members, including part-time lecturers and adjunct professors, increased 3.5 times over, from 22,919 in 1990 to 79,823 in 2005; this value peaked at 94,423 in 2012 before declining to 78,315 in 2019, down 3638 (4.4%) from the previous year.

The proportion of full-time faculty with doctoral degrees increased from only 48.5% in 1990 to more than 80% in the 2000s. In 2019, 89.7% of full-time faculty members (approximately nine out of ten) held doctoral degrees. This high proportion of full-time faculty with doctorate degrees indicates expansion in the emphasis on the research functions of universities and the role of higher education institutions in national R&D.

Meanwhile, Korean higher education faces many structural issues. Korea is no exception to the population decline caused by the low birthrate, and universities are having difficulty recruiting students and reducing budgets due to a decrease in the number of school-age students. To cope with the university crisis caused by this drop in the school-age population, the South Korean government has set up a *university restructuring plan* to reduce the enrollment quota of newly admitted university students by 160,000 over a decade. Through the first evaluation cycle in 2015, the government forced universities with low evaluation grades to reduce their enrollment quotas and succeeded in reducing the enrollment quota by approximately 46,000 over the next 3 years. However, this reduction in the quotas of nonviable universities resulted in a deepening financial crisis for universities.

In order to overcome the shortage of admission resources due to low birth rates, Korea actively started recruiting foreign students in the early 2000s and is still making various efforts to attract more foreign students to Korean campuses. The number of international students in Korea increased nearly 13 times over from 12,314 in 2003 to 160,165 in 2019 (MOE, 2019b). However, the trend of international students entering Korea has recently changed. While the number of students seeking postgraduate degrees is steadily increasing, the number of students enrolled in undergraduate programs is stagnant and has been declining for several years in some areas (Byun & Jung, 2019). Chinese students have traditionally made up the majority of students in Korea, but this proportion decreased from 55.1% in 2017 to 44.4% in 2019, whereas the proportion of students from Southeast Asian countries is growing (MOE, 2019b).

The Role of Higher Education in the National Research System

Universities play a crucial role as producers and disseminators of knowledge as well as human resources training. Traditionally, universities have placed the highest importance on teaching. The primary goals of universities are to educate students so that they may better understand their world creatively and constructively (Gutmann, 2015) and to prepare students to be productive, high-demand workers in the labor market (Samil, 2009). As university research performance is considered an important determinant of national competitiveness (Lee & Jung, 2018; Shin & Lee, 2015), university research is gaining an increasingly important role in the national research system. For example, Korea has maintained intensive financial investments to promote university research and improve the international status of higher education systems through policies such as the BK21 Project (1999–present) and the World-Class University Project (2008–2012), which merged with the BK21 Project in 2013 (Byun et al., 2013; Shin & Lee, 2015).

The launch of the BK21 Project in 1999 could be seen as the Korean government's most active financial investment. The fourth stage of the BK21 Project has continued as of 2020. This long-term project is the biggest financial support program for higher education conducted by the Korean government with the main purpose of improving the research capabilities of universities and establishing the global standing of Korean graduate education (Lim & Shin, 2018). Many studies have shown that the research productivity of Korean universities has increased significantly since the introduction of the BK21 Project (e.g., Shin, 2009).

According to the Korean National Research Foundation (NRF, 2016, 2019), the total number of papers published by Korean universities increased slightly from 64,181 in 2011 to 67,435 in 2018. On the other hand, the number of SCI/SSCI (Social Sciences Citation Index) papers increased by 33.5%, from 20,927 in 2011 to 27,941 in 2018. In particular, the top 20 universities in terms of journal article publication performance in 2018 account for 41.8% of all journal publications. The overall academic journal publication performance of full-time faculty did not

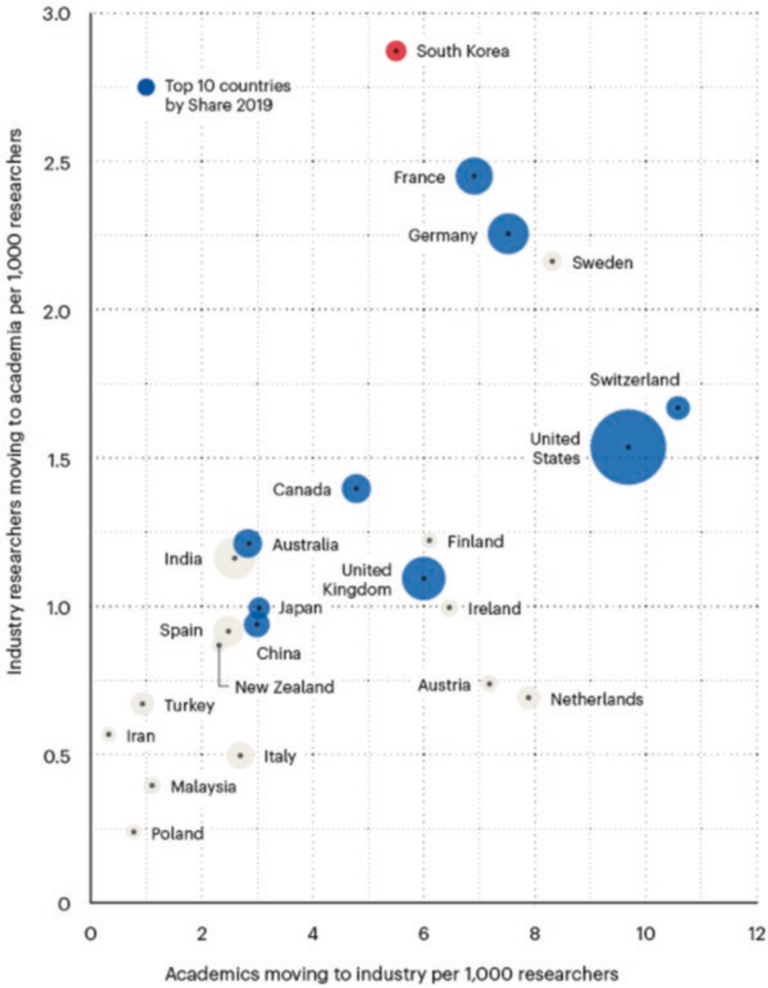

Fig. 9.9 Cross-sectoral moves between industry and academia per 1000 researchers in 2017–2019 for the top 10 countries. Note: Bubbles are sized according to research scale, a function of the number of research institutions in each country covered by the dataset. (Source: Dayton, 2020)

increase significantly, but the proportion of SCI/SSCI papers continued to increase from 32.6% in 2011 to 41.4% in 2018.

Research at Korean universities has developed mainly due to the government's R&D support; as a result, Korean universities have begun to respond strategically to their competition to secure government funding for research. In addition, Korean universities are in the process of establishing various types of research and commercialization systems, such as partnerships between universities and industries, profit generation from spin-off companies, and in-college laboratories and research centers. Close partnerships between universities and industries have been strongly encouraged by government policies such as NURI Project, LINC Project, and the Program for Industrial Needs-Matched Education (PRIME) Project (Lee, 2019). Universities have established legal foundation for commercialization of academic knowledge and university–industry cooperation since 2003. The Industry–Academic Cooperation Foundation plays a role as an independent corporate body within universities to support external and internal activities of university–industry linkages such as patenting, spin-offs, external research fund management, and so on (Lee, 2019).

Figure 9.9 presents cross-sectoral moves between industry and academia per 1000 researchers in 2017–2019 for the top 10 countries by Share in the Nature Index.[1] Dayton (2020) pointed out that "South Korea is a global outlier for its high proportion of researchers moving from industry to academia." Through the spillover from the private companies to universities, partnerships between universities and industries have been improved in South Korea.

The number of university-affiliated research institutes increased by 12.5%, from 4528 in 2014 to 5092 in 2018 (NRF, 2019). Accordingly, the number of full-time researchers associated with university-affiliated research institutes increased by 36.8%, from 2794 in 2014 to 3822 in 2018. International academic conferences and academic events are mainly held by university-affiliated research institutes, and universities play a key role in research cooperation through these events.

The number of patent applications and registrations made by Korean universities has increased over the past 5 years (NRF, 2017). Specifically, the number of overseas patent applications has increased from 2664 in 2012 to 3553 in 2016 (33.4% increase), and the number of overseas patent registrations has increased from 807 in 2012 to 1520 in 2016 (88.4% increase). The top 10 universities in terms of patent holdings have higher proportions of overseas patents than domestic patents, and overseas patent registrations account for 68.4% of all university patent holdings. The sector in which the most patents have been applied for is the IT sector, for which the average number of full-time faculty applications for patents has continued to increase each year.

The number of technology transfers from universities has increased each year to 4744 in 2016, and the rate of R&D investment cost recovery from companies through technology transfers has steadily increased (NRF, 2017). Technology transfers mainly target small- and medium-sized enterprises (90.9%), with the IT sector accounting for the largest targeted proportion.

In summary, the role of higher education in the national research system in South Korea is an educator to prepare students to be productive, high-demand workers in the labor market, and a generator of scientific and technological innovation, and a collaborator with industries.

[1] The *Nature Index* is a database of author affiliation information collated from research articles published in an independently selected group of 82 high-quality science journals. For further details, see https://www.nature.com/articles/d41586-020-02580-2

Concluding Remarks

Korea's national research system was developed as part of its economic development plans. Due to a lack of resources, Korea strategically selected a few areas and prioritized resource allocation to these areas at an early stage of development (Lee & Jung, 2018). In the initial stage, national research institutes played a major role in importing new technologies from abroad and transferring new technologies to private enterprises during the 1960s and 1970s. However, due to extreme inflation and vulnerability to changes in the global trade environment, the Korean government changed its economic operating system under the initiative of the private sector. In the 1980s, the Korean economy shifted to one based on technologies, such as automobiles and semiconductors. Since the 1990s, the Korean government has supported university research, and the role of universities in the national research system has become increasingly important. The role of universities as the main disseminators of knowledge in society has intensified, and they have become more diverse in terms of cultivating talented personnel, conducting research, and collaborating with industries. In Korea, university research has developed under government-driven policies based on national economic perspectives. Korean university research has developed quickly since the mid-1990s and has primarily emphasized research outputs and academic commercialization (Lee, 2019). As a result, Korea ranked 12th in terms of SCI publications in 2018 (KISTEP·& KAIST, 2019). The proportion of university research that is applied or developed is relatively higher in Korea than in other countries, and the number of patent applications and registrations by Korean universities has increased (NRF, 2017).

The success of Korea's economic growth and scientific development might have resulted from Korea's sociocultural context combined with Confucianism, capitalism, and enthusiasm for higher education. However, the history of the development of university research and teaching in Korea is relatively short and has occurred under government-led R&D policies based on a nationalistic scientific view. The role of universities in the national research system is still ambiguous and limited in scope. Research and teaching activities at Korean universities have grown significantly in quantity but are still lacking in quality compared to those of world-class universities. As a next step, we must enhance university research culture and quality and expand the route to R&D innovation by utilizing university research and teaching competitiveness.

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Soo Jeung Lee is Assistant Professor in the Department of Education, Sejong University. She was awarded a research fellowship of the Alexander von Humboldt Foundation in 2014 and joined INCHER-Kassel during 2015-2017. She studied higher education and received a Ph.D. from Seoul National University in 2014. Her research interests are research performance and knowledge transfer, the academic profession, the university and the labor market, and higher education research and policy. She has published in international journals such as *Higher Education, Studies in Higher Education*, *Journal of Technology Transfer,* and *Scientometrics*.

Hyejoo Jung is a lecturer in the Department of Education, Seoul National University. She studied Higher Education and received her Ph.D. from Seoul National University in 2020. Her research interests are concerned with academics in formative career stages and comparative study of higher education in East Asia.

Chapter 10
Recent Science and Technology Policies in Turkey: The Shifting Role and Profile of the National Higher Education System

Baris Uslu, Alper Calikoglu, Fatma Nevra Seggie, Sedat Gumus, and Yasar Kondakci

Abstract As the 17th biggest economy in 2018, Turkey is one of the emerging countries in the global economy. Turkey recently released an ambitious vision of becoming one of the top ten economies in the world in its centenary date, 2023, which urges a transformation of economic structures in the country. Hence, the government has introduced several change interventions to reinforce the capacity of its higher education (HE) system, widen its science and technology capacity, and tie its science and technology policies to HE. As part of these initiatives, Turkey has increased the number of universities, introduced the research university framework, and widened the Technopark policy. Although these policy interventions have contributed to Turkey's progress toward its vision in science and technology, there is a

B. Uslu (✉)
Department of Educational Sciences, Faculty of Education, Canakkale Onsekiz Mart University, Canakkale, Turkey
e-mail: barisuslu@comu.edu.tr

A. Calikoglu
Department of ICT Education, IMKB Vocational School, Ministry of National Education, Canakkale, Turkey

F. N. Seggie
Department of Educational Sciences, Faculty of Education, Bogazici University, Istanbul, Turkey
e-mail: nevra.seggie@boun.edu.tr

S. Gumus
Department of Educational Sociology, Danish School of Education, Aarhus University, Aarhus, Denmark
e-mail: sgumus@edu.au.dk

Y. Kondakci
Department of Educational Sciences, Faculty of Education, Middle East Technical University, Ankara, Turkey
e-mail: kyasar@metu.edu.tr

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considerable gap between its progress and the targeted accomplishments. Rather than quantitative expansion of HE system, the main concern remained around the quality of the outcomes in HE and the effectiveness of science and technology policies in accomplishing Turkey's 2023 vision. Based on this concern, this paper aims at discussing the underlying reasons behind the gap between its targets and realized accomplishments in science and technology policies and related these reasons to Turkey's HE policy.

Keywords Knowledge society · National innovation ecosystem · Science and technology policy · Higher education system · Scientific production

Introduction

The economic growth of countries is closely related to their policies in the interrelated domains of science and technology and higher education (HE). There is a close relationship between countries' science and technology development policies on the one hand and their HE policies on the other. Countries determine the direction and pace of their scientific and technological developments with various policy tools in these two domains. However, it is important to acknowledge the fact that the strength of the ties between science and technology development and HE policies differs from one country context to another. In some countries, innovation and advancements in science and technology largely rely on public investments, while in many others, the private firms act as the main player in knowledge and technology production.

Economic growth theories provide insights on the contribution of the scientific and technological development policies on the developmental level of countries. There are two broad theoretical explanations for economic growth; the neoclassical and evolutionary perspectives (Nelson & Winter, 1974). The neoclassical approach asserts that science and technology policies push the firms to a hypothetical point of optimal research and development (R&D) investment, whereas the evolutionary perspective asserts that science and technology policies are applied to each firm on an individualized understanding (Akçomak, 2016). Akçomak (2016) stated that around the world the contemporary science and technology polices are a hybrid form of these two main approaches; however, in Turkey, R&D support policies are largely informed by the neoclassical economic theory. Akçomak (2016) indicated that the neoclassical economic theory asserts that the state develops a science and research policy in which the state tries to ensure its active involvement in regulating the market to eliminate the risk of the market failure together with an equal distribution of resources among the units, firms in this case, and develops tools such as R&D supports and loans. In contrast, the evolutionary economic approach to science and technology is largely based on building systems and networks of innovation, trying to eliminate the systemic failure (rather than the market failure), building an innovation policy, following distinguished policies for selected sectors, applying contingent support systems, and promoting knowledge circulation to facilitate innovation policies. The neoclassical innovation policies toward creating a knowledge-based economy in Turkey have accelerated the evolution of the university-industry relationship.

Turkey has set ambitious goals for its economy in 2023, its centenary date, which have pushed the country to increase investments in different sectoral domains, including HE (details are presented in the following sections). However, the competitive economies around the world have changed their structures. Parallel to this shift in different countries, Turkey has also been trying to change the structure of its economy from agricultural or service sector dominated to knowledge based, which has the capacity to produce high-tech goods. Despite the fact that Turkey is not among the first rank countries in transforming their economies into knowledge-based economies, a comprehensive report affirmed that it has been in transition from a traditional production base to a knowledge base (The World Bank, 2004). The concern to transform the economy re-shapes the size and direction of investments to science and technology in Turkey (Anlağan, 2009). After World War II (WWII), both the United States of America (USA) and Europe were able to generate their own dynamism driving their scientific and technological development. For example, the space race between the USA and the Union of Soviet Socialist Republics (USSR) and the concern to recover from the destruction of the WWII in Europe led these countries to invest in technology (Yılık, 2018). However, Turkey has largely comforted itself with transferring the technology and knowledge created from other countries until very recently. As a result, Turkey has acted retroactively in science and technology development. Nevertheless, new political and economic challenges have been pushing Turkey to follow fundamentally different orientations in science and technology.

Given the general understanding of the policies for science, technology, and innovation in Turkey, it can be argued that the Turkish scientific and technological development movement exhibits several characteristics which are peculiar to its own context. The first characteristic is that, unlike the case of many developed countries, in Turkey science, technology, and innovation are largely aligned with its HE. As a result, the state has an active role in determining the size and direction of scientific and technological developments in Turkey. The state-dominated scientific and technological development policies can be illustrated with the relatively recent policy of Technology Development Zones (TDZs) (or technoparks) in Turkey. The state has been implementing a protectionist TDZ policy at both public and foundation[1] universities for accomplishing knowledge, technology, and innovation development. TDZs prove that in Turkey the basic innovation and knowledge-based society largely relies on public investments. Yılık (2018) argued that the over-reliance on public investment in science, technology, and innovation is related

[1] Foundation universities in Turkey are non-public higher education institutions which are established by non-profit foundations. While public universities are free for students, these universities charge tuition fees for their programs.

to the dominant business culture. In the USA, business culture is totally based on the free enterprise logic, while in Turkey, it is more regulated by etatist logic. Public funding schemes, tax waivers, subsidies, and flexibility toward employment of academics in public universities show the prevalence of the state-regulated knowledge and technology policies.

The second characteristic that describes the Turkish scientific and technological development movement is that key concepts built around neoliberal movements such as academic capitalism, new managerialism, and the entrepreneurial university have been developing at a slower pace compared to many other countries. Several authors acknowledged the slow response of Turkey to neoliberal pressures and restructuring the HE system (Çetinsaya, 2014; Erdoğan, 2014). However, recently, the Turkish HE system has reached a critical mass. The number of both public and foundation universities has been increased to a capacity level of responding to demand in the country (Gür et al., 2018). Particularly the increase in the number of foundation universities can be an example to the beneficiary-pay (the students themselves) logic in the country. As a result, key characteristics of neoliberal movements in HE around the world have started to be observed in Turkey as well. The neoliberal movements in HE in Turkey are partly related to the concern of using the full potential of the universities for scientific and technological development in the country. The neoliberal movements impacted the relationship between HE and industrialization in Turkey. However, the impact has been moderate and at a slow pace. As a result, universities were placed at the center of knowledge and technology production in the economy. However, the entrepreneurial university concept entered into Turkish HE along with the movement toward adopting an entrepreneurial mindset, which affects the management and governance modes as well as core values, has affected the Turkish HE.

It is evident that these developments in science and technology put several challenges on HE in Turkey with some specific implications on the academic profession. Therefore, academics have also come to play a critical role in the innovation of knowledge and scientific developments in the country. Parallel to the developments in the university-industry relationship, the role and status of academics have been redefined as well. The academics' performance is under more scrutiny and marketplace logic has more regulatory power over the role and status of academics. More importantly, the performance of academics is subjected to measures developed according to market logic. Although the dominance of the state is still very evident on HEIs, academics are now being pushed to perform according to certain predefined goals, and new measures are developed to install performance-based remuneration for the first time (more details are provided in the following sections).

National Investment for Knowledge-Based Development

The 2023 vision of Turkey, becoming one of the top ten economies in the world, has been emphasized many times in national policy documents of science, technology, and economy. In the policy document of National Science, Technology, and

Innovation Strategy 2011–2016, the Scientific and Technological Research Council of Turkey (TÜBİTAK[2]) clearly highlighted the requirement of national investment to expedite the constitution of knowledge-society structure and to empower the knowledge-based economic growth (TÜBİTAK, 2010, p. 7). In this respect, the amount of the R&D spending and its percentage within the gross domestic product (GDP) can give fundamental clues about the innovative potential of Turkey (Fig. 10.1).

As can be seen in Fig. 10.1, in Turkey, the R&D investment ratio in its GDP has been tripled over the last 25 years. The tripled ratio actually indicates ten times larger R&D budget in 2017 ($8.16 billion) than in 1993 ($0.81 billion). This is a highly remarkable achievement to empower the innovation capacity of Turkey during the last quarter century. However, reaching the national 2023 vision is dependent on not only the R&D spending in Turkey but also the R&D growth of potential competitors. Therefore, it is important to analyze the R&D spending in other countries to evaluate the R&D investment performance of Turkey within the global perspective (Fig. 10.2).

The comparison in Fig. 10.2 shows that Turkey's R&D investment ratio in 2016 (0.945% of its GDP) is less than half of the average *gross domestic spending ratio on R&D* in OECD (2.337%) and European countries – EU28 (1.935%). When we compare the Netherlands (18th biggest economy in 2016) and Turkey (17th biggest in 2016), considering their GDP similarity in respect to the data announced by the World Bank (2018), the Netherlands spent $15.8 billion in R&D, while Turkey

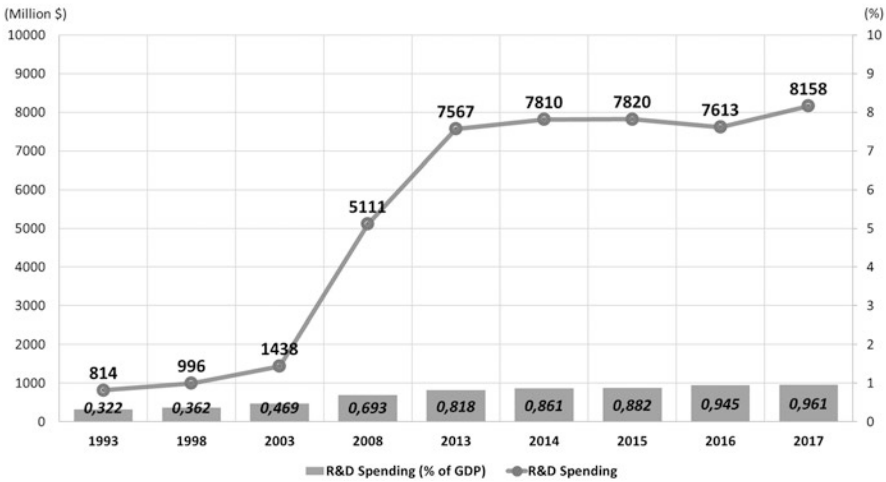
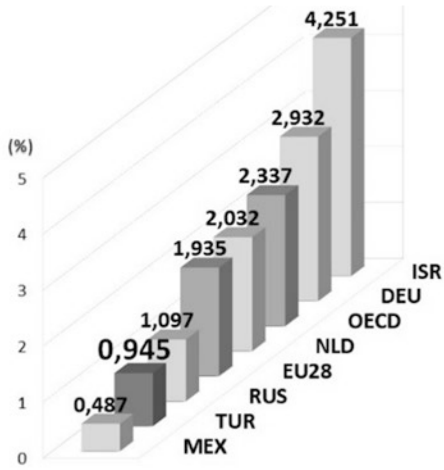


Fig. 10.1 R&D spending in Turkey and its percentage of GDP (* GDP amounts here were converted to US $ using yearly average currency rates of Turkish Central Bank (TCMB, 2018), for example, (3.54 TL + 3.78 TL)/2 = 3.66 TL for 1 $ in 2017) – 1993–2017. (TurkStat, 2018)

[2] TÜBİTAK is a national public agency governed by a Science Board. It aims to develop science, technology, and innovation policies and support research and development in both public and private sectors.

Fig. 10.2 The comparison of R&D spending percentage within 2016 GDPs (OECD, 2018)



invested \$8.2 billion in R&D in 2016. If we take the population and geographic proximity into account, it might also be meaningful to compare Turkey with Germany. Germany invested 12 times more in R&D (\$102 billion) than Turkey in 2016. With its relatively small population, Israel also spent \$13.5 billion for its R&D operations (\$5.3 billion more than Turkey's) in 2016. Considering similar economic growth rates, Russia, a member of BRICS[3] countries, spent roughly \$6 billion more for R&D growth than Turkey in 2016. Among OECD countries, Turkey's R&D spending was only higher than Mexico (\$5.2 billion) in 2016.

Although Turkey had a higher spending than Mexico (the 15th biggest economy in 2016 and 2017), its R&D investment is still far behind the top ten economies in the world. Thus, Turkey obviously needs to ensure a significant rise in its R&D spending for the remaining 4 years to be able to still pursue its national 2023 vision. Further, as Göçer (2013) highlighted, the sectoral distribution of R&D investment and their contribution to the national performance of knowledge and technology production gain much more importance in terms of the effective use of Turkey's R&D budget (Table 10.1).

In many parts of the world, national governments tend to increase the financial support for scientific research through research council structures (e.g., Deutsche Forschungsgemeinschaft [DFG] in Germany, National Research Council [NRC] in Canada, or National Research Foundation [NRF] in South Korea). Similarly, the Turkish government has provided certain amount of financial support to academic projects (Table 10.1) via selective funds of TÜBİTAK. Turkish HEIs also reserve some amount of their budget to operate their internal research funds. However, according to the report of Outlook on HE in Turkey 2017 (Gür et al., 2018), almost 65% of the budget in a public university has been spent for personnel salaries and

[3] BRICS indicates the associative formation of emerging economies in Brazil, Russia, India, China, and South Africa.

Table 10.1 Sectoral distribution of R&D spending and the scientific publication and patent performance of Turkey – 1998–2017

Year	Project Support (MM $)	HE budget (MM $)	R&D spending (MM $) by			Pub.(s)	Int. Pat.(s)	Nat. pat.(s)
			HEI(s)	Corp.(s)	Gov.in.(s)			
1998	49.78	1620	609	314	73	6653	403	371
2003	13.74	2190	953	334	150	15,244	880	300
2008	423.39	5426	2240	2261	611	26,021	4520	349
2013	294.36	7782	3185	3594	789	39,798	7814	1111
2014	325.73	7517	3165	3887	757	40,759	7349	1181
2015	331.16	7015	3101	3911	808	43,780	8596	1504
2016	249.65	7289	2763	4128	722	45,595	9447	1627
2017	252.36	7001	2737	4640	781	42,405	10,664	1760

This table combines the data of TÜBİTAK (2018) for academic project support, Ministry of National Education (MoNE, 2018) for HE budget, TurkStat (2018)for R&D spending by sectors (i. HEIs, ii. corporations [Corp.(s)], and iii. governmental institutions [Gov.In.(s)]), SCImago (2018) for the number of scientific publications [Pub.(s)], and Turkey Patent Office (TÜRKPATENT, 2018) and World Intellectual Property Organization (WIPO, 2018) for the number of internationally granted patents [Int. Pat.(s)] and nationally granted patents [Nat.Pat.(s)]. The amount of US $ here was converted by using yearly average currency rate of Turkish Central Bank (TCMB, 2018)

social security payments. As Uslu (2017) explained, there has been no dedicated research budget, except for the maintenance cost of infra-/super-structure, especially in young universities established after 2005 policy of "at least one university in each city"[4] (Özoğlu et al., 2016). Further, there is an obvious decrease in HEIs' R&D expenditure since 2015 (Table 10.1) despite the continuous increase in HEIs budget (MoNE, 2018) and academic project support in Turkish Lira (TÜBİTAK, 2018).

On the other hand, R&D investment in private sector has steadily increased (even in US $) since 1998 and doubled in 2017, according to 2008 R&D spending of corporations (Table 10.1). The Turkish government has largely supported the R&D investment of the private sector by creating various support mechanisms such as land granting, interest-free credit, tax reduction, or some exemption in social security payment for personnel (Investment Office, 2018). The government has also provided support via TÜBİTAK for large projects in the industry/business sector. Furthermore, the Turkish government has directly invested in the R&D projects of public utilities connected to various ministries of the government, but this support has been stagnant and relatively small compared to corporations' R&D spending since 2013 (Table 10.1). The governmental (or half governmentally dependent) institutions largely work on national high-tech projects. For example, ASELSAN, a partner of the Turkish military, has been supported by the government since 1975 to develop various equipment from satellite to traffic automation system, or from radar systems to electro-optic systems (ASELSAN, 2008).

[4] Turkey had 77 universities in 2005, while 185 in 2017 (Gür et al., 2018).

When the outputs of the R&D investment in all three sectors (HEIs, corporations, and governmental institutions) are combined (Table 10.1), Turkey still lags behind its actual competitors on the road for 2023 national vision in terms of knowledge and technology production. For example, Turkey has published more than 40,000 scientific papers yearly since 2014 and placed in 19th position at the global publication league in 2017 (SCImago, 2018). When we focus on the produced scientific knowledge, however, Turkey fell wide of the mark, staying at the 167th position with 9.49 citations per document in the same year (SCImago, 2018). Turkey is also the 15th country on the 2018 global list of *highest combined shares of patents and scientific articles* (Dutta et al., 2018, p. 194), while it ranked 17th in terms of patent applications in 2017 (WIPO, 2018). The private sector was well ahead in 2017 in terms of their contribution to the patent performance of Turkey (WIPO, 2018). For example, as the Turkish industrial firm with the highest number of patent applications in 2017, Arçelik filed 237 patents (in Patent Cooperation Treaty (PCT) category), while Gebze Technical University, as the Turkish university having the highest number of patent applications, only filed 12 (WIPO, 2018). This outcome shows that the large portion of applied knowledge and technology production has been carried out by the private sector in Turkey.

Another important point to note here is the improvement of the university-industry-government collaboration. The Turkish government invested a relatively high amount of money ($37.77 million between 2011 and 2017) to support the industry-university linkage (TÜBİTAK, 2018). The government has especially prioritized the establishment of a TDZ (including technoparks around universities) in almost every city since the beginning of the 2000s. While Turkish universities have hosted many entrepreneur firms in their technoparks, they have only recently had the right to establish their own Technology Transfer Office (TTO), as in "capital corporation" status, since July 1, 2017 (Official Gazette, 2017).

On a different line of argument concerning technoparks, Başalp and Yazlık (2006) underline that the scarce support for entrepreneurs, especially academic entrepreneurs, limits the effectiveness of technoparks as well as TDZs in Turkey. While TÜBİTAK operates several funds for individual entrepreneurs, the maximum amount for such individuals is relatively quite low (e.g., 150,000 TL = $33,113 as a no return grant[5]) (TÜBİTAK, 2018). Academic entrepreneurs can only establish their own firms in technoparks, if they achieve to receive permission from their university governance (Official Gazette, 2001). Such academic entrepreneurs do not have the official permission to "buy out" of their workload, so they mostly tend to take minimum teaching responsibility (Lee & Rhoads, 2004). Considering their employer position, it will be better to develop various teaching policies to benefit their firms as practical training grounds for their students. Such policies can generate a medium for academics to share their experiences with students in their workplace while providing extra half-time employment or internship opportunities for students (Uslu & Çalıkoğlu, 2017).

[5] The average currency rate was 1 $ = 4.53 TL in 2018 (TCMB, 2018).

National Higher Education System: Quantitative and Qualitative Perspectives

Erdoğan (2014) highlighted the critical role of faculty population for the quality improvement in HE programs. Özer (2011) similarly underlined the high demand for new and well-qualified faculty to ensure the favorable ratio of students per faculty member, especially in new Turkish universities. In this respect, Table 10.2 shows the recent increase in the number of faculty members, especially at the professorship and newly appointed assistant professorship positions. However, due to the dramatic growth in student population, there was a continuous rise in student/faculty member ratio in Turkish universities until 2017, when the ratio was only 2 students lower per faculty member compared to 2016. To minimize the student/faculty member ratio in new universities, the Turkish government has recently established a new regulation that determines the maximum number of full-time faculty members that academic branches or departments can employ (Official Gazette, 2018a). With this regulation, in other words, limiting the number of faculty members in universities, we think that the government aims to channel young academics and researchers to take positions in new public universities. However, in this new

Table 10.2 Quantitative structure of Turkish HE system 1993–2017 (CoHE, 2018a)

Year	HEIs[a]	Stud.(s) (thousand)[b]	University teachers[c] (thousand)				Stud.(s) per uni. teacher	Stud.(s) per fac. member
			Prof.	Assoc. prof.	Assist. prof.	Lecturer		
1993	54	1120	5.4	3.4	4.8	10.3	47	82
1998	71	1450	7.7	4.3	8.1	15.2	41	72
2003	77	1940	10.7	5.1	13.3	19.5	40	67
2005	*77*	*2299*	*11.7*	*5.6*	*14.9*	*21.4*	*43*	*71*
2008	134	2880	13.5	7.2	18.3	24.2	46	74
2013	182	5620	20.0	12.8	31.3	34.1	57	88
2014	183	6060	20.9	14.1	33.3	35.1	59	89
2015	192	6690	22.4	15.0	35.3	36.0	62	92
2016	182	7200	22.5	14.2	34.7	35.0	68	101
2017	185	7560	24.6	14.4	37.5	35.5	68	99

CoHE is the abbreviation of the "Council of Higher Education [Yükseköğretim Kurulu in Turkish]." CoHE is an autonomous institution that supervises the higher education system in Turkey, and its main responsibilities include planning, coordination, and quality assurance of higher education institutions (http://www.yok.gov.tr/en/web/cohe/history)

[a]Includes public universities (112 in 2017) and (nonprofit) foundation universities (68 in 2017) and vocational schools (5 in 2017)

[b]Includes HE students registered in open/distance HE programs because there is no separable data before 2014. Excluding students in open/distance HE programs, the number of students was 3,387,682 in 2017 (while the ratio of students/university teacher was 34.71 and of students/faculty member was 50.82)

[c]"University teachers" indicate the academic personnel who teach classes; research assistants are excluded as they do not have the right to teach. In addition, "faculty" includes full, associate, and assistant professors

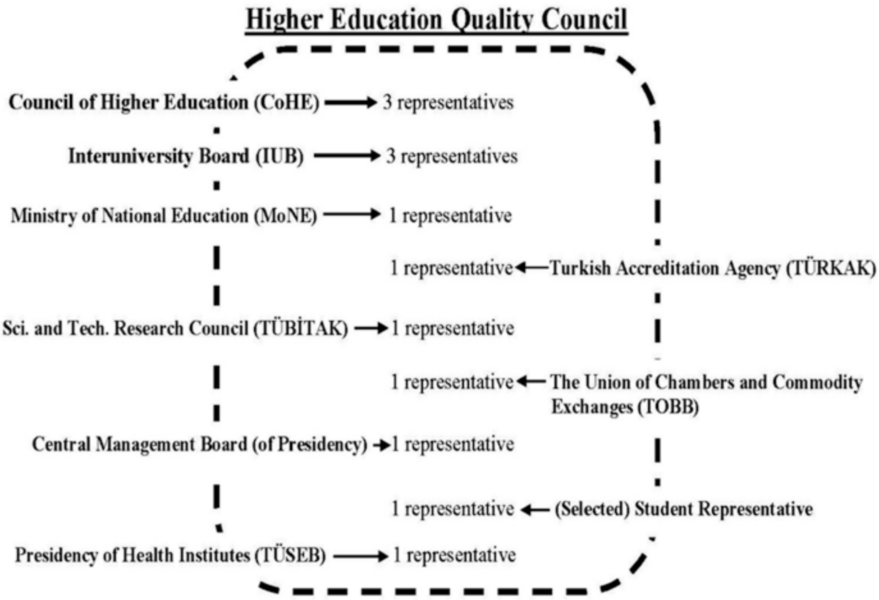


Fig. 10.3 The government body of HEQC (HEQC, 2020)

regulation, the limits are varied in terms of core unit – branch or department – depending on the disciplines; as an example, each branch of department of educational sciences in a faculty of education can employ at most six faculty members.

As another important attempt to oversee the quality development in universities, the Turkish government established the Higher Education Quality Council (HEQC) on July 23, 2015 (Fig. 10.3), and gave authority to this board to carry out independent evaluation on quality in universities (Official Gazette, 2015). HEQC first collected self-evaluation reports from both public and (nonprofit) foundation universities in the years of 2015 and 2016. HEQC has then visited universities to conduct their external evaluation on five topics, similar to the sections in institutional evaluation reports prepared by the European University Association (EUA): (i) Quality Assurance System, (ii) Management System and Institutional Decision Making, (iii) Teaching-Learning, (iv) Research and Development, and v) Social Contribution (or Service to Society) (Uslu, 2017, 2018).

PhD Education: Pursing R&D Employment or Academic Careers

It seems that training well-qualified PhD graduates as the next generation of academics or of R&D workers is another critical factor to enhance both the quality of the Turkish HE system and the capacity of the national innovation ecosystem.

Turkey is a full member of the European Higher Education Area (EHEA), and Turkish universities have organized their programs following a three-cycle structure (associate/bachelor, master, and PhD degrees) of the Bologna Processes since 2001 (EHEA, 2014).

In 2017, the Turkish government initiated the HE project of "Regional Development Focused Mission Differentiation and Specialization" and selected ten universities as research universities by considering their publication performance, citation ratios, project fund acquisition, the rate of doctoral graduates by total graduates, number of academic staff with awards, and patent applications (CoHE, 2017). Within this project, the government also selected five universities in 2017 and five more universities in 2018, assigning them to train human resources in various fields in line with the regional priorities (CoHE, 2018b). The government announced that they would provide extra support to these selected universities such as larger project budgets, more academic staff positions than the designated limits for others, and scholarships for the doctoral students in the assigned disciplines. These developments can be seen as important steps, since they are the very first examples of mission differentiation in the Turkish, HE system. TurkStat (2010) data revealed that 72.7% of PhD graduates were employed in the HE sector, 14.9% worked in the public sector, and 11.5% worked in the private sector. In addition, 60.6% of the PhD holders who participated in the research by TurkStat (2010) stated that they had worked as a lecturer or a research assistant during their PhD training.

Similar to the rest of the world, research assistantship and lectureship are the entry-level jobs in Turkish academia. The Turkish government also introduced for the first time postdoctoral researcher positions in 2017 (Official Gazette, 2017), which can also be considered as entry-level jobs. Including these entry-level positions, academics in each career step hold a public servant status and have job security if they work in Turkish public universities. When we consider the salary of these entry-level positions, lecturers, research assistants, and postdocs received around 60,000 TL[6] (roughly US$13,250)[7] per year after taxes in 2018. The salaries of the same positions, however, start from US$25,000 to US$35,000 after taxes in France, Germany, the UK, and the USA (Angermuller, 2017). While lecturers can individually prefer to continue PhD programs, research assistants must complete their PhD training.

Whether they have occupied lectureship or research assistantship positions or not, each PhD graduate has a right to apply to an assistant professorship position in Turkish universities (Official Gazette, 2018b). While universities can establish their own criteria for assistant professorship, some universities prefer to include the criterion of *at least one refereed-journal article based on PhD research* (CoHE, 2018c). "Üniversitelerarası Kurul (ÜAK) [the Interuniversity Board of Turkey (IUB)]" carries out national tenure review processes, and IUB[8] added the rule of at

[6] Salaries were calculated via http://memurlar.net which uses the official salary coefficients.

[7] Salaries were converted using the average currency rate for 2018: 1 $ = 4.53 TL (TCMB, 2018).

[8] "Interuniversity Board (UIB)" is responsible to administer the national tenure review process.

least one publication (book, chapter, or refereed-journal article) out of thesis studies as part of the tenure criteria in 2015 (Official Gazette, 2018c). Although IUB previously accepted only international book chapters and national/international journal articles for tenure applications, they expanded the tenure criteria adding citations, courses, graduate advisory, and projects with the latest regulation in 2015. Whether PhD graduates occupy an academic position or not, each PhD holder can apply to the national tenure if they have a certain level of foreign language test score and a high enough score on the tenure criteria. Continuing scientific production during 5 years after their associate professor title (not necessary to occupy associate professorship position in HEIs), academics can apply for promotion to full professorship (Official Gazette, 1981). Each university sets its own criteria for promotion to full professorship in line with the official acceptance of their senate. Therefore, unlike associate professorship where the title is earned through IUB and an official position given by a university, assistant and full professorship titles and official positions are dependent on the internal evaluation processes of the individual university in Turkey.

More recently, the Turkish government re-regulated the structure of academic positions on March 06, 2018 (Official Gazette, 2018b). This recent regulation brought changes to the Turkish name of assistant professorship (in Turkish, from the term “Yardımcı Doçent” to a new term “Doktor Öğretim Üyesi”) with a minor salary increase. If we examine the salary rates of faculty members, assistant professors received around 66,000 TL (roughly US$14,600), associate professors around 75,000 TL ($16,600), and full professors around 87,300 TL ($19,300) per year after taxes, in 2018. On the other hand, the salary for faculty members ranged from US$35,000 to US$200,000 in France, Germany, the UK, and the USA (Angermuller, 2017). Such a salary range in Turkey (US$13,250–19,300) is comparatively low to compete in the global academic market. Moreover, according to TurkStat (2010), PhD holders employed in R&D in the private sector earned up to four or five times higher salary than those employed in universities. Such a relatively lucrative salary range has led several PhD graduates, particularly from science and engineering fields, to prefer working in industry/business organizations. Against higher-income opportunities in the private sector, the Turkish government initiated the academic incentive program (in other words, a merit-pay system) in 2015 to attract high-caliber PhD graduates to university jobs. According to this regulation, academics can receive additional payment (maximum amount is roughly 10% of their basic salary) based on their publications, citations, projects, or performance achievements in the previous year (Akademik Teşvik, 2018). However, this incentive program has resulted in three outcomes: (i) an increase in the quantity of publications/projects, (ii) a decrease in the quality of publications/projects, and (iii) a tendency toward more unethical behaviors in Turkish academia (Ültay & Ültay, 2018). While several studies reported that pre- and post-period academic incentive payments show a significant increase in international publications from Turkey (Demir, 2018a; Yücel & Demir, 2018), such an increase was matched neither in the number of articles published in prestigious journals (Table 10.1) nor in the citation rates (SCImago, 2018).

With the initial effect of this academic incentive program in particular, Turkey became third in the list of countries which published most in predatory (in other words, suspicious or potentially fake) journals in 2017 (Demir, 2018b). CoHE has subsequently changed the regulation of academic incentive payments each year since 2016.

Concluding Remarks

Turkey has recently released an ambitious vision of becoming one of the top ten economies in the world by 2023. In order to achieve this vision, several policies have recently been initiated, especially in HE and other R&D sectors. These policies include increasing the number of HEIs, raising the R&D investment, and initiating structural changes in HE system. As a result of these policies, Turkey has increased the number of institutions and students at HE level and the number of publications and patents in the last decade. There are, however, concerns about the adequacy of these developments when we compare Turkey with peer countries (Gür et al., 2018). Qualitative improvements in the above-mentioned areas have matched quantitative achievements. Indeed, a recent global comparison of countries indicated both quantitative and qualitative gaps in science, technology, innovation, and HE in Turkey (Global Knowledge Index, 2018).

Existing data clearly shows that Turkey has made strides in the expansion of its R&D budget, especially in the last 15 years. It is, however, evident that Turkey's R&D investment is still far behind several, if not all, OECD and European countries in terms of its ratio to GDP. In addition, R&D expenditures of HEs (in $) have actually decreased in the last few years. On the other hand, R&D expenditures of private sector have grown rapidly and steadily. Altogether, despite the significant improvements in R&D expenditures in recent years, they do not seem to have been enough yet for Turkey to compete with other big economies in the world. Turkey still needs to further improve its innovation capacity on its way to the national 2023 vision.

In addition to quantitative changes in Turkey's R&D investments, there have also been several important structural changes in Turkey's HE system in the last decade. First of all, Turkey has significantly expanded its HE system in terms of both the numbers of institutions and students. Both the numbers of institutions and students more than doubled in just a decade. As expected, this rapid expansion created financial, infrastructural, and academic challenges for HEIs, especially for the newly established ones (Özoğlu et al., 2016). In addition, this expansion has resulted in a significant decrease in per student expenditure, putting Turkey far behind other OECD countries (CoHE, 2018a). Such consequences suggest that Turkey needs to allocate increased budgets to its HE institutions to ensure that the quantitative expansion in HE system does not negatively affect the quality of education and other services.

Besides the challenge of attracting high-skilled graduates to R&D sectors, rapid expansion in HE system in Turkey created a scarcity in the number of academics and significantly increased the numbers of faculty members per student in HE institutions. Related to this issue, a new regulation on the fixed number of faculty members in branches or departments was issued in 2018. This regulation might help to channel some young researchers from well-established old universities, which are generally in better positions in terms of meeting the needs of faculty members, to newly established universities. However, limiting the numbers of faculty members might also lead to a further increase in the ratio of students/faculty members in relatively crowded programs in some of the prestigious and older universities in Turkey in the coming years. It is also possible that some high-skilled researchers might move abroad because of this new policy if they cannot find higher level of positions in their current institutions.

Another recent significant change in Turkish HE system was the establishment of Higher Education Quality Council (HEQC) in 2015. First, CoHE operated the legal establishment of HEQC as a supporting unit and held the right of appointing 5 members among 21 representatives in HEQC (Official Gazette, 2015). This situation therefore raised questions about the autonomy of HEQC (Gümüş, 2018). In 2017, HEQC was redesigned with a bill passed by the parliament and became an independent governmental body (HEQC, 2020). Now, a board of 13 members, which are the representatives of different governmental and private bodies, governs HEQC (see Fig. 10.3).

In addition to the establishment of HEQC, mission differentiation of HE institutions was introduced to Turkish HE system for the first time in 2017, with the aim of increasing the research capacity and international competitiveness of Turkish HE institutions. As a result of this new policy, one could expect that universities selected for missions of research or regional development gain further popularity among students and might become a significant source of graduate education and research in the coming years. It is however not certain yet how the teaching and research processes in selected and other universities will change, if they will at all or what the exact criteria are to define a research university. Therefore, the government should make necessary amendments to clarify the ways in which research universities can be supported and actually be differentiated from other universities in practice.

All in all, as the 17th biggest economy in 2018 and as one of the emerging countries in the global economy, Turkey aims to become part of the top ten economies and thus a dominant figure in the knowledge society by 2023. Within the framework of neoclassical economy perspective, despite all the significant developments in the last one or two decades, it appears that there is still some considerable gap to close in order to reach the 2023 mission. In order to accomplish this aim, it is then crucial for all parties involved to not only work on the quantitative components of scientific and technological development but also ensure a high level of attainment in quality.

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Baris Uslu is Associate Professor at the Department of Educational Sciences, Canakkale Onsekiz Mart University, Turkey. His research interests include academic profession and intellectual leadership, and higher education governance and policy.

Alper Calikoglu works as a teacher at the Ministry of National Education, Turkey. He obtained his PhD from Canakkale Onsekiz Mart University, Turkey. His research interests include internationalization of higher education, international academic mobility, and academic profession.

Fatma Nevra Seggie is a full professor at the Department of Educational Sciences, Bogazici University, Istanbul, Turkey. She received her PhD from the Higher, Adult and Lifelong Education program at Michigan State University in 2007. Her current research areas include internationalization of higher education, leadership, and campus climate.

Sedat Gumus is Associate Professor in the Department of Educational Sociology, Aarhus University, Denmark. His research interests include comparative and international education, educational leadership, and higher education.

Yasar Kondakci is a full professor in Educational Administration and Planning at the Middle East Technical University. His research interests focus on higher education, educational change, and social justice in education.

Chapter 11
Research and Higher Education in Russia: Moving Closer Together

Anna Panova and Maria Yudkevich

Abstract While in most countries across the world universities are the key drivers of basic research and play a crucial role in national R&D systems, in Russia there is a long-standing tradition of separation of universities and the non-teaching research sector. Although these two roles are now gradually converging, institutional path dependency still plays an important role. In this chapter, we provide a brief overview of both parts of the system and explain the key events and decisions that shape its current form. This historical component helps to provide an understanding of how the mechanisms of path dependency work and what allows the situation to change.

Keywords Research and development · Research and teaching nexus · Research institutions

Introduction

We will discuss the Russian research and higher education systems through an institutional perspective, describing the historical and institutional contexts in which research in the country has been organized and developed. Specifically, we explain the logic of the separation of the higher education sector (presented by universities and other higher institutions) and the non-teaching research sector (presented by research institutions such as the Russian Academy of Sciences), which barely overlap, and we discuss the consequences of such long-term separation. We show the

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A. Panova · M. Yudkevich (✉)
Center for Institutional Studies, National Research University Higher School of Economics, Moscow, Russia
e-mail: apanova@hse.ru; yudkevich@hse.ru

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role of the transition period from a planned to a market economy, with its huge impact on the academic market (in both its teaching and research components). We also explain the grounds for the gradual convergence of the teaching and research components (presented both by developing a teaching mission within leading universities and by increasing cooperation between universities and institutions of Academy of Science). Finally, we draw conclusions regarding the current state of the research and development (R&D) system in Russia.

In Russia, the R&D system is divided into four sectors: government, higher education, business, and private not-for-profit. Various types of organizations are represented in these sectors. In this chapter, we mainly focus on the first two sectors: government and higher education. In most cases, research institutions belong to the government sector, while higher education institutions belong exclusively to the higher education sector. The Russian system also has specific characteristics which require us to choose a specific terminology; we use the word "academic" to refer to the non-teaching research sector of the national system and "researchers" for research personnel in those institutions, reserving the term "faculty" to refer to university faculty.

The last three decades have been quite turbulent for Russia in general and for research/educational institutions in particular. While the reader will encounter many various dates in this chapter, it's important to keep some time periods in mind. Thus, while 1992 was the year that saw the collapse of the Soviet Union and the start of market reforms in Russia, a new law was also introduced in the education sector that changed institutional rules for public institutions and opened the doors for the birth of private ones. The 1990s was a decade of complicated financial conditions throughout the whole economy (including the sectors under consideration here), with a huge brain drain and widespread moonlighting of faculty and personnel at research institutions. While from the mid-2000s the situation began improving, the most important changes are associated with a more recent period, including the launch of the National Research Universities Program in 2009, the creation of the Russian Science Foundation in 2013, and the establishment of the 5-100 program (2013–2020).

Institutional Context

The current situation in the Russian science and higher education sectors is largely determined by the economic and social context, government reforms in these areas, and the institutional structure of science and higher education inherited from the Soviet Union. Science and higher education played an important strategic role for the Soviet Union, providing support for technological development in the industrial and military sectors. In 1989–1990, gross domestic expenditure on R&D as a percentage of gross domestic product (GDP) was comparable to the level in the EU15 countries, at around 1.8% (OECD, 2020). The structure, however, was completely different and based on the principles of central planning. It included three sectors: basic science, which was mainly concentrated in the research institutes of the Academy of Sciences of the Soviet Union; applied science, represented by a set of sectoral organizations (with each branch ministry having its own research facilities, the so-called branch research institutes); and higher education, which was represented by universities and other higher education institutions. Universities were, for the most part, focused on teaching, preparing highly qualified personnel, including for the basic and applied science sectors. Funding for education and science was exclusively public and centrally planned, was carried out in accordance with long-term plans, and did not involve competition between research institutions in working on various scientific problems. Funding was abundant, making the research and teaching sectors quite prestigious. The connection between the higher education sector and the research sector was, however, rather loose. Priority was given to the needs and tasks of the military-industrial complex (Balázs et al., 1995; Gerber & Ball, 2002; Karaulova et al., 2016), while the civilian sector often used outdated technologies and equipment (Oglobina et al., 2002). The system was poorly adapted to the needs of a market economy (Dyker, 2001).

After the collapse of the Soviet Union, spending on science and education fell dramatically (OECD, 2020). Even by 2018, gross domestic expenditure on R&D (GERD) as a percentage of GDP had not recovered from the significant drop following the end of the Soviet era and was fluctuating around 1%. During this same period, expenditure in the EU increased, while China's expenditure grew significantly to match the EU level. The proportion of government-financed GERD as a percentage of GDP in Russia was 0.1%, greater than in all the OECD or EU15 countries (OECD, 2020). The government finances the bulk of R&D, with only one-third of funding coming from industry. This significantly distinguishes Russia from the EU and even from China. It is noteworthy that even in the business sector, government funding for R&D prevails. Such funding (including federal budget appropriations and government sector institutions' funding) of intramural expenditure on R&D in the business sector increased from 51.1% in 1995 to 56.6% in 2017. At the same time, the share of funding on R&D from foreign sources significantly decreased (Belousova et al., 2013; Gokhberg et al., 2019).

The transition from a planned to a market economy has led to changes in the research and educational system at both the organization and institutional levels. The private sector's participation in R&D in post-Soviet times was minimal, with just 4.5% of R&D in 1995 being carried out by privately owned organizations. Moderate growth in the following years meant that by 2017, the share had risen to 22% (Gokhberg et al., 2019). In the business sector, there were no sufficient incentives for the development of innovative activity (Dyker, 2001; Radosevic & Auriol, 1999), a situation caused by, among other things, the quality of the institutional environment (Gorodnichenko & Roland, 2017; Jones & Romer, 2010; OECD, 2011). In 1991, the number of organizations involved in R&D was 4564; by the first half of the 1990s, this total had decreased by 10% (OECD, 2011), mainly due to a reduction in the number of design organizations, construction projects, and exploration organizations, as well as research institutes related to enterprises (industrial enterprises). The total number of organizations performing research and development in Russia has fluctuated since 1995, reaching a low of 3492 in 2010 (Ditkovskiy et al., 2019; Gokhberg et al., 2019) (Table 11.1).

Table 11.1 R&D institutions by type

	1991[a]	1995	2000	2005[b]	2010	2015[c]	2017
Total	4564	4059	4099	3566	3492	4175	3944
Research institutes	1831	2284	2686	2115	1840	1708	1577
Design organizations	930	548	318	489	362	322	273
Construction project and exploration organizations	559	207	85	61	36	29	23
Experimental enterprises	15	23	33	30	47	61	63
Higher education institutions	450	395	390	406	517	1040	970
Industrial enterprises	400	325	284	231	238	371	380
Others	379	277	303	234	452	644	658

Source: Gokhberg et al. (2019) and [a]For 1991, Ditkovskiy et al. (2019)
[b]Since 2005, in connection with the abolition of the Russian Classification of Branches of National Economy (OKONh), the classification of the types of organizations performing research and development has been changed. [c]Since 2015, the number of higher education institutions includes branches of higher education institutions

The emergence of alternative employment opportunities, a reduction in public funding without a significant increase in private investment, low salaries, and a decrease in the social status of scientists all contributed to a change in the structure and quality of the workforce at the academy: namely, the outflow of scientists moving abroad and transitions from the scientific to the business sector. The phenomenon of combining work in academic institutes of the Russian Academy of Sciences (RAS) and in other places, including higher educational institutions, began to develop (Chepurenko, 2015; Gerber & Ball, 2002). The total number of R&D staff, as well as the number of researchers, decreased between 1991 and 2017 (Ditkovskiy et al., 2019; Gokhberg et al., 2019). However, when considering the number of people employed in the R&D system, one must take into account the fact that in the Soviet period, when the number of people employed in this sector reached record numbers comparable with the figures for the USA, its scale was associated with an important structural shift. With high rates of scientific personnel, the numbers of technical personnel were quite low, as for the most part technical tasks were performed by specialists with higher education. Despite performing technical and basic engineering functions, they were still counted as research personnel.

In the post-Soviet era, science has ceased to be a priority for the government. Research institutes have been forced to spend their budgets mainly on wages and to search for various ways of survival – including renting out their premises (Gerber & Ball, 2002; Wilson & Markusova, 2004). At the same time, in most branch research institutes and in the business sector, there has also been a crisis caused by the collapse of the direct funding system during the early 1990s. They have faced tremendous challenges due to the destruction of production chains, the deterioration of infrastructure, and the brain drain (Michailova et al., 2013). For the business sector, the level of in-house R&D has remained low. In general, the system – built for functioning in a planned economy with secure government funding from the government – began to stagnate under market conditions with a lack of competitive skills as well as the actual resources for which research organizations could compete.

Being focused on the "top-down" implementation of projects, the system did not immediately begin to adapt to the development of individual initiatives and the design of tools for its support and development. We see similar changes in the science sectors in other post-communist countries (Balázs et al., 1995; Jurajda et al., 2017; Schuch, 2014; Tiits et al., 2008). In general, the existing institutional research system proved to be ineffective in a market economy without proper support from the state. Necessary structural changes began only in the 2000s (Graham & Dezhina, 2008). However, the government sector, and in particular the largest institutional player – the Academy of Sciences – proved to be incapable of internal structural changes, which led to the external imposition of reforms and a reduction in the role of the Academy (Karaulova et al., 2017). The education sector, in contrast, received an impetus for development. In the 1990s, new legislation governing the higher education sector opened the door to the creation of private universities and laid the groundwork for the sector's rapid growth. Public universities got the opportunity to provide paid services, including teaching students for a fee on basic educational programs. The number of educational programs and students in professions demanded by the market economy – especially in economics and finance, management, and law – grew rapidly. In 1994, the share of students admitted into such programs in public universities was 38%, and by 1999 it had risen to almost 50% (Federal State Statistics Service, 2003).

Higher Education in Russia: A General Description of the System

General Organization

The main role of higher education institutions in the Soviet Union was to train professional personnel; this is still the sole role of many universities (Karaulova et al., 2016; Graham & Dezhina, 2008). The initial post-Soviet development of the higher education sector was mainly associated with the expansion of teaching services. With the transition to a market economy, the higher education sector began to develop, the private sector appeared, and universities started to open branches and new disciplines. A dual-track tuition system emerged, with public universities now able to accept tuition fee-paying students in addition to those financed by the state. The equilibrium in the higher education market has come to be determined more by demand from the population than by government planning. Despite the effective demand from the population, the role of the state has remained significant.[1] At the same time, the essentials of the central planning system are still preserved in the

[1] The share of government expenditure in 2013 was approximately 65%, while 35% was private, of which 23% was the household expenditure (OECD, 2016); by 2017, the share of public expenditure had fallen to 60% (Bondarenko et al., 2020).

Table 11.2 Research and development staff (people) by type of organization

	1991[a]	1995	2000	2005[b]	2010	2015	2017
Total	1,677,784	1,061,044	887,729	813,207	736,540	738,857	707,887
Research institutes	970,565	753,253	718,434	510,523	435,304	435,502	407,962
Design organizations	287,504	129,689	56,488	184,785	157,146	136,263	125,272
Construction project and exploration organizations	149,833	20,870	6811	5443	6324	2849	1537
Experimental enterprises	19,495	13,640	6145	1232	1558	3023	6030
Higher education institutions	90,550	40,015	31,110	33,942	46,776	60,151	56,571
Industrial enterprises	118,414	89,030	54,721	43,524	51,807	53,868	59,421
Others	41,423	14,547	14,020	33,758	37,625	47,201	51,094

Source: Gokhberg et al. (2019) and [a]For 1991, Ditkovskiy et al. (2019)
[b]Since 2005, in connection with the abolition of the Russian Classification of Branches of National Economy (OKONh), the classification of the types of organizations performing research and development has been changed

system's foundations. For example, the state determines annually the number of budget-funded places in public universities. In other words, it determines how many students a particular university will teach using public funds. Public funding of universities is still mainly associated with teaching. Presently, faculty are involved in research and R&D activities only in public universities (and not even in all of them), and the level of such involvement is relatively low.

From the beginning of the post-Soviet period, the number of universities and faculty grew for some considerable time, reaching a maximum of 1134 universities in 2008/2009, with 378,700 faculty and 7,513,000 students (Bondarenko et al., 2018; Federal State Statistics Service 2003; Gokhberg et al., 2007). However, the number of research staff fell in the 1990s and only started to grow again in 2000 (Table 11.2).

After a period of barely controlled growth resulted in the emergence of a large number of weak institutions, many of them were closed or merged with more efficient ones. This process was facilitated by the introduction of monitoring of the effectiveness of universities.[2] This monitoring provides for the annual presentation by universities of statistics on key indicators and includes indicators related to science and R&D.

As a result, in 2018/2019, the Russian higher education system comprised 496 public and 245 private universities (Bondarenko et al., 2020), with the number of universities declining by about one-third over the last decade. This trend is seen in both the public and private sectors. Although private universities are a relatively new form of higher education in Russia, they have nevertheless formed a stable core of 30–40% of all universities over the last 20 years. Since the number of universities

[2]Federal law № 273 On education in Russian Federation, 29.12.2012.

and faculty peaked in 2010, the subsequent decrease in numbers is mainly connected with a demographic crisis and declining birth rates in the early 1990s, which reduced the number of people who could potentially enter the higher education system (Kuzminov & Yudkevich, in press). The number of students has fallen by 44% since 2008 and now stands at 4,245,900 (Federal State Statistics Service, 2003; Bondarenko et al., 2018). The second reason for the decline is the state policy aimed at making education funding more effective. Even so, the students-per-faculty ratio is around 11:1, which is smaller than in most countries. Although there are decreasing trends in a lot of quantity indicators, the funding system invokes the massification trend of higher education. Since the funding of universities is aimed at education, it is profitable for them to increase enrollment as much as possible without changing any other factors and admitting students with low exam performances (Yudkevich, 2019). Massification and lack of proper regulation can lead to a trend of decreasing quality in higher education.

Since 2000, the government has begun to actively regulate this industry. In Russia, the task of improving the quality and effectiveness of higher education is attributed to the state, as the state mainly finances education. There are no other major institutional players capable of quality control in higher education. Most of the reforms were aimed at increasing transparency and accountability; however, the state switched to a project approach. The late 2000s saw the start of policy changes that were aimed at the development of science both at the level of individual faculty members (e.g., the introduction of an incentive contract with bonuses for research productivity) and at the university level. Since the late 2000s, the state has launched one program after another aimed at targeted support of a number of the most powerful and promising universities while simultaneously taking measures to close or reorganize inefficient universities.

Massification brings stratification. Today, there are about 40 leading public universities in the country, including participants in the 5-100 program, national research universities and federal universities, as well as Lomonosov Moscow State University and St Petersburg State University, both of which are regulated by a special law. These universities are research intensive, provide education of better quality, and are able to attract better resources (both financial and human). The quality of the public universities is rather diverse, and faculty in those institutions are not actively involved in research.

Academic Career

A university career usually begins with a person entering a Ph.D. program and becoming a teaching assistant. There are many ranks on an academic career ladder: teaching assistant, lecturer, senior lecturer, associate professor, and professor. Promotion depends on the number of years teaching, degree level, and availability of vacancies in the department. There are no lifetime contracts or tenure for university faculty. Contracts are temporary and renewed on a competitive basis, usually for 1, 3, or 5 years. However, until recently, competition was quite low (Yudkevich, 2019), and contracts were extended nearly automatically. Faculty are supposed to not only teach but also conduct research. However, contracts do not formalize the volume of the research or the expected results. People tend to teach the same courses for many years and become attached to them. The whole system is designed to maintain stability, which is not relevant nowadays. Today, there is much more competition for students, academic vacancies, and resources. Increasing performance requirements from the Ministry lead to 1-year contracts being offered to the majority of faculty. Moreover, individual research performance becomes more important in a scenario of greater competition, especially at leading universities.

In 2014, graduate school reforms were carried out, the purpose of which was to improve the quality of training of scientific personnel. The criteria for obtaining a scientific degree have been complicated, and the number of dissertation councils has decreased. However, universities still face the problem of aging faculty; the proportion of academics older than 65 years is constantly increasing (Gokhberg et al., 2011; Bondarenko et al., 2018). Between 2005 and 2017, the proportion of faculty aged under 30 years decreased noticeably, from 16.1% to just 6.1%, continuing a trend that began in the late 1990s. This problem is caused by the number of young and middle-aged faculty with non-academic opportunities leaving universities during the 1990s, as well as by a period of low influx of young people into universities that lasted more than a decade (due to the low attractiveness of the teaching profession). To solve this problem, universities try to hire their former students immediately after graduation. When universities cannot offer competitive salaries, the solution is to attract students who have not yet entered the labor market because of low academic salaries. This results in inbreeding, where higher education institutions are filled with faculty who have no experience in working outside of that university. However, some universities today are moving to an open, competitive, external hiring system; this is especially so with leading universities, with financial and institutional opportunities to offer. The government also aims to use grant funding to support the most talented young faculty (Kuzminov & Yudkevich, in press), e.g., in the framework of international laboratories program. The program has successfully made it possible for universities, including peripheral ones, to attract young, promising faculty into laboratories headed by international scholars. There is a whole system of such grants today aimed at increasing the number of young faculty, with similar criteria and conditions, which will hopefully make a difference to the problem of aging.

Despite the fact that faculty should train qualified personnel for the science sector, for a long time, faculty were practically not involved in research activities, and the number of research personnel in universities was minimal.

Timeline

The development of science and R&D in the higher education sector was facilitated by several state initiatives that affected universities in general, individual teams of researchers, and individual faculty members. The first important stage for the development of science, and the involvement of the university sector in science, was a partial transition to competitive financing with the emergence in the late 1990s of various Russian (Russian Foundation for Basic Research (RFBR) and Russian Humanitarian Scientific Foundation (RHSF)) and international research foundations. These organizations provide individual grants and have implemented a previously non-existent transparent peer process and support for "bottom-up" initiatives. Grant applications can be submitted both by employees of research institutes and by university staff. Moreover, grants are awarded to both individuals and groups, which has contributed to greater collaboration.

Second, a number of important public policy measures have been implemented since 2012. The state has obliged universities to switch to a new system of remuneration – effective contracts. This type of contract obliges universities to introduce incentive payments. Some of the universities took advantage of this opportunity to introduce allowances for research activity. In addition, the state obliged universities to increase average wages. The policy forced the doubling of average regional wages by 2018, which was partly designed to attract academically strong faculty and help secure talented young people positions at universities.

For the *third* step, in 2013, the government began promoting competitive funding instruments. For example, the Russian Science Foundation (RSF) was founded and began to provide large grants for the creation of international laboratories, attracting leading scientists and implementing complex projects in priority science areas.

In 2010, the Ministry of Education and Science launched a mega-grant program, aimed at developing international cooperation, as well as cooperation among universities within Russia, with leading scientists and international organizations in the fields of science, education, and innovation. Within the framework of this program, 272 laboratories were created on a competitive basis, of which 201 were organized in universities.

Other government policy measures affected only a small number of universities and were aimed specifically at creating a sector of leading universities involved in science, R&D, and innovation. These included the creation of federal universities with the aim of developing peripheral regional markets (2008); the implementation of a program of national research universities, designed to develop research missions in selected universities (2009); and, finally, the 5-100 program aimed at increasing the visibility of leading universities in the global academic market (2013).

In 2020, there are a number of universities with special status (leading universities): 29 national research universities (NRU), 21 universities participating in the "5-100" program, the 2 leading "classical" universities (Moscow State University (MSU) and St Petersburg State University (SPbU)), "leading" universities, and federal universities. There is a significant difference between the funding of special-status universities and "ordinary" ones. Average salaries in NRUs, "5-100" universities, and MSU and SPbU are 30% higher than the average at universities without such status; they also publish more research work and in more respectable journals. In addition, MSU and SPbU were founded by federal laws, which makes them drastically different from any other university: they have a special funding processes, norms, and regulations. Other special-status groups usually include mostly the same universities. For example, 12 out of 29 NRUs (and 5 out of 10 federal universities) participate in the "5-100" program (Kuzminov & Yudkevich, in press). So, the system separates around 50 universities, giving them more funding and, with that, greater opportunities for attracting better faculty, which makes the difference between those and "ordinary" institutions even more significant.

The data show that despite the decrease in the number of higher education institutions and their branches in the 2000s, the number of higher education institutions involved in R&D activities is slightly increasing (Bondarenko et al., 2018; Federal State Statistics Service, 2003; Gokhberg et al., 2019).

Research Sector

The total number of scientific research institutes in the 1990s grew by 47% (from 1831 to 2686, Table 11.1), mainly due to the reorganization in branch research institutes (OECD, 2011). In the period from 2000 to 2010, the number of research institutes decreased by 32%, and in 2017 there were 1577 (1117 of which were in the government sector; Gokhberg et al., 2019), fewer than immediately after the collapse of the Soviet Union (Gokhberg et al., 2019). However, for quite a long period, the number of institutes belonging to the Academy of Sciences remained virtually unchanged, mainly due to the strategy of the academies. The RAS has for a long time remained the largest and most active institutional player in the public R&D sphere. It was the heir to the Soviet Academy of Sciences, which was a leading example for other countries. It dominated government research in the Soviet Union from 1925 up until 1991 (and remained relatively unchanged for most of the two subsequent decades). The Academy's supreme body was the general meeting of academicians and corresponding members, and it formed and coordinated a scientific policy for basic research for the whole country.

Strategic challenges for the development of science were solved at institutes of the RAS and branch research institutes. Unlike Western academies, the RAS had a large network of such institutes (Fortescue, 1992) where trained personnel (graduates and young candidates of science) came from the higher education sector (Kuzminov & Yudkevich, in press). This makes it one of the largest examples of research-based national science academies (Karaulova et al., 2017). Researchers at these institutes were provided with constant, guaranteed financing and did not have, on the whole, special incentives for the manifestation of project initiatives, realizing planned studies. Such a device was largely conducive to maintaining the position of the RAS in the post-Soviet era, and it was still the largest network of research organizations in the government science sector in 2000; out of 831 research organizations belonging to various state academies, 454 belonged to the RAS. Between 2000 and 2012, the number of research organizations increased to 484, but the number of researchers in the same period dropped from 61,864 to 52,886 (Berezina et al., 2017). The next largest networks (separate from the RAS) were the "younger sisters" of the main RAS – the Russian Academy of Agricultural Sciences (291) and the Russian Academy of Medical Sciences (58). Despite the fact that the number of organizations did not change significantly during this period, the number of researchers decreased.

The funding of research institutes in the Soviet Union was tied to the number of employees rather than the outcomes of activities, which did not contribute to increasing competitiveness in the world market. For a long time, the RAS was able to maintain a leading position in the domestic market, but the position of Russian science in the international market did not improve. Owning many Russian academic journals inherited from Soviet times, the academies were essentially "gatekeepers" for national science (Karaulova et al., 2016). The need for reform was announced within the RAS itself, but no reforms were made. Instead, the RAS has used its position to fight against reforms and to resist implementation of new public management policies (OECD, 2011). At the same time, government dissatisfaction with the academic sector's performance and the lack of international competitiveness has grown.

In 2013, the Russian government implemented radical reforms (Federal law № 253 21.09.2013 on the Russian Academy of Sciences, the reorganization of the state academies of sciences and amendments to certain legislative acts of the Russian Federation), including a federal law removing the autonomy of the RAS. The goal of the reforms, which covered the entire government science sector, was to increase the efficiency of the academic sector and strengthen its position at the international level, as well as to ensure a full innovation cycle from research and development of advanced high-tech goods and services to market entry. The Russian Academy of Agricultural Sciences and the Russian Academy of Medical Sciences were attached to the RAS. A Federal Agency for Scientific Organizations (FASO) was organized, which was to carry out legal regulation and provide state services in the field of science, as well as manage the real estate of the RAS. As a result, in 2016, there were 820 research organizations subordinated to the RAS-FASO (Berezina et al., 2017).

In addition, the government introduced monitoring of the performance of scientific organizations, which allowed state agencies to identify leaders and outsiders and restructure organizations. Since the end of 2018, research organizations have become subordinate to the Ministry of Science and Higher Education. It is important to note that the reforms were carried out with the active resistance of individual members of the RAS, mainly a result of the introduction of peer review (Karaulova et al., 2017). In attempting to maintain its structure, the RAS actually lost ground.

Despite the reforms, the percentage of funds attracted from enterprises to finance the intramural expenditure on R&D in academic institutions did not change, remaining at 7% (Alieva et al., 2018), which is lower than in scientific organizations that are not part of RAS-FASO. The executives of the RAS were somewhat rejuvenated, but the average age of its researchers ranged around 50 years (Alieva et al., 2018). At the same time, the average age of researchers outside scientific academies decreased from 49 to 46 years.

According to a survey conducted by the RAS, members of the Academy board, its corresponding members and professors of the RAS mostly believe that the situation in Russian science has worsened, and most respondents assess the reforms negatively (Russian Academy of Sciences, 2019). According to their estimates, the pace of development of science in Russia is significantly less than the pace of development in Western countries. In general, respondents opposed the university model for the development of the scientific sector. They named a number of possible criteria for evaluating the activities of institutes, including the level of citation of Russian scientists, the costs of providing a scientist's workplace, and the share of young scientists.

Statistical Overview

Despite the general changes in the R&D sector in terms of resources for funding, in the number of R&D institutions, and in the number of staff, we can be certain that different trends can be observed across the sectors due to changes in government policy at the sector level. As already noted, GERD has been declining since the collapse of the Soviet Union. Government funding continues to play a pivotal role in maintaining and developing the R&D sector. The business sector in the 2000s was the main recipient of government financing, but by 2017 its share had decreased slightly. In 2017, most government expenditure (including federal budget appropriations and government sector institutions' funds) on research and development was divided between the business sector (51.6%), the government sector (39.9%), and the higher education sector (8.6%).

The structure of expenditure on R&D in the context of basic research, applied research, and development did not change significantly during 1995–2017; in 2017, it was 15%, 18%, and 67%, respectively (Ditkovskiy et al., 2019; Gokhberg et al., 2020). The way expenditure on R&D is distributed among different types of activity reflects the path dependence on the development of the R&D sector (Table 11.3).

The expenditure associated with basic research is mainly related to the government sector – 71% of the total expenditure in all sectors (Gokhberg et al., 2019). The business sector now has the most expenditure associated with development, with 79% of the total expenditure on development for all sectors (Gokhberg et al., 2019). At the same time, the higher education sector accounts for 27% of the expenditure on applied research and 18.5% of the expenditure on basic research (Gokhberg et al., 2019). In general, the share of the higher education sector in these areas has grown compared to the Soviet Union. The relative role of the higher education sector has slightly grown.

The distribution of R&D institutions by sector has changed significantly: since 1995, the number of organizations engaged in research and development in the

Table 11.3 Distribution of intramural expenditure on R&D by type of activities and sector of performance (percent)

	1995	2000	2005	2010	2015	2017
Basis research						
Government sector	69.8	71.0	79.3	67.8	75.7	71.2
Business sector	15.9	17.0	8.4	17.7	5.4	10.0
Higher education sector	14.2	12.0	12.4	14.2	18.8	18.5
Development R&D						
Government sector	13.0	14.7	13.8	18.5	18.0	18.0
Business sector	84.8	83.3	83.7	77.7	78.6	78.9
Higher education sector	2.2	1.8	2.5	3.7	3.4	2.6
Applied R&D						
Government sector	34.5	28.4	29.2	33.6	39.0	39.3
Business sector	55.2	60.0	55.1	46.6	36.3	33.1
Higher education sector	10.3	11.0	14.9	19.4	24.2	27.1

Source: Gokhberg et al. (2019)

Table 11.4 R&D institutions by sector of performance

	1991[a]	1995	2000	2010	2015	2017
Government	992	1193	1247	1400	1560	1493
Business enterprise	3009	2345	2278	1405	1400	1292
Higher education	537	511	526	617	1124	1038
Private non-profit	26	10	48	70	91	121
Total	4564	4059	4099	3492	4175	3944

Source: Gokhberg et al. (2019) and [a]For 1991, Ditkovskiy et al. (2019)

government sector has grown by 25%; the number in the business sector has fallen by 45%; and the number in the higher education sector has grown by 103% (the private not-for-profit sector was insignificant) (Table 11.4).

Most organizations performing research and development (up to 60%) in Russia are research institutes. The share of this type of organization has gradually decreased, mainly due to the increase in the amount of higher education organizations that perform research and development. Despite a dramatic drop in the number of organizations in the business sector, there has been an increase of 32% since 1995 in the number of such types of organizations as industrial enterprises engaged in science (Gokhberg et al., 2019).

The total number of R&D staff has decreased. This trend clearly exists in every sector of science and type of organization, except higher education ones: the number of R&D staff working in research institutes has fallen by 58% since 1991, while at higher education institutions, following an initial sharp decline, the numbers have grown after 2000 (Table 11.2). The most significant decline was observed in the business sector. The research labor force (headcount) in 1991 was distributed by sector as follows: government sector 18%, business sector 72%, and higher education sector 8% (Table 11.5).

Table 11.5 Researchers by sector of performance (headcount)

	1991[a]	1995	2000	2005	2010	2015	2017
Government	166,100	146,342	129,725	139,378	131,734	134,794	130,081
Business enterprise	637,200	336,671	267,640	221,445	197,785	198,123	186,347
Higher education	74,300	35,508	28,325	30,111	38,640	45,967	42,113
Private non-profit	900	169	264	187	756	527	1252
Total	878,482	518,690	425,954	391,121	368,915	379,411	359,793

Source: Gokhberg et al. (2019) and [a]For 1991, Ditkovskiy et al. (2019)

In 1995, 28% of the research labor force was located in the government sector, 65% in the business sector, and 7% in the higher education sector (Gokhberg et al., 2019). In 2017, the distribution was 36%, 52%, and 12%, respectively. The percentage of researchers employed in the government sector significantly exceeds the same share for OECD countries (Gokhberg et al., 2019).

In terms of performance, we see the following picture: the number of publications after the collapse of the Soviet Union decreased significantly and began to recover only in the second half of the 1990s (Wilson & Markusova, 2004). At the same time, the level of international cooperation grew. However, the citation impact remained fairly low and was lower than that of most Eastern European countries (Kozak et al., 2015). Russia went down in the SCImago country rating (SJR, 2020) from ninth place in 2000 to 16th place in 2010. By 2019, it had recovered to tenth place. The performance of researchers, particularly the proportion of Russian authors' publications in academic journals indexed in Scopus, has increased from 1.79% (in 1995) to 2.90% (in 2017) (Gokhberg et al., 2019). This trend is also clear in the number of submitted and issued patents, which has increased by about 50% from 1995 (Gokhberg et al., 2019). The change in the growth rate of the number of publications indexed in international scientific databases is mainly associated with the development of higher education. In the period up to 2011, in international databases of scientific publications, the number of authors from academic institutions exceeded the number of authors from universities. However, since 2011, the situation has changed significantly, with the number of authors from universities growing sharply (Guskov et al., 2017; Kosyakov & Guskov, 2019). Despite the fact that in 2011 the institutes of the RAS continued to play a significant role in science, in the Science Citation Index-Expanded, the proportion of Russian scientific works produced by the RAS was 56.3% (Markusova et al., 2014), and the role of the university scientific sector began to increase. Using Scopus data, Kosyakov and Guskov (2019) showed that the proportion of publications in Scopus related to academic institutions between 1998 and 2017 decreased from 47% to 27%, while the share of publications related to universities increased from 32% to 58%. The number of publications of Russian universities in collaboration with the research institutes of the RAS has increased fivefold since 2005, to almost 11,000. Moreover, the proportion of such publications among the total number of Russian publications also rose, from 25% to 40%. However, this number has remained stable for the last 5 years

(Kuzminov & Yudkevich, in press). We also see that many universities have advanced in international rankings.

As for innovation, Russia has improved its position in the Global Innovation Index (Cornell University, INSEAD, and WIPO, 2020) from 64th place in 2010 to 46th place in 2019, mainly due to the financial resources available. However, at the same time, the level of innovative activity and the commercialization of innovations remain rather low (Andrushak et al., 2017). The proportion of organizations implementing technological innovations of the total number of organizations in Russia was 7.9% in 2010 and 7.5% in 2017, which is significantly lower than in developed countries, such as Germany (52.6%), France and the UK (40.9%), the USA (12.8%), and Japan (28.3%) (Ditkovskiy et al., 2019). In addition, during 2010–2016, the share of enterprises participating in joint research projects decreased by 23% (Andrushak et al., 2017).

Between 2015 and 2017, revenue from technology exports generally fell, while payments for technology imports grew (Gokhberg et al., 2019). The deficit has grown significantly. This trend is typical for the government and business sectors. Despite the fact that the share of the higher education sector in international technological exchange is minimal, technology exports in this sector have increased.

Conclusions

The current position of the Russian R&D system is largely determined by the inherited institutional structure with historical institutional divide between higher education and academic sectors, as well as ongoing reforms that to some extent are aimed to assure their cooperation. Since the end of the 2000s, science has again become one of the priorities of public policy. Reforms in the academic sector led to serious resistance from the largest institutional agent, the Russian Academy of Sciences. In the higher education sector, there was no such large agent that could resist reforms and advocate the status quo.

In line with the convergence of the higher education and academic sectors, the role of the higher education sector in R&D is increasing. This can be seen at both the level of resource change and that of the resulting performance. Leading universities are gradually turning into research-intensive institutions. This is due to a change in the mission of universities (including through Excellence initiatives) and changes in incentives for researchers and faculty (the introduction of a new wage system that rewards high research performance). In general, the role of the new managerialism is strengthening in government measures to influence the higher education sector. In addition, one can observe more close cooperation between higher education institutions and academic institutions, which takes the form of institutional partnerships between those institutions, joint educational programs, and research projects/collaborations, as well as the rising phenomenon of part-time employment of academic researchers from RAS institutions at universities.

Universities are interested in such cooperation in order to increase their competitive advantages, while institutions are interested in new, young researchers.

Unlike Soviet times, academic careers are no longer associated with high social status and prestige. The inflow of young people into both higher education and academic sector is low and the problem of aging quite severe. In the leading universities, with better financial and academic incentives, there is a considerable inflow of young academics, while in the rest of the sector, the situation is rather critical.

However, today there is no evidence of the active participation of university and academic sectors of the country in the development of national innovations. To some extent, this is supported by the Soviet legacy, which did not support innovations "from the bottom" nor free flow of ideas between sectors, and by the prevailing pattern of academic careers, where mobility between the academic sector and industry is very much constrained. Moreover, while the state has traditionally been the main initiator and customer of basic and applied research, the real sector of the economy has almost no demand for research in universities and the academic sector, and it is not ready to invest in it. This is due not to the organization of science but is related to the quality of economic institutions in the country, which provides little support for long-term R&D investment for the private sector. State attempts to create an innovative "top-down" environment have also not been crowned with success.

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Anna Panova is a research fellow of the Centre for Institutional Studies at HSE University in Moscow, Russia, and a senior lecturer at the Economics Department of HSE. She has a PhD in Economics. Her research interests focus on the economics of higher education. Her PhD thesis was about academic contracts and university governance.

Maria Yudkevich is a vice-rector at HSE University in Moscow, Russia, and a head of the Center for Institutional Studies at HSE. The main areas of her interest and research work are economics and sociology of higher education with special emphasis on faculty contracts, university

governance, and markets for higher education. She is the author of works on economics and sociology of higher education and has published in leading Russian and international journals. She was a co-organizer of several large-scale international research projects that studied different higher education phenomena in a comparative perspective, including faculty salaries, academic inbreeding, global rankings, and doctoral education.

Chapter 12
The Role of Universities in the Knowledge-Based Society in Lithuania

Liudvika Leišytė, Anna-Lena Rose, Rimantas Želvys, and Sude Pekşen

Abstract This chapter focuses on the question of how the Lithuanian higher education sector contributes to research, development, and innovation in Lithuania. The Lithuanian case is interesting in two regards: On the one hand, the country has been undergoing rapid economic, political, and societal transformation after restoration of independence from the Soviet Union in the early 1990s and is currently one of the fastest-growing economies in the European Union. On the other hand, the country faces negative demographic trends and rapidly decreasing student numbers, which has led to increasing competition between higher education institutions and a consolidation of the higher education sector in the past years. The chapter provides an overview of policies and strategies as well as an evaluation of the innovation capacity of Lithuania, which includes comparisons with the two other Baltic States, Estonia and Latvia, and a positioning in the European Union context. We then present the key characteristics of the Lithuanian higher education system and discuss its contribution to research, development, and innovation and the so-called learning society in the country.

Keywords Academic profession · European Union · Innovation Development · Research-development-innovation · Lithuania

L. Leišytė (✉) · A.-L. Rose · S. Pekşen
TU Dortmund University, Dortmund, Germany
e-mail: liudvika.leisyte@tu-dortmund.de; anna-lena.rose@tu-dortmund.de; sude.peksen@tu-dortmund.de

R. Želvys
Vilnius University, Vilnius, Lithuania
e-mail: rimantas.zelvys@fsf.vu.lt

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Introduction

Lithuania is a small country and one of three Baltic States (next to Estonia and Latvia) located in Central and Eastern Europe. It has been part of the European Union since 2004 and joined the European Monetary Area (€) in 2015. Lithuania has very low public debt (more than two times lower than EU average; Eurostat, 2018a), has a very high share of tertiary education attainment (European Commission, 2018a), and is one of the fastest-growing economies in Europe with a growth of 4.1% of GDP in 2017 (Eurostat, 2018b). Moreover, many universities have been able to update their research infrastructures with support from European Structural Funds in the past decades – all of which are factors that the OECD (2016) considers a basis for successful research and innovation in the country. However, the country has a very low number of companies in the high-tech industry and faces serious challenges based on negative demographic trends; since 1990, the Lithuanian population decreased from 3.7 million to 2.8 million. A decrease of approximately 707,000 inhabitants can be traced back to emigration, while 177,000 can be attributed to lower birth rates (European Migration Network Lithuania, 2018). While immigration to Lithuania has increased nearly fourfold from 2010 to 2017, it continues to be exceeded by emigration, and student numbers are constantly decreasing leading to the need for consolidation in the higher education sector.

In this chapter, we evaluate the key policy developments and the role of the higher education sector in research, development, and innovation in Lithuania. The chapter starts with an overview of policies and strategies for research, development, and innovation and an evaluation of the innovation capacity of Lithuania, followed by an analysis of the role of higher education for research, development, and innovation. After providing a short overview of its distinctive historical context, we present the key characteristics of the Lithuanian higher education system, including its structural characteristics as well as data and recent trends in employment and academic career progression.

Research, Development, and Innovation in Lithuania

In the following sections, we provide an overview as well as an evaluation of policies and strategies for research, development, and innovation in Lithuania.

Policies and Strategies for Research, Development, and Innovation in Lithuania

Governmental concerns with research, development, and innovation policies in Lithuania go back to the late 1990s and early 2000s. Among other factors, they were heavily influenced by, and served as an integral part of, the accession process to the

European Union, of which Lithuania became a member in 2004. The early period of expansion in research, development, and innovation policies in Lithuania witnessed the establishment of a Department of Science and Higher Education under the Ministry of Education and Science in 1998, the 2000 Law on Higher Education which changed funding arrangements and created a non-university higher education sector, and, finally in 2001, the first document dedicated to an integrated strategy for research, development, and innovation, namely, the Lithuanian Science and Technology White Paper, which was issued by the Department of Science and Higher Education. The Science and Technology White Paper served as a basis for a Long-Term Research and Development Strategy, which was formulated in 2003 and aimed at reforming the national innovation system. Among its objectives were the encouragement of collaboration between science and industry/business and private investments into research, increasing the quality of research, establishing more favourable conditions for new technologies, as well as increasing the gross expenditure for research and development (GERD) to 3% and business expenditures for research and development (BERD) to 2% of GDP. These plans were partly inspired by targets set by the European Council (The World Bank, 2003) but that the OECD (2016) describes as "ambitious, yet in retrospective highly unrealistic" (p. 116).

Since 2007, a strong reliance on European Structural Funds (a set of funds aimed at supporting economic development across EU countries, some of which specifically aimed at advancing less developed regions) became visible. During the period from 2007 to 2013, a considerable amount of this funding was invested in research and innovation, especially in the Valleys programme. The Valleys programme, aimed at establishing so-called integrated science, studies, and business centres (similar to science and technology parks elsewhere) at five locations in different parts of Lithuania, was approved by the Lithuanian parliament in early 2007. The funding available within the scope of the programme enabled the involved universities and research institutes to upgrade their equipment and infrastructures. However, a 2016 report by the OECD claims that it has failed to increase research collaborations between universities, research institutes, and the business sector and that the effectiveness of the valleys has remained rather limited so far, partly due to a lack of specialisation and too broad ranges of activities offered (OECD, 2016).

After a government change in 2008, research, development, and innovation were put even higher on the political agenda in an attempt to create an innovation and knowledge economy. In 2010, a national Agency for Science, Innovation, and Technology (MITA) was established. MITA took the role of administering a number of collaborative programmes by the Ministries of Education and Science and Economics, e.g. the Development Programmes for High Technology and Industrial Biotechnologies (2011). In the same year, a new Innovation Strategy (2010–2020) was adopted. This strategy emphasised the importance of fostering innovation by any means while especially underlining the importance of cooperative research projects with business and industry and attempting to integrate various innovation measures of different ministries to this end (Štreimikienė, 2014). Yet, policies and programmes remained tailored to, and depended on support through, EU Structural Funds as indicated in the Operational EU Structural Funds Investments Programme

2014–2020. According to this document, 10.1% of the total Structural Funds allocations to Lithuania, equalling approximately €798 million, are envisaged to be spent in the area of research and development with the aim of increasing expenditure to 1.9% of the GDP by 2020 (European Commission, 2019).

In late 2013, the Lithuanian Innovation Development Programme 2014–2020 was adopted by the government. The programme adopts a broad conception of innovation, encompassing both research-driven innovation and innovation in creative solutions, business models, industrial design, branding, and services, and aims to include a variety of actors in innovation processes. The main goals of the programme are the following: developing an innovative society; increasing the innovative potential of business; promoting the creation of value networks, their development, and internationalisation; improving the formulation and implementation of innovation policies; and promoting innovations in the public sector. In addition, Lithuania 2030, a long-term strategy document outlining visions for Lithuania's future, was published. The strategy aims at creation of a learning society, open to global changes, where people are educated, interested in science and innovations, and easy and familiar with the latest technologies. With regard to research, development, and innovation, the strategy identifies the need for reducing restrictions and complicated regulations for business, enhancing an entrepreneurial culture, enhancing the production and protection of intellectual property, and ensuring that research results in market-relevant innovations. Building upon the Lithuania 2030 strategy, the Lithuanian parliament adopted a Resolution for Policy Changes in Lithuanian Science and Innovation Policies in 2016. This resolution calls for a reform of the Lithuanian research system, making it more efficient and ensuring a better link between educational activities and labour market demands. It also identifies the need for increased competition to improve the international standing of higher education institutions as well as their efficiency and innovation capacities in general and strengthening business participation in (the funding of) research, development, and innovation, as well as relevant policies.

Evaluation of Research, Development, and Innovation in Lithuania

Lithuania has only 2.8 million inhabitants and a very small domestic market, but it is well integrated into the world economy and benefits from the integration into the European Single Market. Yet, the country faces a number of challenges which increase its need for a successful research, development, and innovation strategy. Among these challenges are unfavourable demographic trends. The Lithuanian population is continuously decreasing due to lower birth rates and emigration, especially among young Lithuanians, which leads to substantial brain drain. The country has a very high share of tertiary graduates; tertiary education attainment among 30- to 34-year-olds is significantly higher than the EU average with 58 versus 39.9%

(European Commission, 2018a). Nevertheless, the OECD (2016) reports signs of serious skill mismatches in the Lithuanian working population. Moreover, compared to other European countries, Lithuania has a low number of knowledge and technology-intensive companies (e.g. the high-tech manufacturing sector contributed only 1% to the total value of production) (Statistics Lithuania, 2017).

Lithuania is one of the fastest-growing economies in the European Union. Yet, despite the investments through EU Structural Funds, its innovation performance is relatively low (OECD, 2016). According to the European Innovation Scoreboard (European Commission, 2018b), Lithuania can be seen as a moderate innovator, performing at 75% of the EU average. The country performs particularly well with regard to the innovation dimensions “Innovation-friendly environment”, especially due to its high broadband penetration, and “Linkages”, where collaboration of innovative small- and medium-sized enterprises (SMEs) with each other and private co-funding of public research and development expenditure were rated above the EU average. Lithuania performs least well with regard to the dimensions “Sales impact” and “Attractive research system”. We will elaborate on the latter in the next part of the chapter.

Figure 12.1 shows the evolution of research and development expenditures as a percentage of the gross domestic product in the European Union overall and the three Baltic States, Estonia, Latvia, and Lithuania, from 2000 to 2017. Expenditures on research and development are lower than the EU average in all three Baltic States, whereas expenditures in Lithuania are higher than in Latvia and lower than in Estonia. Research and development (R&D) expenditure in Lithuania has increased from 0.6% in the year 2000 to 1% of GDP in the year 2015, before following the trend of its two neighbouring Baltic countries with a decrease to 0.9% in 2017. As

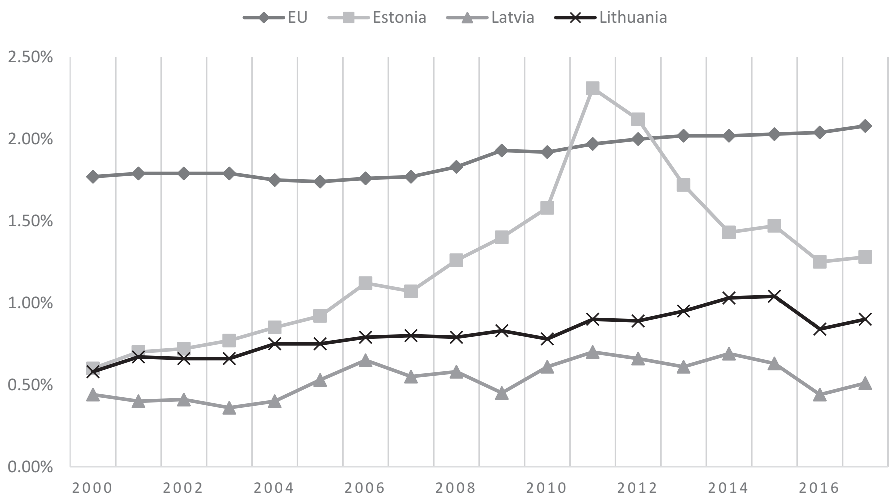

Fig. 12.1 R&D expenditure as percentage of GDP in the European Union, Estonia, Latvia, and Lithuania (2000–2017). (Source: Eurostat, 2020a)

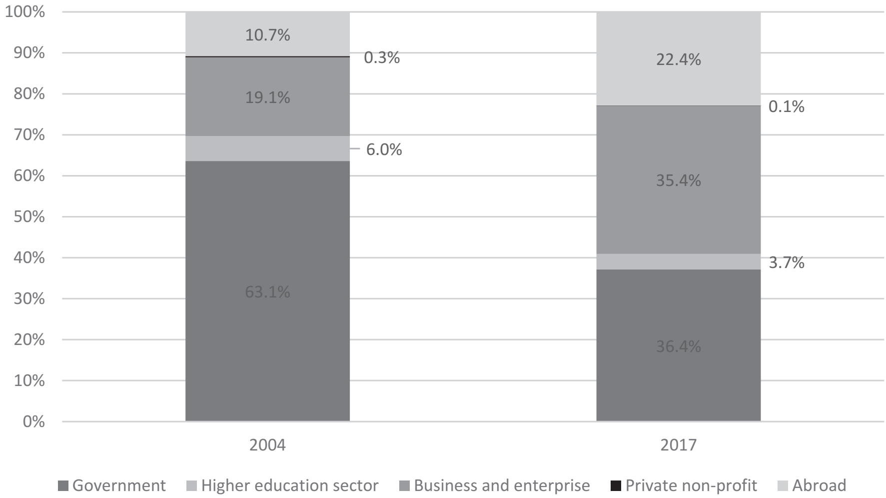

Fig. 12.2 R&D expenditure (GERD) by source of funds (as percentage of total GERD) in Lithuania in 2004 and 2017. (Source: Eurostat, 2020b)

Lithuania has a very fast-growing economy, the absolute expenditure on research and development yields a slightly different picture: while research expenditure as percentage of GDP has increased rather slowly, absolute expenditures (GERD) have grown significantly from €73.1 million in 2000 to €389.7 million in 2015, before a cut-back to 327.6 million in 2016 (Eurostat, 2018a).

Figure 12.2 shows that most of research and development expenditures in Lithuania in 2017 came from the government (36.4%) and from business and enterprises (35.4%). The higher education sector accounted for only 3.7%, whereas private non-profits provide very little support for research and development (0.1%). Approximately 22% of research and development funds came from abroad, which is remarkable, as the EU average is only 9%. In comparison with other European nations, only Latvia, Bulgaria, and the Czech Republic received a higher share of research and development funds from abroad. In contrast, the share of business expenditure for research and development (BERD) (35.4% in 2017) is rather low, considering that the EU average for the same year was 58% (Eurostat, 2020b). In turn, the share of business sector funding of higher education (HERD) and government (GOVERD) expenditure on research and development is comparatively high (OECD, 2016). A comparison with data from the year of accession to the European Union, 2004, with recent data shows a significant decrease of government funding from 63.1% in 2004 to 36.4% in 2017; yet the latter still lies above the EU average of 29.3%.

Apart from the low expenditures, which can be attributed to a lack of resources, and the low participation of the business and industry sector in (the financing of) research, development, and innovation, the main critique of Lithuania's research, development, and innovation system is the lack of policy coordination. According to an OECD report (2016), policy processes lack coherence and systematic practices, as a number of small-scale agencies and different ministries act in isolation and operate overlapping and sometimes even competing schemes. As a best-practice example for implementing unified and effective strategy, the report lists Lithuania's neighbouring country and fellow Baltic State, Estonia (OECD, 2016).

The Role of Higher Education for Research, Development, and Innovation in Lithuania

As presented above, business expenditures on research and development in Lithuania are low, and the public sector is the main actor, part of which can be attributed to historical developments. When Lithuania regained independence from the Soviet Union in 1990, it inherited a research and development system with typically Soviet features. Research was conducted in research institutes and Academies of Science and was separated from the educational activities of higher education institutions (Leišytė et al., 2018). Research institutes were state-funded, and the majority of their research and development activities were aimed at advancing the Soviet military and industry. However, whereas in other post-Soviet countries with a low business expenditure, such as the Czech Republic, Hungary, and Slovenia, public research institutes have continued to play a central role in research and development activities (OECD, 2016), after regaining independence from the Soviet Union, research institutes in Lithuania largely collapsed or were incorporated into higher education institutions, and the research activities within institutions were restored (The World Bank, 2003).

As shown in Fig. 12.3, there has been a profound shift in the share of R&D expenditure by sector of performance. While in the year of accession to the European Union in 2004, most of R&D expenditure, namely, 0.4%, was spent in the higher education sector, followed by the government sector with 0.2% and, finally, the business and enterprise sector with 0.16%, the latter has considerably gained in importance. In 2018, most of the research and development expenditures, namely, 0.4% of GDP, were allocated to the business and enterprise sector, followed by 0.3% in the higher education sector and 0.2% in the government sector. The turning point, at which more R&D expenditure was spent in business and enterprises than in higher education institutions, was reached in 2017.

Research and development in Lithuanian higher education institutions is financed by a variety of bodies, including the Lithuanian Research Council via project funding; the Ministry of Education and Science via research funding, coverage of administrative costs, and PhD studies; the Ministry of Economy via its Agency for Science, Innovation, and Technology (MITA) which issues project-based funding and innovation vouchers; other international sources, especially the EU; and the industry and business sector. The MITA innovation vouchers are issued to companies seeking to conduct joint R&D projects and activities with research institutions and thus are

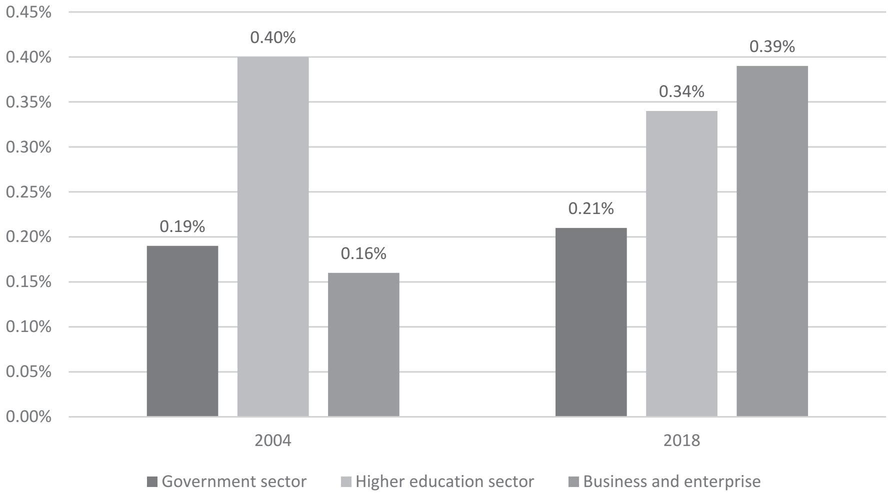

Fig. 12.3 R&D expenditure as percentage of GDP by sector of performance in Lithuania in 2004 (year of accession to European Union) and 2018. (Source: Eurostat, 2020c)

aimed at stimulating cooperation between the business sector and higher education institutions. Yet, according to the 2018 European Innovation Scoreboard, public-private co-publications in Lithuania remain at 30% of the EU average.

An analysis of recent policy documents reveals that the main task of the HE sector with regard to the establishment of a knowledge economy remains to be fulfilling labour market needs. The 2016 evaluation of the strengths and weaknesses of Lithuanian research and innovation by the OECD claims that while technology transfer and research commercialisation structures exist in Lithuania, they remain unconnected to universities and do not reflect academic culture and practices (OECD, 2016). This is supported by academic literature, which shows that, traditionally, entrepreneurialism has been supported by neither legal frameworks nor governance structures or cultures of universities in Lithuania (Binkauskas, 2012). The government tries to increase the input of the university sector into the knowledge economy, mainly allocating EU funds for research and university-business collaboration. One of the major projects in this area was the investment of €299 million for the development of five science valleys in Vilnius, Kaunas, and Klaipėda. However, as discussed above, the valleys did not bring the expected results, and their capacities are not used effectively (Valstybės kontrolė, 2017). Recently, we observed the establishment of projects at Lithuanian universities which aim to implement more effective technology transfer structures, underline the importance of commercial potential of research findings, and increase the financial returns for universities. However, the extent to which these projects will help to bridge the gap between existing transfer structures and academic culture and practices remains unclear at the moment.

Characteristics of the Lithuanian Higher Education System

This section provides an overview of characteristics of the Lithuanian higher education system, including information on its distinctive historical development, its structural characteristics, the organisation of PhD studies, as well as academic careers and career progression.

Historical Context

Lithuanian higher education has a long history, dating back to the establishment of one of the oldest universities in Europe in 1579, Vilnius University, in the country's capital. However, the development of the Lithuanian higher education system was subject to the turbulent historical and political events in the centuries that followed, including a shut-down of Vilnius University and the banning of the Lithuanian language under the rule of the Russian Tsar from 1831 to 1919, annexation of Vilnius and the surrounding area by Poland after the end of World War I, and, finally, incorporation of Lithuania into the Soviet Union from 1940 to 1941 and then again from the end of World War II to 1990. During the Soviet rule, the Lithuanian higher education system was restructured according to a Soviet model of higher education. Higher education institutions became subject to centralised, Soviet state control. They were restructured to meet the educational needs of the Soviet agricultural and industrial sectors and confined to teaching based on state-controlled curricula, whereas research activities were separated from higher education activities and took place in research institutes and the Academy of Sciences (Leišytė et al., 2018).

At the end of the Soviet era, the Lithuanian higher education and research system consisted of only one university, one music conservatory, five institutes, four academies, and one Higher Party school, but witnessed a relatively high enrolment ratio (33.25% in 1990) (Leišytė et al., 2018). After the restoration of independence in 1990, the autonomy of universities was restored, the most significant steps being the approval of the Status of Vilnius University in 1990 and the Framework Law on Higher Education and Science in 1991 (Leišytė et al., 2018, 2019), and universities began to conduct research again. During the following decades, Lithuanian higher education has been subject to profound transformations. The higher education system underwent enormous expansion and moved from an elite to a mass system with free higher education for eligible candidates, increasing student numbers and institutional diversification due to the recognition of private as well as non-university higher education institutions.

Structural Characteristics

To date, Lithuanian higher education is organised in a binary system with (both public and private) university and non-university (college) higher education institutions. Colleges offer professional bachelor degrees, while masters and doctoral studies are only offered at universities. Relative to its population size, Lithuania has a large number of higher education institutions. The number of higher education institutions peaked in 2015 with a total of 22 universities (14 public and 8 private) and 24 colleges (13 public and 11 private) (Leišytė et al., 2019). Since 2000, there have been two significant waves of reforms, one including the introduction of the binary system in 2000 and one following the 2009 Higher Education Law, which introduced more competitive funding and enhanced the autonomy of universities, granting them a new legal status.

As a consequence of decreasing student numbers and increasingly performance-based funding mechanisms, the competition between higher education institutions has drastically increased since 2009. Calls for a consolidation of the system arose, and with a change of government in late 2016, plans for downsizing the higher education system through institutional mergers, decreasing the number of study programmes, and stricter criteria for state-funded study places for high school graduates were introduced. At the time at which the survey for the "Academic Profession in the Knowledge-Based Society (APIKS)" project was conducted (October to January 2018), some mergers were already taking place, while others were in discussion. Framing mergers as a means to achieve higher quality at first and then resorting to arguing that the survival of higher education institutions was at stake; the Ministry of Science and Education promised financial rewards to institutions that would agree to merge. Until the end of 2018, 1 merger had taken place, reducing the size of public universities in the Lithuanian higher education system to 12. In addition, there were 7 private universities, 12 public colleges, and 10 private colleges, resulting in a total of 41 higher education institutions. Another merger of the oldest Lithuanian university, located in the country's capital—Vilnius University—and a regional university, Šiauliai University, was planned and completed by early 2021. Other previously planned mergers—between Vilnius Gediminas Technical University and Mykolas Romeris University and between Lithuanian Sports University and Lithuanian University of Health Sciences—were cancelled as they were heavily opposed by the academic communities (Delfi, 2019; Diena, 2020).

The service role of universities is embedded in the 2009 Law on Higher Education and Research, which states that the key missions of universities are providing studies, conducting research; contributing to regional and national development, and developing members of society receptive to scientific knowledge. External institutional evaluation monitors the implementation of the service mission, as one of the evaluation criteria is the regional and national impact of HEIs. The qualification requirements for the academic staff also include activities of cooperating with media, delivering public lectures, and using other means of spreading scientific knowledge to general public. Therefore, the service role of HEIs is manifested on national, institutional, and personal levels. Some universities provide free legal and psychological consultancy for local communities, and some schools are affiliated with universities and colleges. University specialists also consult local municipalities. However, cooperation with politicians on a parliamentary level takes place only episodically.

Academic Careers

In the academic year 2018/2019, 9247 academics were employed at Lithuanian universities (Table 12.1) The vast majority of them (8958) were employed at public institutions. Academics can be divided into two groups—those engaged in both research and teaching activities, such as full professors, associate professors, lecturers, or assistants, and those who hold positions for research only, namely, senior researchers, associate senior researchers, researchers, and junior researchers. Males and females are represented quite equally across academic positions at Lithuanian universities.

Academic careers in the Lithuanian higher education system are characterised by short employment periods. This is especially applicable to lecturers, whose contracts are usually awarded for no longer than a year. Longer contracts are provided to professors after they have successfully re-applied to their position two times; however, they still must submit to an evaluation of their performance at least every 5 years. As such, positions are not permanent in a sense that it is understood in many other countries, but nevertheless, a high disposition towards hiring people from within the same institution leads to the fact that up until now, it has been highly common for Lithuanian academics to remain at one institution throughout their careers.

Table 12.1 Number of university staff in the academic year 2018/2019 by academic rank

Academic rank	Number of university staff (2018/2019)
Full professor	1262
Associate professor	2179
Lecturer	3081
Assistant	1203
Senior researcher	218
Associate senior researcher	319
Researcher	464
Junior researcher	513
Other	8
Total	9247

Source: Information provided by the official statistics department of Lithuania

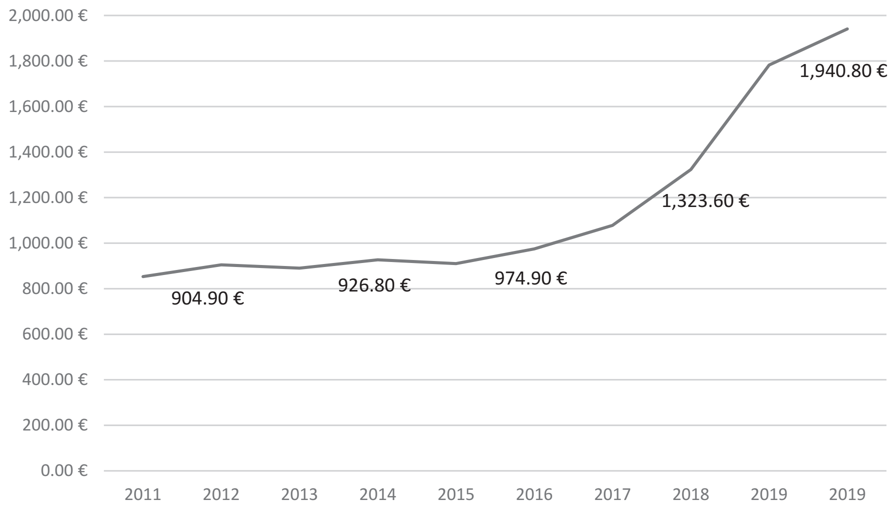

Fig. 12.4 Average monthly salaries of Lithuanian academic staff in € before taxes. (Source: Statistics Lithuania, 2019a)

Figure 12.4 shows the average monthly salaries of academics in Lithuanian higher education institutions before taxes. Overall, a significant increase of the average salary can be witnessed, especially between 2017 and 2019. However, since their legal status was changed in 2012, universities can set the salaries of their staff autonomously and have pursued different policies of increasing salaries. Therefore, salaries differ between institutions as well as by academic rank. In addition to their regular salaries, academics can receive bonuses of up to 100% based on their performance (e.g. teaching hours, supervision of dissertations, excellent publications) and can also work in externally funded projects and earn up to 50% additional remuneration here. Under certain circumstances, the total salary of Lithuanian academics can thus be two to three times higher than their base salary. Moreover, Lithuanian academics have been known to work for several employers, sometimes even taking a full-time position at one university and a part-time position at another. However, with the decrease in the number of students and the mergers that took place, such practices have become less common, and many academics are struggling to secure a full workload and thus their base salaries.

Low salaries have previously been identified as one of the main barriers to incoming academic mobility (e.g. Leišytė & Rose, 2016; Rose & Leišytė, 2017). Despite the increase in the past years, salaries of Lithuanian academics are lower not only compared with their international peers but also compared to salaries paid in the Lithuanian private sector, which poses an additional challenge for the recruitment of staff to the Lithuanian higher education sector. An innovation strategy document released by the Parliament in 2016 recognises these challenges and aims to "provide competitive salaries to Lithuanian researchers in order to strengthen the scientific potential" and to "reform the system of evaluation and financing of scientific activities, based on international indicators of monitoring of scientific and innovative activities" (Parliament of the Republic of Lithuania, 2016, p. 5).

According to the European Innovation Scoreboard (European Commission, 2018a, b), Lithuania performs least well with regard to the innovation dimension "Attractive research system". Data show that while the population with tertiary education in Lithuania lies far above EU average, there are few doctoral graduates and very few foreign doctoral students. While the rate of Lithuanian academics co-publish with international colleagues is moderate, the citation rate of publications is far below the EU average.

Since 2009, the Lithuanian government has attempted to enhance the quality and effectiveness of higher education and research by increasingly implementing performance-based funding, granting higher degrees of institutional autonomy to higher education institutions, and enhancing the role of the Research Council of Lithuania in research evaluation. As Lithuanian universities gained more autonomy to manage their assets and resources and pursue strategic interests, a shift of collegial structures and processes towards market-oriented processes of standardisation and performance management took place, and many universities have implemented point systems built on quantifiable criteria that are used as a basis for academic promotion and re-appointment decisions (Leišytė et al., 2017). At the same time, pressures for internationalisation became apparent in the development plans of the Ministry of Education and Science and through the acceptance of double-degree programmes, the promotion of English language programmes, and an increasing number of agreements between Lithuanian higher education institutions and institutions abroad (Leišytė et al., 2018).

Plans to enhance the quality of research have also led to changes in doctoral training in the Lithuanian higher education system. In contrast to many other countries, quality concerns were not tied to rapidly increasing numbers of doctoral students. In contrast, since the mid-2000s, fewer and less qualified students have chosen to take up doctoral studies due to adverse demographic trends and non-competitive salaries (Želvys, 2007). After a governmental decree aimed at reforming doctoral training in Lithuania in 2010, the Research Council plays a more prominent role not only in the evaluation of research but also in evaluating an institution's capability to award doctoral degrees. Doctoral training, which traditionally takes place at the departmental level, is now more commonly organised at the committee level, and these doctoral committees can include academics from several departments or even different institutions to ensure that a critical mass of established researchers in a field is engaged in the provision of doctoral training. In 2018, 2.2% of students enrolled in tertiary education are doctoral students, which is considerably lower than the EU average, which amounts to 3.8%. The total number of doctoral students has remained relatively stable between 2015 and 2018 (2737 and 2720, respectively, of which approximately 55% are female).

Lithuanian PhD candidates are students but receive a monthly stipend which is usually based on government funding. Industry funding for PhD students remains limited. In line with salaries for other academic positions, governmental stipends were very low (less than €400 per month), but they have recently been increased nearly twofold to €722 per month for first-year doctoral students and €836 per month for second- to fourth-year doctoral students. Previous research has shown that it may be difficult to retain PhD graduates in high-tech fields, such as laser technology and biotechnology, as salaries in the respective industries are much higher. Nevertheless, research positions in the non-academic R&D development sector are very rare, and, therefore, the majority of PhD graduates remain in academia (Leišytė & Van Hoed, 2013). In 2018, 18,000 persons were employed in academic R&D institutions, 8000 of which had academic degrees. In the business sector, 6100 persons were engaged in R&D activities, 476 of which had academic degrees (Statistics Lithuania, 2019b). Due to funding programmes by the government and Research Council of Lithuania, there has been increasing outgoing mobility of PhD students over the past years, while the intake of international PhD students has remained very low.

Conclusion

In this chapter, we have provided an overview of policy developments for research, development, and innovation in Lithuania as well as of the structure and functions of the Lithuanian higher education system and its role for the national knowledge production. Over the last century, Lithuania has undergone huge political, economic, and social changes. Since the restoration of independence in 1990, the Lithuanian higher education system has been subject to profound transformation and has moved from an elite to a mass system, including a rapid expansion in terms of both student numbers and number and types of higher education institutions, until the late 2000s. Reforms were furthermore influenced by Europeanisation through the Bologna process and accession to the European Union in 2004, leading to the first long-term strategies for economic development and R&D.

Lithuania has the potential for a strong and successful research, development, and innovation system. It is one of the fastest-growing economies in Europe and has a high share of tertiary graduates across all fields, including science and technology. Due to the availability of European Union Structural Development Funds, higher education institutions have been able to develop a stronger research infrastructure. In 2008, a science valley programme with the aim of establishing geographical concentrations of research infrastructure and providing conditions for active cooperation between business and science was introduced. However, the country still faces a number of challenges. It lies far below EU average concerning the number of knowledge and technology-intensive companies and has relatively low expenditures on research, development, and innovation as a percentage of its GDP. Furthermore, there are reports of a mismatch between higher education graduates' skills and economic needs, and policies for research, development, and innovation in Lithuania have been criticised for a lack of coordination between the relevant ministries, leading to a fragmentation of policies and instruments. Additionally, Lithuania is facing the serious challenge of demographic decline and high rates of emigration, especially among young Lithuanians.

Instead of knowledge society, Lithuanian policy documents usually employ the term “learning society”. This term was adopted due to its more dynamic nature and the fact that it does not focus solely on economic development but extends to the empowerment of individuals and civil society. The latter is deemed especially important in countries undergoing transformation towards democracy, free markets, and liberal education, such as Lithuania following the restoration of independence in the 1990s (cf.: Jucevičienė & Karenauskaitė, 2003). Our review of policies, strategies, and programmes for research, development, and innovation suggests that the Lithuanian government has also taken steps to increase the contributions to the knowledge economy, the most prominent examples being the establishment of the so-called science valleys, which act as centres for entrepreneurship and technology transfer. Yet, existing reports and literature suggest that technology transfer structures remain largely ineffective, largely because of the lack of specialisation and incompatibility of the services offered with academic cultures and practices. This is in line with the statistical data presented in this chapter, which suggests that the role of the higher education sector in both the provision of funding for and performance of research and development has decreased in comparison to the business and enterprise sector in the past years. To this point, it remains unclear to what extent existing initiatives designed to make technology transfer structures more effective and increase market-oriented processes within universities, including the management of academic performance, will be effective.

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Liudvika Leišytė is Professor of Higher Education and Vice-Director at the Center for Higher Education at the TU Dortmund University, Germany. Research interests include higher education governance and management, changing academic work, digitalisation of universities, and higher education policy. She received the 2018 Emerald Literati Award for the highly commendable article in the journal *Learning Organization*. During her postdoctoral study at Harvard University, she won the early career paper award at the 2008 PRIME conference. She has published five books, has written numerous chapters and articles in renowned higher education journals, and is a member of six editorial boards.

Anna-Lena Rose is a researcher at the Professorship of Higher Education, Center for Higher Education, and a PhD student at the Faculty of Business and Economics at TU Dortmund University, Germany. Her PhD project is titled "The Emergence of Interdisciplinary Structures in Academic Project Settings." Her research interests also include organizational change in universities, changing academic work, academic mobility, and entrepreneurship education.

Rimantas Želvys is Head of the Education Policy Centre and Professor of Education at the Institute of Educational Sciences, Vilnius University in Lithuania. His research interests include education management and policy, development of higher education, and education reforms. He is an author of more than 80 scientific publications, and 6 books and monographs. Previously he worked as an expert and consultant for the World Bank, OECD, and the European Commission for educational projects in post-socialist Eastern European and Central Asian Countries.

Sude Pekşen is a researcher at the Professorship of Higher Education, Center for Higher Education, and a PhD student at the Faculty of Business and Economics at TU Dortmund University, Germany. She holds a master's degree in sociology with a focus on comparative sociology and transnationalisation from the University of Duisburg-Essen, Germany. In her PhD dissertation, she investigates the digitalisation of higher education access. Her research interests also include comparative higher education organisation and the academic profession, focusing on gender and diversity.

Chapter 13
Academic Profession for Knowledge Society in Estonia

Eve Mägi, Eneli Kindsiko, and Maarja Beerkens

Abstract The academic environment in Estonia went through a major transformation over the last three decades. The dissolution of the Soviet Union meant a structural change in the organization of the higher education and science system, and it required a rapid reorientation towards a western scientific community and to the needs of a drastically changed economy. Estonia seems to have an imbalance between a well-developed higher education and science system and a less developed innovation system. However, the case illustrates how a traditional view on *Research and Development* may be inadequate for a 'new economy' that is dominated by innovative start-ups and small enterprises. The future of the academic profession is another challenge. The ageing profile of the academic personnel shows the importance of financial measures as well as changes in career policy in order to ensure the attractiveness of the academic profession in the long run.

Keywords Academic career · Innovation system · Knowledge production · Research and development · Estonia

E. Mägi
Praxis Center for Policy Studies, Tallinn, Estonia
e-mail: eve.magi@praxis.ee

E. Kindsiko
Tartu University, Tartu, Estonia
e-mail: eneli.kindsiko@ut.ee

M. Beerkens (✉)
Leiden University, Leiden, The Netherlands
e-mail: m.beerkens@fgga.leidenuniv.nl

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Introduction

Estonia, as a former Soviet country, has gone through a fundamental transition over the last 30 years that included a major restructuring of nearly all political, societal, and economic institutions. The transition also affected the higher education and science sectors. It changed not only how the sector is organized but also its funding, student numbers, governance models, linkages with industry, and academic norms – virtually all aspects of the system. Emerging from this transition, Estonia became known for its rapid economic recovery; small, open economy; and public sector innovation including developments in 'digital government' (OECD, 2011). However, this rapid development has also brought new challenges as the country searches for ways of stimulating further economic growth and maintaining its leadership position in its current areas of strength. The advancement of knowledge-intensive industry is a key for further development, and the contributions of the knowledge sector, both in research and in higher education, are crucial. Many of the foundational conditions associated with further development are already in place. The country has a very strong education system, ranking consistently at the very top of the OECD's PISA study of secondary school students (OECD, 2016a) as well as the adults' literary test (2016b). It has an internationally competitive economy as measured by the Global Competitiveness Index (Schwab, 2018). The current challenge faced by Estonia is how to build on this strong foundation to take the next leap forward. Estonia is an interesting case study of a country that went through a major transition of the sector in less than one (academic) generation and is now faced with high societal expectations to bridge the gap and become one of the world's leading economies.

What have been the fundamental changes in the sector in the last 30 years? At the beginning of the 1990s, the Estonian academic system followed the Soviet academic model. This meant a Napoleonic system where research and higher education were separated: research was conducted in research institutes under the Academy of Sciences, and higher education was provided by universities. In the early 1990s, this model was replaced with the Humboldtian model where research and higher education are integrated in universities. The change occurred at least partly out of pure necessity. By the end of the 1980s and early 1990s, the economy was collapsing, and the government was operating under extreme financial constraints. Sustaining two types of organizations was simply not feasible. The integration was also supported by non-financial arguments. External policy advisors from abroad pointed to the benefits of cross-fertilization between the two sectors. After a somewhat gradual wave of merging research institutes with universities, the system was, to a large extent, turned around by 1995.

The transition concerned not only formal structures but, perhaps even more importantly, the 'softer' side of academia. Reorienting towards the West meant re-creating international cooperation and scientific networks from the beginning. Researchers needed to find other venues for publishing their work and adapting their work accordingly. Additionally, academic norms changed, such as requirements for career progress. International publications and being successful in competitive research funding schemes started to take priority. The collapse of the old economic structures and industry meant an end to existing linkages between research institutions and industry. These links needed to be reinvented. In short, the period of transition meant a considerable re-socialization for most academics over a very short period of time.

Major changes affected the higher education landscape. Opening up the higher education market for private providers meant a rapid increase in the number of higher education institutions. At its peak, Estonia had almost 50 universities to serve its total population of ca. 1.3 million people. This created a highly fragmented system where a quality of education could not be assured. On the other hand, the expansion made higher education accessible to many people who had previously been unable to obtain education due to a highly selective and elitist higher education system. With the new millennium, the higher education sector started to consolidate, and the government started to build up a robust quality assurance framework. Demographic decline was putting further pressure on private universities, contributing to consolidation.

Currently, the main challenges of Estonian academia are not much different from most other Western countries. Financial constraints to meet all societal expectations as well as an optimal allocation mechanism are important discussion points. More broadly, finding a balance between international scientific excellence and local societal needs is a familiar challenge to many small, non-English countries. Academic staff is expected to participate in a global research system while simultaneously contributing to locally relevant research puzzles and preserving teaching and research in the native language. Furthermore, Estonian academic staff is ageing rapidly – the majority (68%) are aged 40 or above, and a fifth (20%) are 60 or older (Mägi et al., 2019). Thus, the Estonian academic system needs to raise the attractiveness of an academic career among the younger cohort.

In this chapter, we will analyse the most important trends and challenges of the Estonian higher education and research system, particularly as relevant for the academic profession and knowledge economy. We will first look at the performance of the Estonian research, development, and innovation infrastructure and then discuss the higher education and science system specifically. In the last part of the paper, we will focus on the academic profession, particularly on the career models and early stage researchers. The chapter analyses the main characteristics of the Estonian knowledge system and hopes to provide some insight into how Estonian academia has been adjusting to changing societal expectations.

Research, Development, and the National Innovation System

The collapse of the Soviet economy in the beginning of the 1990s brought an end to the old innovation system. The gross domestic product (GDP) of the country dropped by 40% between 1991 and 1994, and most of the old industry vanished, particularly the research and development (R&D)-intensive components (e.g. industry linked to military). The Estonian economy recovered quickly, arguably with high social costs. The quick economic growth was largely based on foreign investments, mostly from neighbouring Nordic countries. Relatively low labour costs were a major factor for attracting foreign investment. As a result, the growth of the economy did not rely on R&D input, even though the country had a solid education and research system in place. This created a situation which the OECD country report described as an 'imbalance between a relatively well-developed system for education and research, and a much more poorly developed innovation system' (Huisman et al., 2007, p. 29).

After the first period of economic recovery, attention turned towards the development of a knowledge economy and innovation. The government's strategic plan for 2002–2006 set an explicit target of reaching 1.5% of GDP in total R&D expenditures by 2006. The strategy also built on the emerging strength of the Estonian innovative economy, such as information technology, biomedicine, and material technologies (Ministry of Education, 2001). The new strategy for 2007–2013 and the subsequent strategy for 2014–2020 increased the target even further. Strategy documents for 2014–2020 aimed to increase the share of R&D expenditure to 3% of GDP by 2020, from which 1% was expected to come from public funding and 2% from private sources (Ministry of Education and Research 2014). Yet, at the start of 2020, the Government of Estonia failed to increase the share of public funding in R&D to 1% due to other demands on public budget, and it remains at the level of 0.71%.

According to the European Innovation Scoreboard (2019), Estonia is a strong innovator. In terms of the private sector, Estonia has been marked as a good place to start and run a business, mostly due to well-developed e-services. It takes around 3 h to start a new company in Estonia, 98% of companies have been established online, and 95% of tax declarations are filed online (The Estonian Investment Agency, 2020).

R&D Funding and Employees

Comparing the Estonian performance in various R&D measures, it performs better than most former Eastern Bloc countries but is lagging behind the leading economies in Europe. More specifically, it performs better than its southern neighbours Latvia and Lithuania, but still significantly behind its northern neighbours Finland, Sweden, and Norway (Raudjärv & Pärson, 2018**).** In 2018, the expenditure on R&D in Estonia was 1.4% of GDP, which is much lower than the target set for 2020 of 3% (Table 13.1).

When focusing on R&D employees, the picture is rather similar. Around 1–2% of the employed population worked in R&D. Women and men are quite equally represented in the sector, with women accounting for 47% of the R&D labour force

Table 13.1 Expenditure on R&D in Estonia 1998–2018 (Statistics Estonia, 2020a)

	R&D expenditure			R&D personnel		
Year	% business sector	% non-profit (incl govern.) sector	Total ('000 EUR)	% business sector	% non-profit (incl govern.) sector	Total (# persons)
1998	20%	80%	28,822	12%	88%	6562
2000	23%	77%	37,032	14%	86%	6531
2002	31%	69%	55,698	17%	83%	6921
2004	39%	61%	82,702	22%	78%	7882
2006	44%	56%	150,994	29%	71%	8792
2008	43%	57%	208,040	31%	69%	9621
2010	50%	50%	232,760	32%	68%	10,074
2012	58%	42%	380,695	27%	73%	10,492
2014	44%	56%	286,736	28%	72%	10,492
2016	51%	49%	270,336	28%	72%	9234
2018	42%	58%	365,643	30%	70%	9479

in 2018. Focusing more narrowly on researchers, Estonia is somewhat below the European average; as of 2016, in the European Union, the average number of researchers was 8.1 per 1000 employed, while in Estonia it was 6.9 per 1000 (OECD, 2018a). Although Estonia employs more researchers than many other former Eastern Bloc countries, it employs far less compared with Nordic countries like Denmark (14.9 researchers per 1000 employed), Sweden (14.4), or Finland (14.3). Furthermore, the growth in the number of researchers has been rather modest. From 2006 to 2016, the number of employees grew from 5.5 to 6.9. For example, in 2006, Estonia was at the same level with Ireland (5.9 researchers per 1000 employed), but by 2016 Ireland had doubled the number of researchers (12.9).

Since re-independence in 1991, the increase in both the quality and volume of academic research in Estonia has been quite remarkable. After joining the European Union in 2004, the R&D infrastructure received considerable support from the EU Structural Funds (The Estonian Ministry of Education and Research, 2014). However, the overall share of expenditure per researcher is rather modest compared to many other countries. There is a sharp difference between the wages of researchers from the public sector as compared to those from the private sector. Between 2008 and 2018, the wages of private sector R&D employees in relation to the average wage in Estonia rose from 175% to 208%, whereas the wages of public sector R&D employees decreased from 125% down to 113% (Estonian Research Council, 2019). Low remuneration of public sector R&D employees has been one of the main challenges in the Estonian R&D system. The difference between the salary of public and private sector R&D personnel is partly explained by different distribution across fields of activities. For example, in 2018, the majority of private sector R&D staff worked in information and communication technology or manufacturing fields, which tend to have higher salaries, on average.

R&D and Economic Structure

The share of total R&D employees by sector has remained relatively consistent over time, with the higher education sector employing around 60%, the business sector around 30%, and government about 10% (Table 13.1). One of the reasons why most R&D employees are in the higher education sector might be explained by the overall structure of the Estonian economy. The Estonian economy is founded on a large share of microenterprises (93.9%) and small- and medium-sized enterprises (SMEs) (5.9%), coupled with a rather small share of large enterprises (0.2%)[1]. The large share of microenterprises can explain why there are a relatively low number of R&D employees in the business sector. Previous studies have signposted how both SMEs and microenterprises have less human resource to allocate to R&D activities, but they also lack good networks and have limited knowledge of possible financial support offered by government or the EU (Inan & Bititci, 2015; Abouzeedan et al., 2013). While innovation in large companies is built on R&D, innovation in SMEs depends more on clusters and networking and in microenterprises on technological improvements and addressing customer needs (Inan & Bititci, 2015). This pattern can also have implications for university-industry cooperation, since cooperation tends to take place between large- and medium-sized enterprises and universities, and there is less interaction with microenterprises.

The limited share of large enterprises in Estonia does not mean poor or diminishing R&D activities. Instead, what we can observe is a change in paradigm – a new understanding of how innovation and R&D takes place. Over recent decades, the contribution of SMEs and microenterprises to R&D has increased, but this is a phenomenon that is difficult to capture from country-level statistics (basing on the number of employees in R&D or funding on R&D activities). Innovation and R&D 'is no longer limited to corporate R&D labs, and is often the outcome of collaborative efforts in which businesses interact and exchange knowledge and information with other partners as part of broader innovation systems' (OECD, 2018c, pp. 4–5). Especially in science-driven fields like biotech and nanotech, being small allows flexibility and for work to take place outside of 'dominant paradigms' of R&D (OECD, 2018c). Despite its small size, Estonia has become a jurisdiction where numerous start-ups and tech-related companies emerge. Estonia is ranked third in Europe for start-ups per capita (right after Iceland and Ireland), with 31 start-ups per 100,000 inhabitants, which succeeds the EU average 6 times (Funderbeam, 2017, p. 7). The amount of funding that some of the start-ups have managed to attract from foreign investors is also impressive for a scale of a small country, e.g. *Transferwis*e (money transfer service) has received 116 million USD and *Skeleton Technologies* (ultracapacitor-based energy storage) has received 51 million USD (Funderbeam, 2017, p. 8). Most of the Estonian start-ups that have been able to attract external funds are technology focused. While large enterprises might have a separate

[1]According to Eurostat, microenterprises refer to enterprises with less than 10 workers and SMEs to enterprises of 11–250 workers.

department or unit that is solely focussed on R&D, SMEs and microenterprises operate differently – R&D activities may happen in less systematic ways, but this flexibility provides a space for more radical and open innovation. In this sense, traditional measures of R&D activities (e.g. counting the people that have been officially titled as R&D personnel by the enterprise) may not be capturing new trends within national research and innovation systems.

National Higher Education and Research System

The Estonian higher education system follows the principles of the European Higher Education Area and the Bologna Process. Education policy is largely shaped by the Estonian neoliberal approach and has included substantial changes in the funding of higher education and research, new academic career structures, changing labour market trends, and internationalization. The Higher Education Act of 2019 simplified and streamlined the regulations of higher education. The new higher education legislation increases flexibility for both institutions and students, by focusing on the goals of higher education rather than on detailed guidelines. Involving non-university members in the governance of universities is intended to strengthen the ties between higher education institutions (HEIs) and society. Non-university members have a larger share in university councils, which are involved primarily in strategic and financial planning. The law supports developments in career models and is aimed at motivating the choice of academic careers and enabling the creation of tenure positions. The classification of academic staff as teaching staff and research staff is no longer promoted.

There are two types of higher education institutions in Estonia: academic universities (*ülikool*) and professional higher education institutions (*rakenduskõrgkool*). The binary system consists of six public universities, one private university, seven public universities of applied sciences, and five private universities of applied sciences. While academic universities offer bachelor, master, and doctorate degrees, universities of applied sciences offer only bachelor degrees and to a limited extent, and based on a specific permission, master degrees. While formally there is no differentiation within the public academic universities as they all provide education at all academic levels and are engaged in research activities, the universities vary by size, fields of specialization, research intensiveness, and funding (Saar & Roosalu, 2018). In terms of both research and learning output, Saar and Roosalu (2018) differentiate between the University of Tartu, the comprehensive 'flagship' university of the country, two large universities (Tallinn University and Tallinn University of Technology) with a narrower profile, and other smaller (including the private) universities with significantly fewer students and a limited focus.

Similar to many other countries, Estonia experienced growing student numbers in the 1990s, which was partly accommodated by new private institutions. Interestingly, bachelor enrolment numbers have been consistently dropping in the 2000s. The primary reason behind the drop is the demographic change, i.e.

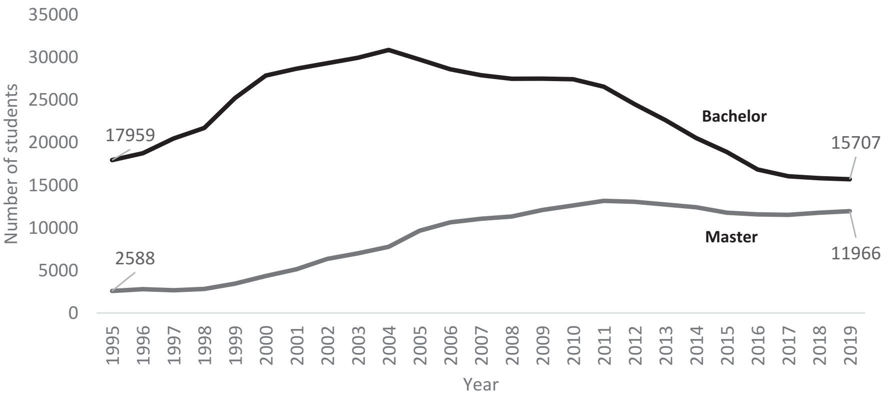

Fig. 13.1 Bachelor- and master-level enrolment in higher education, 1995–2019. (Statistics Estonia, 2020b)

declining and ageing population. Between 1995 and 2019, enrolment at the bachelor level decreased by 13%, while master-level enrolment grew by over 4.5 times as many students (Fig. 13.1).

Another interesting trend over the same 10-year period is the ageing of the student population. In 2018/2019, 45% of bachelor-level enrolments are filled by those 25 and older, whereas in 2008/2009, that number was only 37%. In Estonia, the average student is 26 years old (Haaristo et al., 2017), which is similar to Nordic countries (Hauschildt et al., 2015), while also setting Estonia apart from many European countries where the average age is less than 25. Thus, Estonian students are still at the master level when students in many other countries are already at, or even close to graduating, the doctoral level.

Since 2017, Estonia has been applying a revised funding model (created in 2013) in higher education which was intended to increase funding stability for HEIs. It made higher education tuition-free for all students in public universities. Before the reform, universities were allowed to admit fee-paying students next to regular tuition-free students. As stated in the Universities Act, universities receive baseline funding (at least 80%) and performance funding (up to the extent of 20%). The latter is allocated on the basis of performance indicators and an agreement signed with the Ministry of Education and Research. The most significant (35%) of the six indicators is the share of graduates who have completed their studies within the nominal term. Research funding in Estonia is primarily competitive and project based. The Estonian Research Council (ETAg) is the main body responsible for funding R&D, research mobility, and external cooperation. While the state is the main source for research funding, resources are also obtained from business, foreign funds, and other European Union initiatives.

The Academic Profession and Early Career Researchers

Dynamics in PhD Numbers

Between 1996 and 2019, doctoral enrolment numbers in Estonia have increased four times, from 569 to 2316. The number of doctorates as an essential ingredient for knowledge-based economy and society has been an important government priority. Due to the downward demographic trends in Estonia, the number of potential domestic PhD candidates is likely to decline (Eamets et al., 2014), and the additional supply will possibly come from international applicants. This, in turn, has created a societal discussion about future shortage of Estonian-speaking academics to teach in the national language, as well as to sustain Estonian as an academic language. The discussion is encouraged by increasing the number of master programmes taught in English and orientation towards international publishing in research.

Yet the major challenge is not the number of doctorates but the time that doctoral candidates take to finish their degree. The government has revised the funding system as well as sharpened quality assurance in order to improve PhD graduation rates. In 1996, for every graduation, there were 22 doctoral students; in 2019 that figure declined to 10 (Statistics Estonia, 2020a, b). While admissions levels have been relatively flat, the number of students enrolled in PhD programmes has been accumulating as time-to-completion rates increase.

Like its neighbouring Nordic countries, doctoral graduates in Estonia are among the oldest at the time of graduation – 36 years on average – with a sharp variation across study fields (Kindsiko et al., 2017). Numerous factors contribute to long periods of doctoral study. First, the monthly stipend for doctoral students as junior academics was first introduced in 2004, and the amount was 80% (383 EUR) of the average wage (462 EUR, gross salary) in Estonia. By 2019, the stipend had decreased to 47% (660 EUR) of the average wage (1407 EUR, gross salary). Although some universities pay extra to their doctoral students, monthly incomes tend to stay below average. More fortunate are the students who can work under a research grant managed by their supervisor. Because of low funding, many prefer to work also outside the university. This is especially the case for students in fields like law, economics, medicine, or ICT, as the expected wage for specialists from these fields tends to be several times higher than the PhD stipend. Work outside the university has been reported by the students themselves as the most important obstacle to their progress during doctoral studies (Eamets et al., 2014).

Considering the age of Estonian doctoral students, their studies tend to overlap with the time most people are planning to start a family. The responsibilities towards the family compete for both time and finances with educational responsibilities. Next to working outside the university, family duties are considered another major obstacle that inhibits progress towards completing doctoral studies (Eamets et al., 2014). Maternity/paternity leave does not increase the likelihood of dropouts, but it does extend the time period to achieve the degree. In the case of the birth of a child, both male and female students are eligible for maternity/paternity leave up to 3 years per child. Data obtained from doctoral candidates between 2003 and 2014 at the University of Tartu, the largest university in Estonia, illuminates some of the reasons why students extended their studies; slightly more than 50% of all students took academic leave, with larger numbers in the social sciences (68%) than the natural sciences (44%). A fifth (21%) took maternity/paternity leave, and a quarter (25%) took leave for health reasons. More than half (58%) of all students took their leave during the last nominal year of study (the fourth year).

Some fields like the social sciences or medicine enrol a large share of students who were admitted after several years working as practitioners outside the academic system, compared with students in the natural sciences who more frequently progress straight from a bachelor to a master's and finally to a doctoral degree through a linear pathway (Kindsiko et al., 2017; Kindsiko & Vadi, 2018). This trend has resulted in younger doctoral graduates in the natural sciences (average age 34 years), with older graduates in social sciences (39 years) and in humanities and the arts (41 years) (Kindsiko & Vadi 2018, p. 116).

The graduation requirements for the doctoral degree are rather strict compared to many other countries. In Estonia, a PhD can be earned either by publishing three internationally peer-reviewed academic journal articles with a supplementary chapter that connects these articles into a coherent framework or by publishing one internationally peer-reviewed academic article or book chapter and writing a full monograph. Considering the time it takes to publish an academic article, students struggle to fulfil the requirements within the nominal 4-year time period.

Career Patterns After Graduation

After graduation roughly 60% of doctoral graduates pursue an academic career, 30% combine academic and non-academic jobs (e.g. a medical doctor working in a hospital, but also teaching in university), and 10% pursue a non-academic career (Vadi et al., 2015). A study tracking the careers of graduates in 2000, 2005, and 2010 ($n = 389$) revealed that, when differentiated by discipline, graduates from the natural sciences are most likely to end up in academic careers (75% chose a full-time academic career track), while only 35% of graduates from medical and health sciences followed this route (Kindsiko et al., 2017, p. 69) (Table 13.2). Furthermore, over the years, the share of individuals moving to non-academic or combined careers has increased. In other words, there is a considerable variation in career patterns which seems to change over time.

Across European countries, Estonian academic staff is among the oldest. For example, the share of academic staff aged 60 and older in 2018 was 20%, just slightly lower than Bulgaria and Latvia at 25% (Eurostat, 2020). This may be related

Table 13.2 Dominant career patterns of PhD graduates, by field (Kindsiko et al. 2017, p. 69)

Discipline	Academic	Combined	Non-academic
Natural sciences	75%	10%	15%
Agricultural and veterinary sciences	70%	–	30%
Humanities and the arts	60%	15%	25%
Social sciences	45%	45%	10%
Engineering and technology	40%	35%	25%
Medical and health sciences	35%	45%	20%

to the fact that the entry to the academic career (the graduation of doctoral studies) begins at rather high age. Thus, academic staff stays longer with the system, while the academic career is losing its attractiveness among younger generations due to both the decreasing prestige of the profession and low remuneration compared to the private sector alternatives (Kindsiko & Vadi, 2018).

The Evolving Academic Reward System and the Trajectory of Career Progression

There were 3897 academic staff members in HEIs in the 2019/2020 academic year, as registered in the Estonian Education Information System (2020). There is no national planning policy for academic staff working in higher education. The government approves the higher education standard which establishes uniform requirements for their academic degree, educational qualification, research and development activity, student supervision, pedagogical skills, and professional experience. HEIs may establish additional requirements if needed to achieve their objectives and/or learning outcomes of the curriculum. The employment contracts of academic staff are filled through an open competition, and all candidates are considered equally.

The funding of Estonian R&D activities relies heavily on project-based funding, which is estimated to be around 73–96% of total funding (Koppel, 2016; Ukrainski, 2016). In 2011, Estonia was the OECD country with the largest share of project-based research funding (OECD, 2014). This has been, and continues to be, one of the biggest challenges for Estonian R&D, especially in terms of research conducted by universities. The great reliance on project-based funding has minimized the employment security for many research groups, decreasing attractiveness of an academic research career – especially in terms of securing a new generation of academic researchers (Kindsiko et al., 2017). Estonian academic researchers have been especially successful in gaining Horizon 2020 grants; the success rate has been 13.92%, while the EU average is just 12.16% (European Commission, 2020). This is largely incentivized by very low financial support from the government and so the EU funding is crucial, especially for researchers working in universities. Universities have been successful in gaining financial support for building up their research infrastructure (e.g. top-level laboratories and machinery), but providing competitive wages to its academic staff continues to be a challenge. Even more importantly, temporary work contracts that are linked to the grant funding seem to lead to the fact that job satisfaction is lowest among top researchers (Mägi et al., 2019). Low salaries may be one of the reasons why Estonia has found it difficult to increase its share of employed researchers. The salaries of higher education teaching staff differ according to position, workload, number of years worked, and qualifications. Actual income is also dependent upon participation in various R&D-related projects.

As in other countries, the academic appraisal system in Estonia is strongly based on international publications. This has led to questionable side effects in terms of both academic careers and academic roles. The strong reliance on academic articles as the measure of productivity does not support an atypical career path, for example, movement between industry and academia (Kindsiko & Vadi, 2018; Blackmore & Kandiko, 2011). Studies among doctorates in Estonia have revealed how this reward system is strongly disencouraging people from fields like law, medicine, ICT, and economics to consider the academic career track (Kindsiko & Vadi, 2018). As these areas of expertise are highly valued by the non-academic labour market, if graduates had to choose which career track to stay on, non-academic careers would frequently have priority over academic career – decisions that could lead to shortages of academics working in certain fields (Kindsiko & Vadi, 2018). For academics with higher teaching loads, the emphasis on publications also limits the possibilities for advancement and promotion. Furthermore, the research-based appraisal system is likely to divert attention from teaching activities to research activities, and evidence seems to indicate that, over time, academic staff have started to spend more time on research activities and less on teaching activities (Mägi et al., 2019).

The distribution of academic positions by gender highlights a rather equal gender division at the junior and middle levels, but at the top there is a sharp overrepresentation of men. While at the junior level (i.e. lecturer) the proportion of women is 50%, in the top position (i.e. professor), the proportion drops to 24% (Universities Estonia, 2018). Differences between male and female academics are evident in other aspects; male academics are more often involved in external activities, with the exception of volunteer-based work/consultancy which is more prevalent among women (Mägi et al., 2019).

Recent Changes in Academic Career Progression

Recent studies on academic careers in Estonia have revealed that individual career-related decision-making is influenced considerably by situational aspects, such as the current state of affairs on both the academic and non-academic labour market, and so PhDs from different cohorts are exposed to radically different career-related opportunities (Kindsiko & Vadi 2018). The aftermath of post-Soviet era and re-independence in 1991 triggered large-scale restructuring both in higher education and in the academic career system (Kindsiko & Vadi, 2018). The countries entered the English language-based global academic competition with huge disadvantages,

Table 13.3 Academic career of doctoral graduates from 2000 and 2010 (Kindsiko & Baruch, 2019, p. 130)

Graduation year	3 years after graduation			5 years after graduation		
	Junior	Middle	Top	Junior	Middle	Top
2000	40%	55%	5%	30%	56%	14%
2010	67%	31%	2%	52%	45%	3%

Notes: TOP (e.g. full professor); MIDDLE (e.g. associate professor); JUNIOR (e.g. lecturer); *n* = 389 individuals

and they had to catch up with a more research-oriented Western Europe (Kwiek, 2017). Considering the situational differences compared with rather stable Western countries (e.g. the UK or Germany), academic career trajectories in Estonia, as in other post-Soviet countries, reveal how 'even a decade or two can reflect dramatically sharp differences in what a career will be like' (Kindsiko & Vadi, 2018, p. 114).

A study tracking the career progress of 389 Estonian doctoral graduates between 2000 and 2010 revealed how graduates from the year 2000 experienced a rather atypical and fast career progression, where some obtained top positions (e.g. full professorship) within the first 2–5 years after gaining their degree (Table 13.3). However, graduates from 2010 faced a much slower career progression, and a few had been appointed to a full professor position 10 or more years after the degree (Kindsiko et al., 2017).

The fast career progression of those joining PhD programmes in the 1990s and graduating around the start of the 2000s took place in the middle of large-scale reforms and restructuring of higher education. Once the previously banned research fields were re-opened (e.g. political sciences) or largely reformed (e.g. economics), it created unique openings and very fast career progression for those graduates who transitioned into an academic career. In other words, as Stephan and Levin (2015, p. 58) note, 'the 60-year-old is not only 25 years older than the 35-year-old but was also born in a different era when values and opportunities may have been significantly different'. The numerous waves of higher education and research system reforms created remarkably different and often non-comparable conditions for starting academics.

Conclusion

Estonia has managed to successfully transform its research and science system in a relatively short time period. The transformation has touched upon all aspects of the system, from formal, organizational structures to academic norms and networks. The country now faces the next challenge: how to move forward to become one of the leading economies of the world. This requires further development of knowledge-intensive, innovative industry and places high expectations on the higher education and R&D system. Adequate financing of the system is an important issue. Although public funding has been continuously growing, the total R&D expenditure is far from the targeted 3% of GDP. While research infrastructure has been improving rapidly to catch up with world-class laboratories, salary levels are not competitive. The relatively low salaries provided to PhD students seem to have a negative effect on time-to-completion rates and delay the entrance of new talent into the academic labour market. As in many other countries, the model for distributing research funds is under debate. The very large share of funding focused on specific projects rather than larger programmes of research, creates instability in the system, and may discourage the long-term development of research excellence.

Estonia is attempting to address the challenges of the new environment – the knowledge economy and the knowledge society. Will supporting research and innovation in this new economy require a different approach than simply supporting traditional industrial R&D labs? The current research funding system is dominated by the idea of competitive research project funding, which until now has arguably served the transformation of the research system very well; but should a new approach be adopted to provide greater stability and encourage the best graduates to pursue academic careers? It is also clear that the national research and knowledge system – particularly in such a small country as Estonia – is subject to global competition and continuous effort must be paid to sustaining and strengthening this complex and essential system. Furthermore, there are questions about the identity and sustainability of the Estonian academic space, typical to a small country. While internationalization has made a major contribution to the development of the Estonian knowledge system, a tension between international excellence and sustainable, domestic contribution of the science system still remains.

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Eve Mägi is PhD student at the University of Tartu. She teaches courses on international education and didactics. Her research interests include teaching and learning, curriculum design, international education, and the research-teaching nexus, but her scope of work also includes inter-disciplinary studies. Eve is the leader of the education policy programme at the Praxis Center for Policy Studies. She is the country expert in professional networks such as SIRIUS and NEPC, and a leader in various international teams, such as EUROSTUDENT. She has authored many country reports on education in Estonia and she serves as an expert in a number of projects of the European Commission.

Eneli Kindsiko is Associate Professor in Qualitative Research at the School of Economics and Business Administration, University of Tartu, Estonia. Eneli's current research focusses on the academic labour market, particularly on its uniqueness and peculiarities, as well as on academic career in non-English and small countries like Estonia. She has published a monograph, *Organisational Control in University Management: A Multiparadigm Approach* (Emerald, 2018), and a number of academic articles and reports on academic careers, recent PhD graduates, and university management.

Maarja Beerkens is assistant professor in international governance at Leiden University, the Netherlands. Her research covers a wide range of issues in higher education and science policy, from quality assurance, research management and internationalisation to student experiences and teaching practices. Her book *Public Policy for Academic Quality: Innovative Policy Instruments* (co-edited with D.D. Dill) examines an interaction between state-centred, market-based, and self-regulatory instruments in higher education quality assurance. Her interest in policy-relevant research is expressed in her involvement in various advisory projects for the European Union, World Bank, and national governments in and outside of Europe.

Chapter 14
Higher Education and the Knowledge Economy: Economic Higher Education Policies and the Persistence of the German Research and Development System

Nicolai Götze

Abstract This chapter outlines the institutionalization of a knowledge economy in Germany, clarifies the role of the higher education sector in the national research and development (R&D) system, and outlines the policies designed to strengthen the relations between higher education and the economy. As an analytical scheme, two distinguishable ideal-typical relationships between higher education and the knowledge economy in Germany are elaborated: "higher education *for* the knowledge economy" and "higher education *in* the knowledge economy." A clear reform-induced change in the higher education system has been observed, primarily for higher education *for* the knowledge economy (e.g. through higher education expansion). Since the 1990s, increased political efforts have been made to place universities in the knowledge economy by pushing the commercialization of knowledge. However, there is no clear evidence of the impact of policies that position higher education *in* the knowledge economy. In general, the German R&D system is characterized by a high degree of institutional stability.

Keywords Academic career · Excellence Initiative · Innovation system · Germany · Triple-helix

N. Götze (✉)
International Centre for Higher Education Research Kassel, University of Kassel, Kassel, Germany
e-mail: goetze@incher.uni-kassel.de

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Introduction

Conceptualizations of the knowledge economy generally assume that knowledge is becoming the central factor in economic development. In this context, higher education policy aims, above all, to promote economic growth. In this context, a growth policy emerges in which research and higher education policy is treated as a "subset" of economic policy (Olssen & Peters, 2007). This chapter outlines the institutionalization of a knowledge economy in Germany, clarifies the role of the higher education sector in the national research and development (R&D) system, and outlines the policies designed to strengthen the relations between higher education and the economy. Two theoretically derived (ideal) types of relations between higher education and the knowledge economy are discussed: "higher education *for* the knowledge economy" and "higher education *in* the knowledge economy." The German higher education system is a federal system. The state merely sets the legal framework, while the federal states are responsible for shaping university policy. Nationwide programs must therefore be coordinated with the individual states. This chapter aims to show the relationship between universities and the knowledge economy for the whole of Germany. In keeping with the saying "same but different," clear national developments can be identified although the intensity of these developments may vary from state to state.

The German Research and Development System

The research and development (R&D) system in Germany consists of three central pillars:

1. The mainly publicly funded higher education system, characterized by the binary divide between public universities and Universities of Applied Sciences (UAS)
2. Public nonuniversity research institutions (Max Planck Society, Helmholtz Association, Fraunhofer Society, Leibniz Society, and ministerial research institutions)
3. Research and development facilities in companies and industry

The division of labor between these pillars emerged over time and has remained relatively stable until today. Universities have been assigned a major role in basic research and science-based teaching though there are some exceptions that will be discussed later in the chapter. Under current state laws, the core function of universities is to foster the development of science. Despite the narrative of the knowledge society and knowledge economy, in which knowledge production at universities is aligned with social and economic needs, universities are historically framed as organizations with a "high degree of organizational autonomy from outside interests" (Bleiklie et al., 2013, p.1) and still have a strong theoretical and intellectual emphasis (Teichler, 2008). Universities of Applied Sciences, on the other hand, are primarily oriented toward the practical application of scientific knowledge. Historically, they have been institutionalized primarily as teaching-only organizations. At present, however, greater emphasis is being placed on application-oriented research, particularly research and development in companies and industry, with a focus on economic exploitation. The orientation of nonuniversity research institutions is highly differentiated. The Max Planck Society (founded in 1949) focuses primarily on disinterested basic research. It receives a global budget from the state and, therefore, has a high degree of autonomy and self-governance (Dusdal, 2017). The Fraunhofer Society focuses on application-oriented and industry-related research. It mainly conducts program research in which the goals of the clients, who in part also finance the research, come first (Dusdal, 2017). The Helmholtz Centers are specialized in "big science" (de Solla Price, 1963) with complex equipment infrastructure. Here, so-called precautionary research is conducted, which is thematically located in the fields of climate, energy, or materials research (Knie & Simon, 2010). The Leibniz Association is a heterogeneous association of institutes, ranging from multidisciplinary, application-oriented basic research to the provision of science-based services. The so-called "Ressortforschungseinrichtungen" can be characterized as research institutions subordinate to the ministries, which carry out "research by political decision" (Lundgreen et al., 1986, p. 20) and are subordinate, in this sense, to the state and political needs for action and decision-making (Barlösius, 2016) (Fig. 14.1).

Since the 1990s, the balance between these pillars has been very stable. If one assesses the weight of the pillars along with the R&D expenditures, the business sector is the largest; in 2018, spending on R&D in the business enterprise sector accounted for over two-thirds (69%) of all R&D expenditures (OECD, 2020). This is followed by expenditure in the higher education sector at 18%. Government spending, which mainly represents nonuniversity research, accounted for 13% of expenditures. Overall expenditures on research and development as a share of gross domestic product have increased moderately over the last three decades, from 2.6% (1990) to 3.1% (2018). This level of growth is quite modest compared to the increase between the 1950s and the 1970s, when both public and private investment as a share of GDP more than doubled (Kölbel, 2002). Nevertheless, the data show that research and development in Germany is still growing in importance; however, the more recent growth in R&D has taken place without any clear sectoral shifts, in contrast with developments between the 1950s and 1970s, which was characterized by a clear movement from public to private investment in R&D (Kölbel, 2002). The division of labor in the German innovation system is clearly structured and, historically, very stable. As de Weert (2011) points out, the German innovation system is thus characterized by a clear sectoral innovation chain: "The core competences of this innovation chain have been clearly assigned" (p.114).

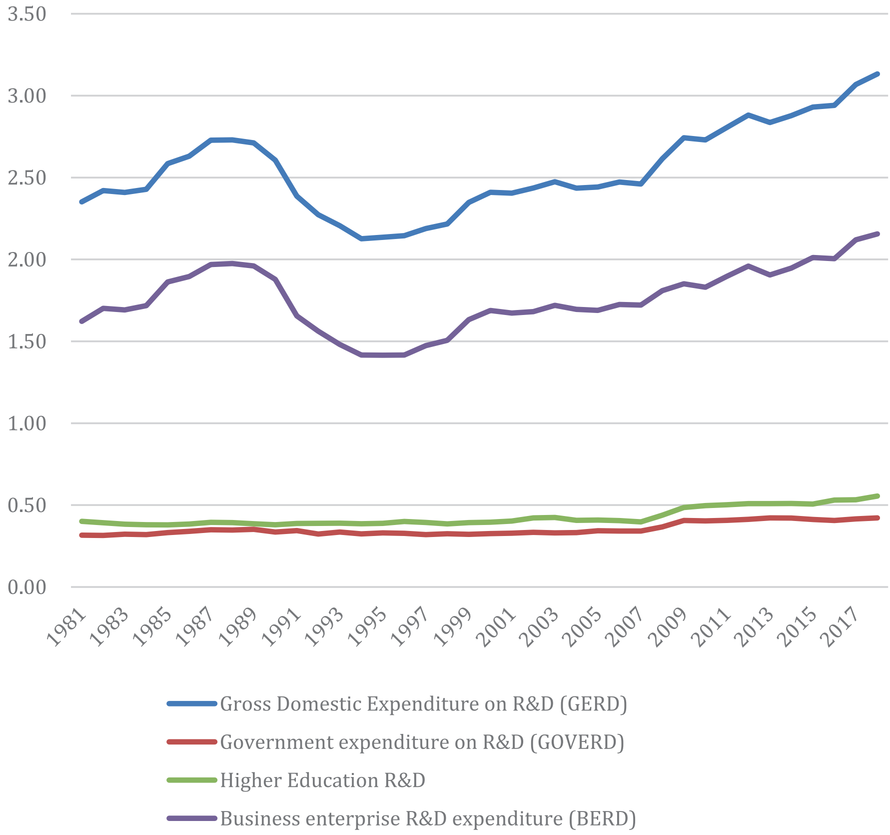

Fig 14.1 R&D expenditures by sector of performance as a percentage of GDP. (Source: OECD, 2020)

Historical Context and the Role of Higher Education in the German R&D System

Science in general, and the university in particular, has a long tradition in Germany and is historically and organizationally shaped by a deeply institutionalized ideal of science, a factor that reform proposals still have to deal with today (Bartz, 2006). After the Second World War, the federal higher education system of West Germany was initially characterized by a reinstitutionalization of the prewar higher education model, which was strongly shaped by the Humboldtian ideal of science and the organizational structure of the "Ordinarienuniversität" (Dusdal, 2017; Hüther & Krücken, 2018). The "Ordinarienuniversität" was characterized by strong self-administration and autonomy of professors (ordinaries) over content. Thus, the respective chair was largely uninfluenced by external regulations on examinations, employment relationships, doctorates, and habilitations (Pasternak & von Wissel, 2010). In this context, the Humboldt ideal of science dating back to the nineteenth century was the central normative reference point in the German science system. In addition to the unity of research and teaching and the freedom of science, this was based on the so-called "pure" idea of science; in the sense of purpose-free research and education, science should be free of direct social or economic expectations of benefit. Thus, it was Humboldt's view that the organization of the higher scientific institutions "must produce and maintain an uninterrupted, self-regenerating, but casual and unintentional cooperation" (Humboldt, 1810, p.230). During the postwar period, freedom of science was also enshrined in the constitution in West Germany (Teichler, 2012). With reunification in 1990, the East German university sector was incorporated into the West German sector (Dusdal, 2017). So historically and currently, German universities are characterized by a high degree of autonomy and have institutionalized a relative distance from economic and other social logics of exploitation[1] (Massih-Tehrani et al., 2015). This autonomy is also reinforced by the "Deutsche Forschungsgesellschaft (DFG)" (German Research Foundation) as the central self-governing body of science in Germany, which is also the most important funding agency for (competitive) third-party funds in research. Although the practical orientation and economic valorization are emphasized by national and international innovation policies (see Chap. 3), the DFG is still a central lobby for the self-governance of science, and its funding logic is oriented toward disinterested basic research (Breschi & Cusmano, 2004).

However, there is also a long history of application-oriented research and vocational-oriented teaching in the German higher education system. The technical universities, for example, already had close ties with industry in the nineteenth century and are still more strongly embedded in relationships with industry today (Krücken, 2003). In 2014, Professors in technical universities account for approximately 10% of all professors in Germany (Federal Statistical Office, 2016). In 1968, the Universities of Applied Sciences (UAS) ("Fachhochschulen") were institutionalized, which brought together tertiary education institutions[2] with a more application and occupation-oriented focus (Enders, 2016). In contrast to universities, the UAS focus primarily on teaching and were not initially intended to be research-focused institutions. According to Enders (2010, p.445), "the establishment of Universities of Applied Sciences by the state was associated with the intention of creating higher education institutions (HEIs) that could satisfy the growing demand for education more cost-effectively than teaching and research-related universities." In 2014, professors in UAS account for approximately 45% of all professors in Germany (Federal Statistical Office, 2016). Thus, there is a clear organizational division of labor in the German higher education system; disinterested basic research

[1] This is an ideal-typical description. Even within universities, application and purpose are deeply rooted in the tradition of single scientific communities. For example, in the engineering sciences—also in the context of universities—a strong connection with industry can already be seen during the nineteenth and twentieth centuries (Meier & Krücken, 2011).

[2] Universities of Applied Sciences were not newly founded but rather a merger of various educational institutions.

and science-based teaching are the core competencies of universities, application-oriented or economically valorized research is the core competency of technical universities, and vocational-oriented training is historically assigned to UAS.

Knowledge Economy and Higher Education Policy in Germany

Conceptualizations of the knowledge economy postulate that knowledge, in both its incorporated form (human capital, knowledge workers) and its materialized form (technological innovations), is a central economic factor (Becker, 1960; Bell, 1973; Lundvall, 1992; Nelson, 1993; Powell & Snellman, 2004; Stehr, 1994). In this sense, a knowledge economy is characterized by the fact that it is no longer the quantity of the factors of land, physical capital, and labor that are decisive for economic prosperity but instead the generation, accumulation, and organization of theoretical or scientific knowledge (Bell, 1973) and "intellectual capabilities" (Powell & Snellman, 2004). HEIs and research institutes are now positioned as central organizations that not only contribute to scientific knowledge but also serve an economic function. The economic function is defined either as promoting the intellectual abilities of future knowledge workers through teaching or as contributing to knowledge production through research. On the basis of the literature on the knowledge economy, the relationship between higher education and the economy can be concretized by means of two distinct ideal types, which complement the promotion of science via basic research: "higher education *for* the knowledge economy" and "higher education *in* the knowledge economy." Each of these ideal types and their corresponding policies will be discussed in turn; Table 14.1 sums up the main characteristics of these two ideal types.

Table 14.1 The relationship between higher education and the knowledge economy

	Higher education *for* the knowledge economy	Higher education *in* the knowledge economy
Beginning of institutionalization	1960s	1990s
Theoretical foundation	Human capital theory, knowledge economy, and postindustrial society	National innovation systems, mode 2, triple helix, and knowledge-based economy
Main topic	Higher education and economic growth Linear innovation model	Economic growth via research commercialization, the higher education institution as economic organization, and university-industry linkages Nonlinear innovation model
Policy	Quantitative-structural dimension (university expansion)	Qualitative dimension (commercial practices of university research, hybridization of higher education institutions and economics)

Higher Education for the Knowledge Economy in Germany

Higher education for the knowledge economy can be identified as a strategy that places higher education in the context of human capital development. Higher education for the knowledge economy is conceptually related to human capital theory (Becker, 1960; Harris, 1953; Mincer, 1958; Schultz, 1961; Edding, 1963) and early approaches to the knowledge economy (Machlup, 1962; Bell, 1973). It centers higher education graduates (knowledge workers, human capital) as an indirect means of achieving economic growth and thus places the educational function of HEIs in the foreground.

The Expansion of Higher Education

Higher education policies for the knowledge economy can be traced back to the 1960s. The rapid expansion of German higher education in the 1960s and 1970s and the institutionalization of the UAS can be seen in this context (Enders, 2010). However, higher education for the economy also appears to be a central goal in current policy. The Bologna Process can be seen as an instrument to expand higher education. In addition to the primary goal of international harmonization of degrees, the goal of shortening study periods (as well as reducing dropout rates) was envisaged in the Bologna Process. Shortening study periods was desirable because it represented a cost-effective adjustment to the OECD's criticism of the insufficient number of graduates in Germany (Vehrkamp, 2007). This goal of a cost-effective increase in student numbers was supplemented by a change of funding arrangements associated with new public management. There was a clear shift in governance instruments toward performance-based allocations, in which the number of students in the standard period of study plays a particularly important role in the funding of German HEIs (Jaeger et al., 2005; Ziegele, 2008).

As Fig. 14.2 shows, the number of students has been rapidly increasing since the beginning of the new millennium. Policies which aim to expand enrolment have pushed HEIs to meet the growing demand for tertiary degrees. However, as Dohmen and Krempkow (2014) show, the per-student funding of teaching has been declining in recent years; the public funding of universities is not keeping pace with quantitative expansion, and we can observe an ever-increasing massification of higher education. If we compare expenditures on higher education with expenditures on research and development, a financial shift toward research and development can be seen despite the increasing number of students. In 2000, 58% of the funds were still earmarked for teaching compared to 55% in 2011 (Dohmen & Krempkow, 2014).

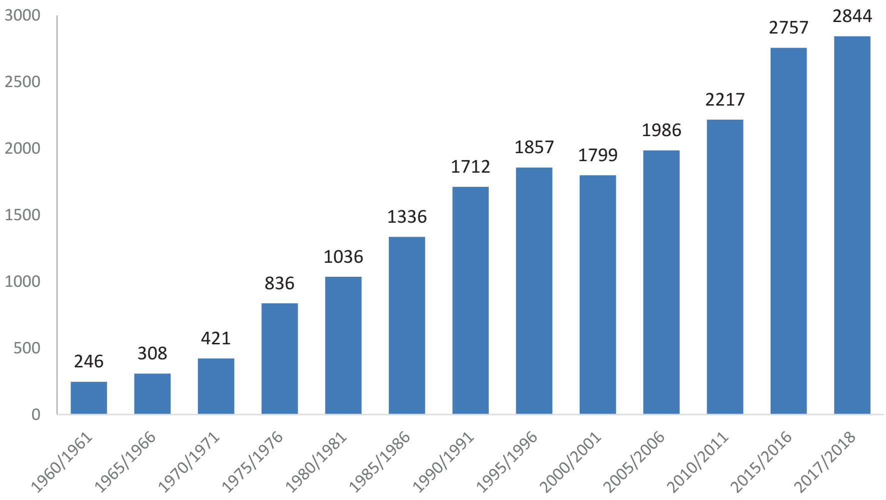

Fig 14.2 Development of the number of first-year students between 1960 and 2018. (Source: German Federal Ministry of Education and Research (BMBF) 2019)

Doctoral Training for the Knowledge Economy

As part of the policy of "higher education for the knowledge economy," doctoral training in Germany is also undergoing significant changes. The parallel expansion of the higher education sector and the rapid growth of the R&D sector are diversifying the functions of doctoral education. In the context of a higher education policy fostering a knowledge economy, "reforms seek to increase the employability of doctorate holders to match them with demands of the non-academic labor market" (Ambrasat & Tesch, 2017). There appears to be a gradual program drift of German doctoral training, which adds up to the traditional academic work-based model.

Until the 1990s, doctoral training was seen primarily as preparation for an academic career. Per Humboldt's scientific ideal of a community of teachers and students (Humboldt, 1810), a work-based model of doctoral education was predominant in Germany. The doctoral student was seen as an independent researcher who is in close contact with his advising professor and who, through his dissertation research, is "gradually maturing into a scholar in the process of his or her work" (Schneijderberg & Teichler, 2018, p.16). The vast majority of doctoral candidates were employed at HEIs to serve as research workers or assistants. Due to the expansion of doctoral education and the resulting greater selectivity of higher career levels (professorship) (Schneijderberg & Götze, 2020), the majority of doctoral students are now pursuing a nonacademic career (KBWN, 2013). The American "teaching-oriented model" served as a reform model for doctoral training that is geared to broader competencies, matching with the needs of a nonacademic labor market (Ambrasat & Tesch, 2017). In contrast to the German "working-based model," doctoral training here takes place within the framework of a study curriculum. However, only a gradual “program drift” takes place in Germany (Schneijderberg, 2018). Structured doctoral programs have been introduced in Germany, but they make up only 10% of total doctoral candidates. For the vast majority of doctoral candidates, only selective program components have been introduced (Schneijderberg & Teichler, 2018) which adds some course arrangements to the dominant academic work-based model of doctoral training.

Higher Education in the Knowledge Economy in Germany

The second ideal type is “higher education *in* the knowledge economy.” Distinct to the quantitative-structural policy to increase the academically trained labor force, policies in the context of this ideal type place German HEIs directly in the knowledge economy by fostering the commercialization of research results. The importance of educating the knowledge worker for the economy is complemented by a focus on the promotion of commercial-technological innovations. This policy is grounded in concepts such as “Innovation Systems” (Nelson, 1993; Lundvall, 1992), “mode 2” (Gibbons et al., 1994), or “triple helix of university-industry-government relations” (Etzkowitz & Leydesdorff, 2000), which assume a (radical) transformation of the science system, in which science is more strongly characterized by heterogeneous places of knowledge production (Tuunainen, 2005; Hessels & van Lente, 2008). The production of knowledge at HEIs is subject to a qualitative change toward an orientation on social relevance and economic usability due to the increasing networking with other social spheres in the innovation system (Heidenreich, 2003, Godin, 2012). Thus, a hybridization (Tuunainen, 2005) or blurring of boundaries (Krücken et al., 2007) of science and economy in the context of a nonlinear innovation process is the focus of these concepts. This change has two forms. First, HEIs are directly positioned as economic actors. According to the model of entrepreneurial universities (Clark, 1998; Slaughter & Rhoades, 2004; Münch, 2011), they should contribute directly to the commercialization of research through patenting, licensing, and the promotion of university spin-offs. They should be seen not only as scientific organizations but also as economic organizations. Second, attention is focused on innovation networks between HEIs and companies. Thus, within the framework of a nonlinear understanding of innovation, the close networking between science and industry along the entire research and development process is emphasized (Hessels & van Lente, 2008).

Policies that situate German higher education in the knowledge economy can be traced back to the 1980s, and this approach continues to be emphasized by different policy instruments. The Commission on Economic and Social Change (1977) and the German Federal Ministry of Research and Technology (BMFT)/German Federal Ministry of Economics (BFWi) (1978) emphasized the importance of cooperation between industry and science with regard to small- and medium-sized enterprises. The introduction of knowledge and technology transfer offices was positioned as a central instrument for furthering these relationships: “This [the promotion of specialized technology transfer offices] would be a decisive contribution to the modernization of the national economy and would facilitate future processes of structural adaptation" (Commission for Economic and Social Change, 1977, p. 287). In the course of promoting closer cooperation between science and industry, knowledge and technology transfer became an institutional mission. As a reaction to political expectations regarding the organizational promotion of relations between universities and industry, knowledge and technology transfer offices were institutionalized almost everywhere in German HEIs during the 1980s and 1990s (Meier & Krücken, 2011).

While the introduction of a transfer infrastructure did not affect the core content of research, a political understanding emerged in the 1990s that emphasized the transcendence of the boundaries between the economy and science. A qualitative change for universities, in the sense of a stronger focus on economic exploitation, was integrated into the national policy agenda (Krücken et al., 2007). This orientation toward a blurring of boundaries between science and business became a fundamental element of government policy:

> Research is not an end in itself. In the long run, research should lead to economic growth and new jobs. All parts of the innovation process, starting with basic research up to the diffusion of new products and procedures, should be linked up. (BMWi/BMBF, 2002, as cited in Krücken et al., 2007, p. 687)

Since that time, a differentiated set of governance instruments have been established to promote two dimensions of higher education in the knowledge economy: first, the direct economic activity of HEIs or scientists, and second, the networking of universities and companies. At the legal level, the Higher Education Framework Act (1998) made knowledge and technology transfer a central task of public HEIs (Grimm & Jaenicke, 2012; Wissenschaftsrat, 2016). Inspired by the US "Bayh-Dole Act," an amendment to the Employee Invention Act (ArbNErfG) was made in 2002, transferring the commercialization possibilities of inventions to HEIs. Thus, in the course of the amendment, the so-called professor's privilege (Hochschullehrerprivileg) was abolished. The professors' privilege regulated that the benefits of commercializing inventions, but also the associated risks, were the personal responsibility of the professor (Czarnitzki et al., 2015). This dramatic shift gave higher education administration a new organizational role in the field of knowledge and technology transfer (Meier & Krücken, 2011). At the same time, the patenting process for inventions was outsourced from the university or the knowledge and technology transfer office to regional patent agencies Meier & Krücken, 2011 process (Hülsbeck et al., 2013).

In addition to this legal change, the financing of HEIs can be seen as a central mechanism for situating German HEIs in the knowledge economy. For example, a whole series of third-party funding programs are being introduced at the federal and state levels that attempt to support the generation of commercial innovations and entrepreneurship at HEIs as well as networking between universities and industry via both project funding and institutional funding. These funding programs which are mainly the German Federal Ministry of Education and Research (BMBF) and the German Federal Ministry of Economics and Energy (BMWI) focus on various aspects which are situating HEIs and academics in a knowledge economy (for a more detailed overview of all programs, see BMWI, 2019):

1. Programs that foster entrepreneurship and start-ups on the program or institutional level (e.g., EXIST (BMWI), StartUpLab@FH (BMBF), GO-Bio (BMBF))
2. Programs that support institutional or individual research and innovation partnerships with (regional) business partners (e.g., Central Innovation Program for SMEs (ZIM) (BMWI), Innovative Higher Education (BMBF), Research at Universities of Applied Sciences (BMBF), Research Campus - public-private partnership for innovation (BMBF))
3. Programs which focus on building and strengthening innovation clusters between universities and business enterprises (e.g., Go-Cluster (BMBF/BMWI), The Leading-Edge Cluster Competition (BMBF))

Beyond federal state funding, most states have also set up their own innovation programs. However, these programs are much smaller in financial scope and are not listed here in detail. European research funding within the framework of the European Research Framework Programmes (European Commission, 2012) appears to be central to the situation of HEIs in the knowledge economy. These primarily support collaborative projects between industry and science and thus aim to orient research toward economic interests (Breschi & Cusmano, 2004; Massih-Tehrani et al., 2015). It is interesting to note that in addition to universities, the UAS, which at the time of their institutionalization were primarily focused on teaching (Enders, 2010), are increasingly being addressed as central actors with regard to applied and commercially oriented research. Various funding programs located between HEIs and companies focus on the UAS as central research actors (e.g., the funding programs research at Universities of Applied Sciences (BMBF) and Innovative Higher Education (BMBF)).

Apart from government policy, the self-governing organizations in Germany (first and foremost the DFG) are decisive actors in terms of higher education and the knowledge economy. At the formal level, the recognition of knowledge and technology transfer as a central task of science supports the goal of situating HEIs in the knowledge economy, which is supported by academic organizations (e.g., German Research Foundation et al., 2002). In this respect, the DFG's current website is also informative, emphasizing the hoped-for mutual benefit of collaborative networks between science and society:

> Knowledge transfer is […] an important activity for the DFG, and the organisation funds the transfer of knowledge between research and practice across all disciplines. The DFG hopes that transfer funding will have a double effect, encouraging more economic and social innovation while enabling collaborative projects to stimulate new research questions and therefore further basic research. (German Research Foundation, 2016)

However, following Meier and Krücken (2011), it can be assumed that these are primarily changes in the formal structure to legitimize the self-governing bodies in their organizational environment. Contrary to the funding of science by the BMBF, the BMWI, and the European Commission, in practice, the DFG, for example, continues to represent "an area of retreat from state, economic and non-scientific interests" (Massih-Tehrani et al., 2015, p.59) and primarily promotes the autonomy of science (Wagner, 2010, p.23ff)[3]. Also, the Excellence Initiative/Excellence Strategy, as a central funding instrument of the German Research Foundation, can be seen as focusing more on excellence in basic research. Even though structuring via networks is central to cluster policy, cooperation between academics and those outside the scientific community is of secondary importance (Sondermann et al., 2008).

Looking at the empirical findings on the situation of German HEIs in the knowledge economy as described above, no clear picture of the actual influences of the policy of higher education in the knowledge economy on concrete scientific practice can be discerned to date. Indeed, the orientation of national policy can be clearly ascertained, but there is little existing evidence that the performance of HEIs and science is more strongly influenced by commercial exploitation logic due to this policy change. It is true that after the abolition of the professors' privilege, there will be an increase in the number of patents registered via HEIs. However, this development is countered by a decline in the number of patents applied for by scientists or companies. Overall, the number of higher education patents has been falling since 2002 (Cuntz et al., 2012; Schmoch, 2007). In their study, von Proff et al. (2012) found that there was no evidence of an increase in university patenting due to the policy changes in 2002. Czarnitzki et al. (2015) even found a significant negative correlation between the abolition of the professors' privilege and the total number of higher education patents. With regard to higher education spin-offs, the study finds no significant changes as a result of the reform (Czarnitzki et al., 2015). Moreover, hardly any reliable empirical findings on the development of higher education spin-offs are available in the context of the governance instruments described above (Kulike, 2012). However, the general development of business start-ups has been in sharp decline since 2002. The share of business start-ups in the working population has fallen from 2.76% in 2002 to 1.06% in 2018 (KFW-Gründungsmonitor, 2019).

Furthermore, official financial statistics of HEIs show that the exploitation of scientific knowledge from patenting, licensing, and spin-offs has only minor financial importance for HEIs. For example, the administrative income of HEIs, which also include these exploitation revenues (if one excludes medicine or university clinics from the statistics), are at a low level compared to other types of income, stable at approximately 4% of total revenues (Fig. 14.3).

With regard to the cooperation between science and industry, available data suggest a moderate change. First, as a result of the increase in third-party funding of HEIs, programs that make cooperation between science and industry a prerequisite

[3] The former president of the DFG (2007–2012), Prof. Dr.-Ing. Matthias Kleiner, remained ambivalent about the funding logic in a press release (German Research Foundation, 2010). For one thing, WTT and the "give-and-take interaction" between science and society should be strengthened by the DFG; however, he emphasizes that "basic research will continue to form the focus of our activities."

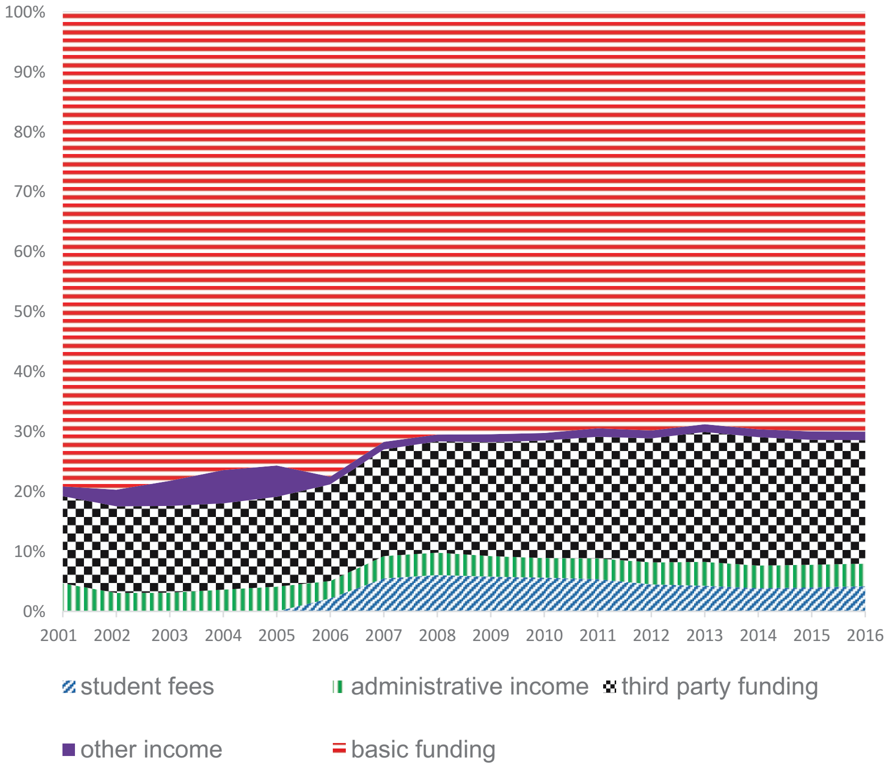

Fig. 14.3 Revenues of higher education institutions by type of financing between 2001 and 2016 in percent. (Source: Federal Statistical Office (2002–2016), own calculation)

for funding are growing in importance. Second, since the 1990s, there has been a relatively strong increase in third-party funding from the business sector compared to other OECD countries (see Fig. 14.4). Both aspects suggest that the change at the political level has also led to an increase in relations between HEIs and companies at the performance level. The decline in the share of higher education research and development by industry between 2006 and 2010 can be explained by the increased public funding of basic research that accompanied the Excellence Initiative. Since 2010, the funding of R&D by industry has stabilized at around 14% of total higher education R&D.

Considering the data according to the different types of HEIs, the change appears to affect German Universities of Applied Sciences more strongly. Firstly, there has been a sharp increase in funding from public, third-party funds. This suggests that the change in relations between the higher education sector and the business sector culminates in the academic drift (Neave, 1979) of UAS (Hüther & Krücken, 2018). As a result, the research orientation of the UAS has increased significantly in recent years (Enders, 2016). For these HEIs, public research funding via third-party funds often takes place in the context of funding programs that also mention

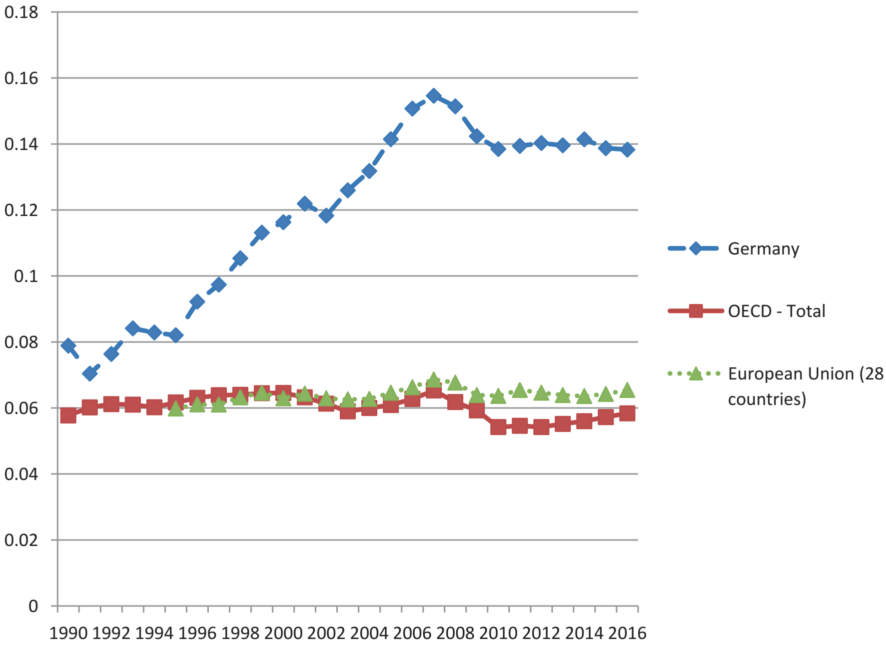

Fig 14.4 Higher education research and development financed by industry as percent of total higher education research and development for Germany, the EU (28 countries), and the OECD. (Source: OECD, 2019)

university-industry relations and regional economic development as central funding goals. For example, the BMBF programs "Research at Universities of Applied Sciences" and "Innovative Higher Education" can be cited. Moreover, the growth rates of commercial finance are much more pronounced at Universities of Applied Sciences (German Federal Statistical Office, 2002–2016).

Whether the stronger relations between universities and business have led to a blurring of boundaries and the integration of an economic logic of exploitation into scientific practice requires further research. Research indicates that scientists who cooperate with industry are more inclined to keep their research results confidential (Evans, 2010a; Haas & Park, 2010; Lam, 2010), and the influence of industrial contacts on research content has also been identified (Evans, 2010b).

Conclusions

In summary, Germany has followed a pathway of continuing development toward a knowledge economy. Thus, research and development has increasing importance for the economy as can be seen from the level of private spending on research and development.

Contrary to the thesis that the center of knowledge production shifts more and more from higher education to other places of knowledge production (Gibbons et al., 1994), the importance of the higher education sector in the German R&D system has remained stable since the 1990s. R&D spending in the higher education sector has been growing in parallel with private spending on R&D since the 1990s and accounted for 18% of total spending in 2018. Both the balance and division of labor in the R&D system appears to be largely stable.

The effect of policy which positions higher education in the knowledge economy appears to be characterized by path dependencies. There is indeed a general political focus on promoting the commercialization of research and cooperation between universities and companies. However, findings related to a qualitative change in scientific practice concerning the "university in the knowledge economy" are ambiguous. There is evidence of a nationwide institutionalization of knowledge and technology transfer centers at HEIs (Meier & Krücken, 2011). Nevertheless, there is little evidence of a change in practice at HEIs toward a more direct orientation of research toward commercial exploitation. For example, statistics on exploitation practices in HEIs, such as patenting and spin-offs, indicate that a policy of higher education in the knowledge economy has no (demonstrable) effect on the stronger, direct economic exploitation of scientific knowledge.

If one evaluates the cooperation between HEIs and companies based on third-party funding, a very clear increase can be observed up to the 2000s even by international comparison. However, when the "Excellence Initiative" (2005/2006) was launched, the share of industry funding of the total funding decreased considerably and has currently stabilized at approximately 14%. The analysis of the development in individual types of organizations shows that the development is path dependent. Growth is stronger in the UAS than in universities, and technical universities in particular receive a large amount of third-party funding (from industry) (Schneijderberg, 2020). In this respect, nontechnical universities continue to appear to follow Humboldt's deeply rooted ideal of purpose-free science more closely. So the policy of higher education in the knowledge economy seems to find fertile ground above all in those organizations in which a historically grown, practical orientation exists. Especially in the UAS, the financial support of the business sector can be seen in the context of the development of a research mission. Here, research funding by companies and practice-oriented public research funding appear to be a good way of fulfilling the new, legally stipulated research mission.

Compared to the policy for the promotion of higher education in the knowledge economy, there is clear development in the quantitative-structural policy of higher education for the knowledge economy. For example, current higher education policy such as performance-related pay based on student numbers appears to be leading HEIs to accept more and more students. At the same time, financial resources are shifting from teaching to research and development. So a massification of higher education takes place in which the financial support for teaching does not increase in parallel with the number of students.

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Nicolai Götze (M.A. in Sociology and Social Research) works as a research associate at the International Centre for Higher Education Research (INCHER), Kassel, Germany. He is working on the German study of the international project “Changing Academic Profession in Knowledge Societies (APIKS)” funded by the BMBF as well for the Austrian study “APIKS-Austria” which is carried out by the Danube University Krems. His research interests are in science and higher education research with a special focus on the relationship between science and society, bibliometrics, and international comparative research.

Chapter 15
A Portuguese Tale on Knowledge-Based Society: Narrowing Bonds Between Higher Education and the Innovation System

Teresa Carvalho, Sara Diogo, and Rui Santiago

Abstract Within the knowledge society framework, higher education has become a driving factor for democratizing and rising equality in societies and consequently stimulating economic development (Panitsidou et al., Procedia Soc & Behav Sci, 46: 548–553, 2012). In Portugal, as elsewhere, higher education institutions (HEI) were expected to play a key role within the changing dynamics in the orientation of knowledge production and dissemination. Research and the national scientific system are closely connected to the higher education system, with knowledge production being mostly concentrated in universities, especially in public ones. In this context, HEIs are considered as a privileged locus of change framed by the knowledge society providing the new epistemological, ontological, and methodological logics as well as legitimacy for a new "political economy" of knowledge. However, this chapter has a double purpose. On the one hand, it intends to present an overview of the Portuguese higher education system and its relation to the research and innovation system. On the other hand, the paper seeks to analyze the contemporary conceptions of the "knowledge-based society" in the Portuguese state policies and HEI narratives, as well as the expected role assigned to academics in the new knowledge production, dissemination, and transfer systems.

Keywords Innovation policy · Higher education system · Academic careers · Research and development

T. Carvalho (✉) · S. Diogo · R. Santiago (Deceased)
Department of Social, Political and Territorial Sciences, University of Aveiro, Aveiro, Portugal

CIPES (Research Center on Higher Education Policies), Matosinhos, Portugal
e-mail: teresa.carvalho@ua.pt; sara.diogo@ua.pt

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Introduction

Knowledge has become central to contemporary politics and policymaking across nations, especially evident in the prominence acquired within national higher education systems and in research and development (R&D) systems. It is this integration of education and science public policies into the social and economic structures of modern societies that sustained the acknowledgment of the transition from the information society (Bell, 1973) to the networked society (Castells, 2000) and, later, to the knowledge society, with knowledge being the fundamental capital of the twenty-first century (Castelfranchi, 2007). This last connotation emerged during the Lisbon Process (2000), with the strategic goal of "making the European Union (EU), on a world scale, the economic space based on innovation and knowledge that is more dynamic and competitive, capable of raising economic growth levels, with more and better jobs, and with more social cohesion" (European Commission, 2000, p. 4). In this sense, political discourse in Europe in the last decades have been using knowledge society as a meta-narrative, or as a governance tool, to accomplish European integration and enhance its competitiveness. Through the establishment of the European Research Area (ERA), the Lisbon Strategy became the tangible mechanism of the EU to enhance cohesion and social development and foster economic competitiveness based in R&D investment (Chou & Gornitzka, 2014; Chou & Ulnicane, 2015). Innovation and technology development are thus expected to be the result of a complex set of relationships among actors in the system, namely, enterprises, universities, and government research institutes (OECD, 2017).

This view of science as containing political and strategic value and simultaneously subsidiary to the economy is not new. In reality, this perspective of science has its genesis in World War II and in the context of competition and tension of the Cold War (FCT, 2014). However, in Europe, the orientation of science to economic development assumes hegemonic dimensions precisely with the Lisbon Process.

In Portugal, as elsewhere, higher education institutions (HEIs) were assigned a key place within this new changing context in the orientation of knowledge production and dissemination. Portugal has a binary higher education system, integrating both public and private universities and polytechnics. Research and, therefore, the national scientific system is closely connected with the higher education system (Heitor & Horta, 2012), with knowledge production being mostly concentrated in universities and, among these, within public ones (Conceição et al., 2006). Under the Lisbon Strategy framework and the construction of a knowledge society, Portugal (similarly to other OECD countries) has been redesigning science and technology (S&T) policies in recent years. By national innovation system, we refer to the linkages established jointly and individually among the different actors involved in the production, development, and diffusion of economically useful knowledge (Lundvall, 1992).

Within this definition in mind, this chapter first aims to present an overview of the Portuguese higher education system and its relation to the research and innovation system. The authors analyze contemporary conceptions of the "knowledge-based society" in the Portuguese state policies and HEIs narratives, its impact on the relation between the higher education system and the research and development/innovation system, and in HEI narratives, missions, and identities. How has Portugal changed in response to competitive pressures of/in the global knowledge society/economy?

Overview of the Portuguese Higher Education System and the Evolution of Science and Innovation Policies in Portugal

Although the Portuguese higher education system is one of the oldest in Europe, the genesis of national scientific policy dates back to the late 1960s. Prior to 1974—the dictatorship period which was in force between the years of 1926 and 1974—the Portuguese research system was characterized by the central position that public laboratories held (Magalhães, 2001; Ruivo, 1991), and research was mostly carried out in governmental institutes and departments, not in universities. This political centralism and administrative structure were visible by the fact that research did not depend on a single ministry, but quite the contrary, assuming a plural or joint tutelage which could include, for example, the Ministry of Education, the Ministry of Agriculture, Health, etc. (Magalhães, 2001).

The integration of Portugal in the, by then, European Community (now EU) in 1986 signals the possibility of obtaining EU structural funds channeled to the emergence of the national scientific research system. The development of science and innovation policies in Portugal is thus intrinsically linked to the development of European policies, and science gets a new impetus in 1995 with the creation of the Ministry of Science and Technology and the Foundation for Science and Technology (FCT) in 1997. Today, the FCT, supervised by the Ministry of Science, Technology, and Higher Education (MCTES), is the national public agency to support research in science, technology, and innovation in all areas of knowledge. In fact, as Rollo et al. (2012) refer, the history of the FCT is intertwined with the history of science and technology itself and with the organization of science in Portugal.

From the mid-1990s, science and innovation policies in Portugal went through several developments with the new ministry created during the socialist government (1995–1999). The reorganization of research through disciplinary fields (i.e., Exact, Natural, and Applied Sciences, Technology and Social Sciences, Humanities and Arts) and evaluation of research units started in 1997 (Torgal, 2012), after which followed an increase in research units as it also increased the pace of their establishment and the number of positions for PhD holders (Torgal, 2012). Scientific production started to be concentrated in HEIs, particularly in universities, and developed in R&D units (officially established in 1998: Regulation 1/98 of R&D units) and state laboratories (Heitor & Horta, 2012; Santiago et al., 2008). These new structures are now accredited by the Ministry of Science and Higher Education according to scientific and technological productivity and measured by the number of publications, patents, prototypes, etc. Though having less weighting, additional elements were also taken into account, such as postgraduate training promoted by research units, participation in R&D projects, application of knowledge to new products, resources applied to scientific activity, and the plans and objectives of the units (Heitor & Bravo, 2010; Heitor & Horta, 2012; Horta, 2010; Santiago et al., 2008).

Through these periods, it is undeniable that the design of public policies for science and innovation focused on promoting economic development and national competitiveness. However, from 1995 onwards, the linkage of research to the economy translates a clear incentive to the emergence of new modes of knowledge production capable of creating transferable scientific and technological knowledge, particularly for the business world (Santiago & Carvalho, 2011). In 2001, the Decree-Law 197/2001 created financial incentives for industries investing in R&D expenditure based on the argument that these incentives would help enterprises to become more competitive in the increasingly global market and would allow the country to attract more qualified investment (cf. Table 15.1). In 2005, under the "technological impact" metaphor as a motto of governance, the Portuguese government made an effort to increase the public investment in R&D, which was considered the highest in this sector across Europe (Heitor & Bravo, 2010). At the same

Table 15.1 Evolution of expenditure on research and development (R&D) activities in percent Gross Domestic Product (GDP), by sector of performance/implementation (1990–2017)

	Sector of performance (implementation)				
Years	Total	Enterprises	Government	Higher education	Private nonprofit institutions
1990	0,46	0,12	0,12	0,17	0,06
1992	0,52	0,12	0,12	0,24	0,07
1995	0,52	0,11	0,14	0,19	0,08
1997	0,56	0,13	0,14	0,23	0,07
1999	0.68	0,15	0,19	0,26	0,07
2001	0,76	0,24	0,16	0,28	0,08
2003	0,70	0,23	0,12	0,27	0,03
2005	0,76	0,29	0,11	0,27	0,09
2007	1,12	0,58	0,12	0,33	0,11
2008	1,44	0,72	0,11	0,50	0,13
2009	1,58	0,75	0,12	0,58	0,14
2010	1,54	0,71	0,11	0,57	0,15
2011	1,46	0,69	0,11	0,53	0,13
2012	1,38	0,69	0,07	0,50	0,12
2013	1,32	0,63	0,09	0,59	0,02
2014	1,29	0,60	0,08	0,59	0,02
2015	1,24	0,58		0,57	0,02
2016	1,28	0,62		0,57	0,02
2017	1,32	0,67	0,07	0,56	0,02
2018	1,35	0,69	0,07	0,56	0,02

Source: PORDATA (2020)

time, the private sector—especially the enterprises—strengthen its participation in R&D, while tax incentives were granted to industries that funded scientific and technological (S&T) knowledge and used the results of their research, or scientific and technological knowledge, to discover or substantially improve materials, products, and services or even improved industrial processes. Table 15.1 shows the growth of national public investment in R&D as well as the diversification of funding sources. Despite the diversification effort, the state remained the main actor and regulator of the scientific system, namely, through external evaluation processes (Decree-Law 125/99 and 91/2005).

The data in Fig. 15.1 comparing the Portuguese gross domestic spending on R&D with the OECD average shows an increase in Portuguese expenditure until 2009, after which time it starts to decrease and continued to do so during the next 3 years.

With respect to the analysis on the levels of expenditure by performance sectors in Portugal (cf. Table 15.1), there is an increase in the expenditure coming from enterprises during 2007 to 2012. The state and the higher education sector together represent the highest proportion of expenditure, except for in 2011 and 2012, when expenditure in these two sectors is slightly lower than that of enterprises; this can be explained by a decrease in state expenditure due to the economic crisis, which particularly affected Portugal with the 2011 bailout. In Portugal, the expenditure level on R&D activities in 2014 represented 1.29% of GDP, which is clearly below the value of 2.36% for the OECD countries and 2.04% for the EU (and, e.g., 3.16% of the Finnish expenditure). Figs. 15.2 and 15.3 show that in spite of the country's evolutionary efforts in this domain, Portugal is still positioned in the "semi-periphery" (Delicado & de Almeida Alves, 2013), i.e., in the tail of countries with the lowest percentages of R&D expenditure when compared to the OECD and EU expenditure share in R&D.

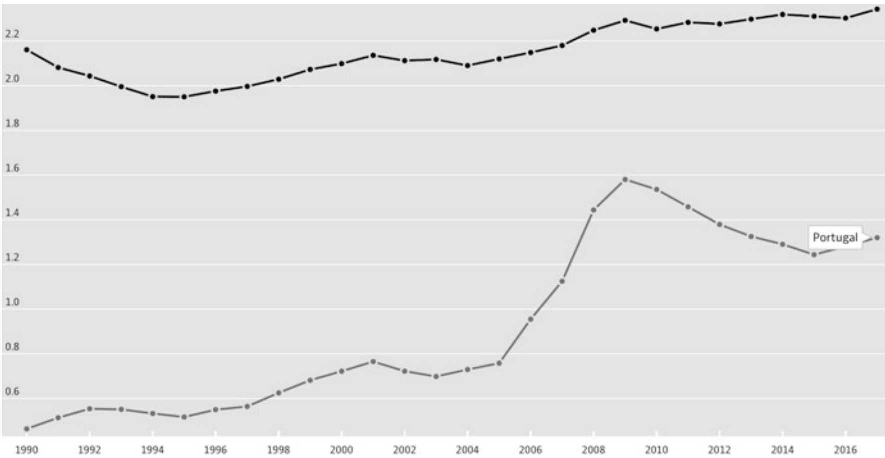


Fig. 15.1 Portuguese gross domestic spending on R&D compared to the OECD average (black line). (Source: OECD (2018a))

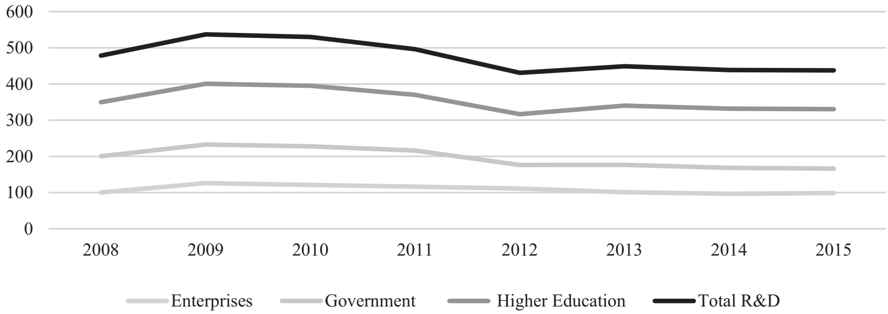
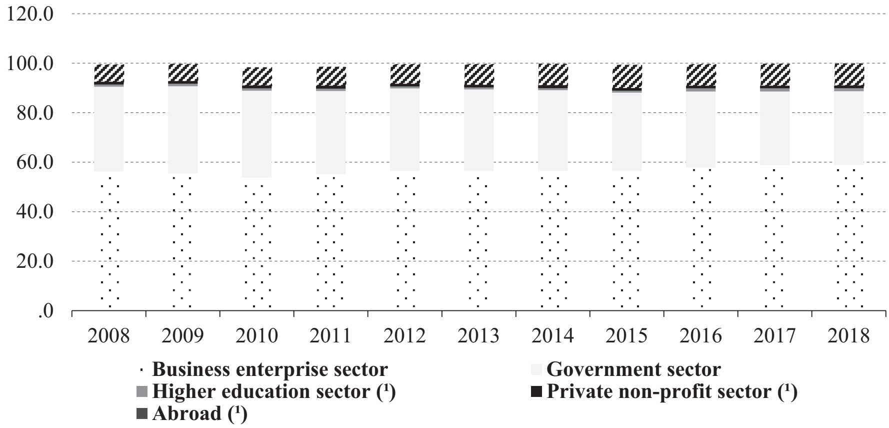


Fig. 15.2 Evolution of the gross domestic expenditure on R&D in Portugal by sector of activity. (Source: Adapted from the OECD (2019))



(¹) 2017 instead of 2018.

Fig. 15.3 Gross domestic expenditure on R&D by source of funds, EU-27, 2008–2018 (% share of total). (Source: Adapted from Eurostat (2019a))

According to Eurostat (2019a, b), Sweden (3.25%) and Austria (3.09%) were scored highest among the EU countries in terms of R&D investment—and were also the only two member states to report a level of R&D intensity above 3% in 2016—followed by Germany (2.94%), Denmark (2.87%), and Finland (2.75%). Figures 15.3 and 15.4 evidence the European reality of strong participation of enterprises in expenditure in all 28 EU countries, followed by the State, Higher Education, and Private Nonprofit Institutions. From 2006 to 2016, R&D expenditure in the business enterprise sector rose from 1.12% of GDP in 2006 to 1.32% by 2016, which represents an overall increase of 17.9% (Eurostat, 2019a, b). The second largest sector performing R&D was the higher education sector, whose R&D intensity increased slightly faster, and up overall by 20.5% in the same period (2006–2016), reaching 0.47% of GDP by 2016.

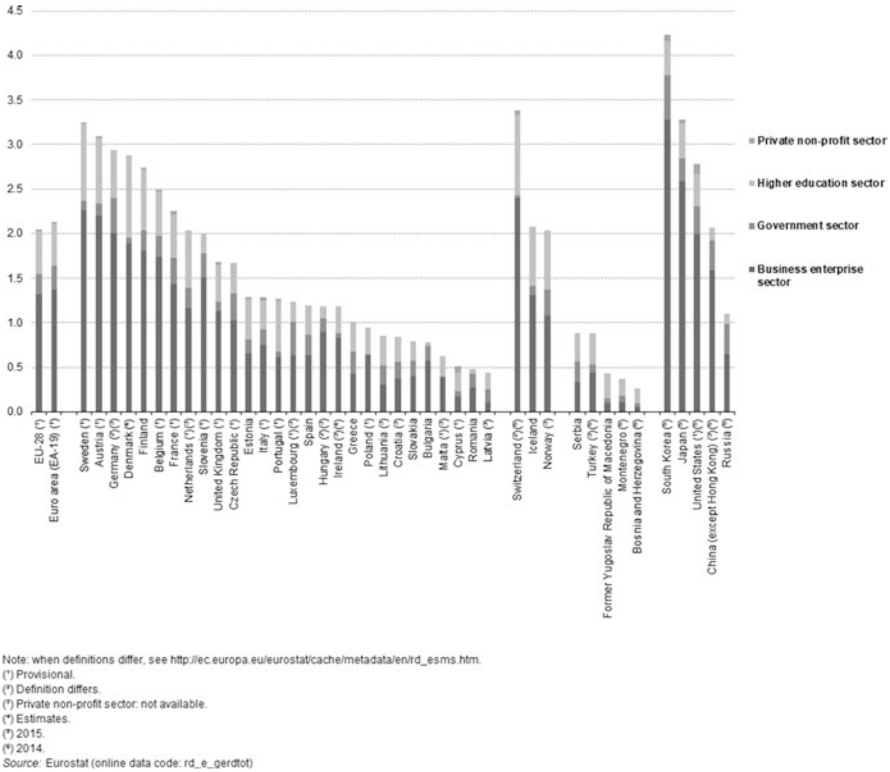


Fig. 15.4 Gross domestic expenditure on R&D by sector EU-28, 2006–2016 (%, relative to GDP). (Source: Adapted from Eurostat (2019b))

It should be noted that although R&D investment for the higher education sector initially rose faster than that for the private sector, the ratio in the 28 member countries of EU stagnated from 2010 onward. However, in the EU-28, the R&D expenditure in the government and higher education sectors was quite similar. Figure 15.4 confirms that Portugal (and Netherlands) had a relatively high ratio of R&D expenditure by the higher education sector. In the EU-28, during the period of analysis (2006–2016), R&D funding by the higher education and private nonprofit sectors was relatively small, just 0.9% and 1.7% of the total, respectively (Eurostat, 2019a, b).

According to the European Commission data (Eurostat, 2019a, b), the higher education sector played a relatively small role in funding R&D expenditure in most member states, exceeding 4% only in Cyprus (5.8%), Portugal (4.4%), and Spain (4.3%), as illustrated in Fig. 15.4.

The financing and regulatory activity of the Portuguese scientific system is expressed in the relevance placed in the evaluation of the research units, considering that it conditions the distribution of public funding for research activities. The adverse economic context combined with the influence of neoliberal policies works as legitimating factors to the changes introduced in the last evaluation exercise, in 2013 (at the present, research units are still in the process of being evaluated) when compared to previous processes (1996, 1999, 2002, and 2007). In this evaluation exercise, the FCT worked with the Center for Science and Technology Studies of the University of Leiden to produce a bibliometric study of Portuguese researchers, based on the analysis of the Web of Science (WoS) publications (FCT, 2014). This shift translates a new epistemological and ontological perspective on the production and dissemination of knowledge in Portugal, mostly focused on the results which, in turn, were evaluated in terms of quantitative and predefined production targets. The evaluation was developed in partnership with experts from the European Science Foundation (ESF), thus translating the direct influence of European policies of excellence into research (McNay, 2015; Pruvot & Estermann, 2014). However, this evaluation process has proven to be one of the most problematic processes ever: It was extended for a long time and presented controversial results, leaving many dissatisfied. This discontentment merged mostly due to the differences between disciplines and the associations between the results of the evaluation exercise and the funding (Deem, 2016).

The results of this evaluation, associated with the decrease of public funding in science which was also translated to a decrease in research grants, place the Portuguese scientific and technological system in a very vulnerable position (Delicado & de Almeida Alves, 2013). The emergence of the XXI constitutional government in 2015 and the position of the new Ministry of Science, Technology, and Higher Education (Manuel Heitor) were, in this way, marked by the need to restore confidence in the system and in public policies (e.g., new attempts to tighten scientific research within the business environment and society as a whole), as well as the promotion of scientific employment.

Science and Innovation Policies in Portugal and Their Effects in the (Scientific) Employment

The development of public policies on science and innovation, very much sponsored by the Europeanization journey of the country, resulted in a continuous increase in the number of PhD holders in Portugal. To a large extent, this growth is a consequence of the massification of higher education in Portugal, considering that the increase in the number of students resulted in an increase in the number of professors, and obtaining a PhD degree was an essential condition to advance in the academic career. The status of the teaching career created in the late 1970s (through the Decree-Law 448/79) was based on five levels (trainee assistant, assistant, assistant professor, associate professor, and full professor); one could access the career with the bachelor's degree (in the category of trainee assistant), but continuity in the career was only possible after obtaining the doctor degree followed by a probationary period of five years as an assistant professor. Obtaining a doctor's degree was practically restricted to those who had access to a career in higher education and was essentially financed by the state through HEIs.

The creation of a scientific research career is, at the same time, concomitant and dependent on the university career. The career structure and scientific research (Decree-Law 415/80 of 27th September) is created in close connection with the status of the university teaching career. This was defined in a subordinate way and dependent on the university career. In the preamble to the Decree-Law of 1980 (p. 3007), it states:

> Universities should have a body of researchers, certainly more restricted than that of Professors, but also necessary. It is important, however, to never lose sight of the special characteristics of these institutions. Therefore, it is justified, and even imposes, to assign the role of coordinator to the Full professor of the expertise field.

As such, the design of scientific research was clearly and exclusively associated with the higher education field.

The following data compares the number of existing researchers in Portugal with the number of these professionals in OECD countries' average (cf. Figure 15.5).

According to the OECD (2017), the average number of professionals doing research in the EU countries in 2006 was 6.1% per every 1000 employed people, while in Portugal, this figure was 4.8 percent. However, the number of researchers increased immediately after the introduction of Decree-Law 415/80, and this trend continues to grow until 2012. For example, in 1982, the value of this indicator for Portugal was 1 percent, increasing to 5.5 percent in 2007 (Observatory of Inequalities, 2017). In the EU, between 1995 and 2006, the number of researchers per 1000 employees rose from 4.8 to 6.1. For the same period, Portugal presents lower figures than the average of the OECD and EU countries although this

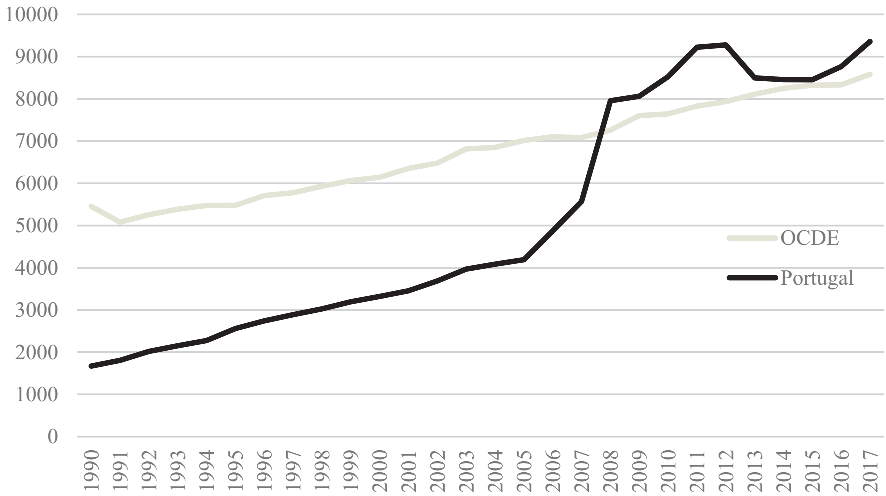


Fig. 15.5 Evolution in the number of researchers per 1000 employed in Portugal (1982–2016) compared with the OECD average (1990–2017). (Source: Adapted from OECD (2018b))

difference has been narrowing with the increase in scholarship provision granted by the FCT (FCT/MCTES 2017). In fact, despite an almost continuous increase, the proportion of researchers employed in Portugal is still lagging when compared with the OECD and EU average for the 27 country members. According to the Observatory for Inequalities (2017) data, this has been a trend since 1982 although Portugal has managed to slightly reduce the differences vis-à-vis these two organizations. Whereas in 1982 there was a difference of 3.8 researchers per 1000 employees between Portugal and the OECD average, in 2005, this difference was 3.2 (4.1 vs. 7.3). However, as a result of the funding coming from the EU structural funds, and of the national policies stimulating the development of science and research referred to earlier, the state is now encouraging the achievement of the PhD degree regardless the needs identified at the level of the academic career.

Portugal was not spared from the narratives on knowledge society influencing the definition of science and technology policies in the last years. As a result of the implementation of these policies, there was an extraordinary increase in the number of PhD holders in the country, at a time when HEI were not opening new positions—a situation that has been worsening due to the austerity policies promoted by the bailout in 2008 (Carvalho & Diogo, 2018a; Heitor & Horta, 2012). The increase in funding for training at the doctoral level has been mainly sponsored by FCT, which mostly comes from European funds, through the granting of PhD scholarships. Whereas in 1994 the total number of doctoral fellowships granted by the FCT were 945, in 2007, this value reached its peak with 2030 PhD scholarship holders—a number that has been decreasing since then. In 2013, for example, the total number of doctoral fellowships granted by the FCT was 613, significantly lower than that in 1994 (FCT/MCTES, 2017). As a matter of fact, from 2007 onward, the decrease in the provision of scholarships is more dramatic, particularly from 2012 to 2013 when there is an abrupt cut in scholarship grants. Except for the years of 2005 and 2007 when the number of PhD fellowships for the social sciences was slightly higher, the areas of engineering and technology sciences and the natural sciences obtained the largest number of scholarships during the period of analysis. Such distribution by disciplinary fields could be the driving factor explaining the inclusion of doctors in the entrepreneurial fabric since these areas are considered as having a closer connection to the business world. The commitment of national policies to increase the granting of doctoral scholarships has a direct effect on increasing the number of PhD holders in the country, as can be seen in Fig. 15.6, which shows the evolution in the number of PhD holders in Portugal from 2003 to 2012.

The Statutes of the University and Polytechnic Teaching Career, which have remained practically unchanged since the end of the 1970s, were substantially altered in 2009 (through the Decree-Law 207/2009). The career was reduced to three categories (assistant professor, associate professor, and full professor) with the doctorate being an essential condition to access the academic career. The responsibility for obtaining the PhD degree is transferred from the HEI to the individual (Carvalho, 2012). Concomitantly, there is a decrease in the number of higher education students and a decrease in public investment for this sector (Fonseca, 2012). In 2008, there were 24,115 academics in Portugal; the majority—around 60%

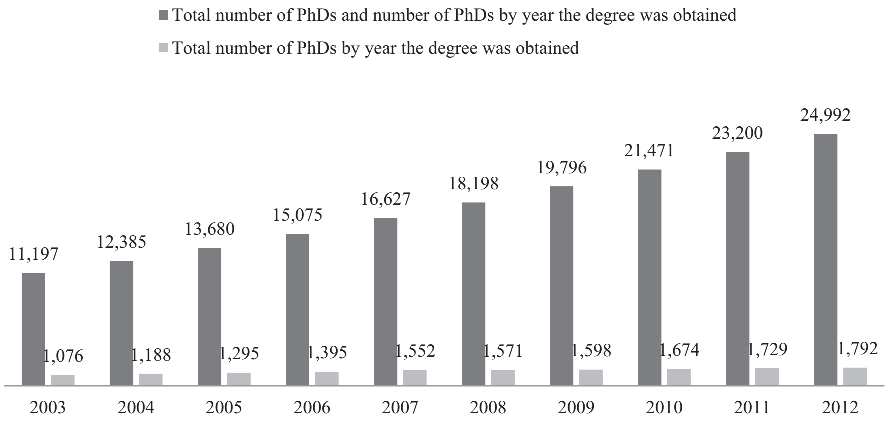


Fig. 15.6 Evolution of the total number of PhDs and number of PhDs by year they obtained their degree (2003–2012). (Source: Adapted from Barroca, Meireles, and Neto (2015, p. 20))

Table 15.2 Professor's distribution by academic rank in universities

Type		Position	2008 N	2008 %
Tenure		Full professor	1125	7,9
		Associate professor	1969	13,8
		Subtotal	**3094**	**21,6**
Nontenure	Tenure track	Auxiliary professor	5386	37,6
		Assistant	1220	8,5
		Trainee assistant	72	0,5
		Subtotal	**6678**	**46,7**
	Nontenure track	Invited full professor	136	1,4
		Invited ass. professor	258	3,1
		Invited aux. professor	1002	7
		Invited assistant	2306	16,1
		Others	16	4,1
		Subtotal	**3718**	**31,7**
Total			**14,324**	**100**

Source: DGEES (2018)

(n = 14,324; Table 15.2)—were in the university sector and the minority in the polytechnics (n = 9791; Table 15.3).

Given the weak investment in R&D in the private sector, the employment of PhD holders largely depends on the opening of positions in HEIs, which, in turn, have proven incapable of absorbing all those people qualified with this degree. The substantial increase in higher education graduates, and particularly of PhD holders, is also explained by the efforts to introduce comparability within ERA. These efforts have been accompanied by transformations in HEIs framed by trends that translate to a decrease in state funding. Consequently, since the beginning of the millennium,

Table 15.3 Professors' distribution by academic rank in polytechnics

Type		Position	2008	
			N	%
Tenure		Principal coordinator professor	36	0,4
		Coordinator professor	678	6,9
		Subtotal	**714**	**7,3**
Nontenure	**Tenure track**	Adjunct professor	2109	21,5
		Assistant (1° and 2° triennium)	343	3,5
		Subtotal	**2452**	**25,0**
	Nontenure track	Invited principal coordinator professor	56	0,6
		Invited adjunct professor	1923	19,6
		Invited assistant professor	3506	35,8
		Others	1140	11,6
		Subtotal	**6625**	**67,7**
Total			**9791**	**100**

Source: DGEES (2018)

the number of PhD graduates has been growing without a similar correspondence to the available positions in HEIs. This situation has resulted in international and national concerns. In fact, the OECD draw attention to Portugal's growing supply of highly qualified manpower and the lack of structures and capacity to deal with this: "If the system expands at the current rate – and the official target is even higher – it is clear that the existing structures will not be able to utilise the growing supply of highly qualified manpower" (OECD, 2007, p. 68). This scenario raised social and political awareness (also due to pressures from the EU) leading Portugal to carry out the first census statistical operation in 2012 by the Directorate of Education and Science Statistics (DGEEC) about PhD holders in Portugal. In 2012, the number of Doctors in Portugal was 24,992—an extraordinary increase compared to the figure of 15,075 in 2006. The number of researchers grew faster than in any other OECD country (Heitor & Bravo, 2010). The increase in the number of researchers has consequently resulted in an increase in the number of international publications (Heitor & Horta, 2012), as can be seen in Fig. 15.7.

According to data from the DGEEC (2016), among the EU countries, Portugal had the largest increase in that decade in terms of scientific publications, from 510 (in 2005) to 1, 298 (in 2015). Nevertheless, despite these numbers, there are differences among disciplinary fields that should be highlighted. The largest number of publications are in Medical Sciences and Health, followed by Exact Sciences (Maths and Physics) and Engineering and Technology Sciences (DGEEC, 2016, p. 5). Curiously, it was in the multidisciplinary areas, Humanities and Social Sciences, where a more significant increase in the average annual growth rate can be observed. These data may represent a reconfiguration in what is socially defined as being the researcher profile in these areas (Lund, 2012) and may represent changes in the traditionally dominant professionalism (Fig. 15.8).

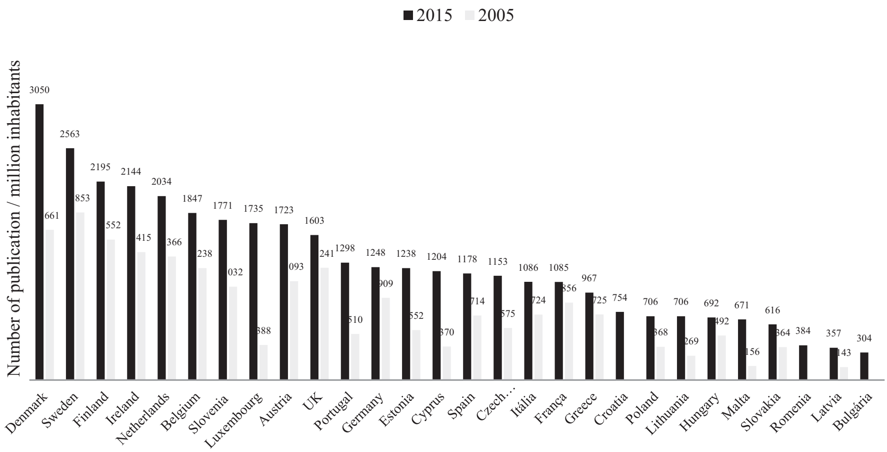


Fig. 15.7 Number of publications indexed to *Web of Science* per million inhabitants in the various countries of the European Union: 2005 and 2015. (Source: DGEEC (2016, p.3))

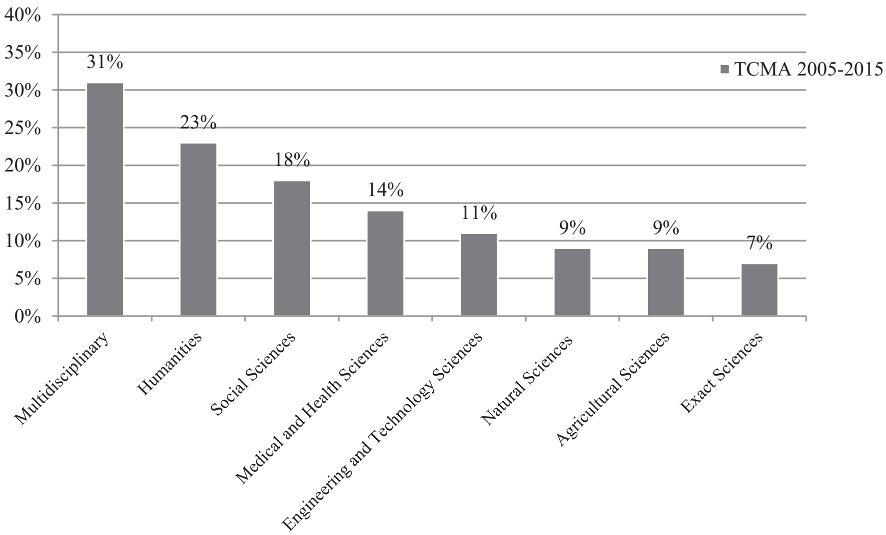


Fig. 15.8 Annual average growth rate (TCMA), between 2005 and 2015, of the number of Portuguese publications indexed in the Web of Science by disciplinary fields. (Source: DGEEC, (2016, p. 6))

In addition to the impact of scientific policies on the qualifications of Portuguese people and scientific production, it is also important to reflect on the employment conditions of this segment of the population. The vast majority of PhD holders in Portugal in 2012 were employed in higher education (83%), with a slight increasing trend of employment in industries (2% in 2006 to 4% in 2012) and nonprofit institutions (3% in 2006 to 5% in 2012) (Barroca et al., 2015). Not only did the number of researchers/PhD holders increase (as mentioned previously), but also the number of those working in enterprises and in HEIs, between 2006 and 2014. During this time, these figures contrast with a decrease in PhD holders working in nonprofit institutions and government institutions. Concomitantly, industries tend to absorb more PhDs from the natural sciences and engineering areas than those from social sciences and humanities.

Probably more relevant than the analysis of the location will be the analysis of the employment situation of PhD holders. The implementation of European policies to encourage the so-called knowledge-based society and the changes that followed national higher education reforms have been translated into an increase in the precariousness of the working relations of younger populations (Teichler & Höhle, 2013; Höhle, 2015); similar trends tend to appear in Portugal. According to data from the DGEES, about 41% of doctors in Portugal have a temporary contract, and there are relevant differences in disciplinary fields. As can be seen in Fig. 15.9, the expression of temporary work is greater in the natural sciences; in opposition, the lowest expression is in agricultural sciences.

One consequence of the imbalance in supply and demand of PhD holders in the labor market is the precariousness of research work; however, this is just one facet. Another consequence of this imbalance is expressed in the increased migration of Portuguese researchers to other countries, a phenomenon known as "brain drain" (Delicado & de Almeida Alves, 2013). This migration, which is to a large extent forced (Gomes, 2015), translates the *solution* for the rising levels of unemployment among a highly skilled population. In fact, although unemployment rates in 2006 and 2009 were relatively low for PhD holders (0.47% and 0.44%, respectively), in 2012, these numbers raise up to 2.1% (DGEEC, 2012). In this way, it is possible to verify that the effects of implementing public policies of science and innovation in

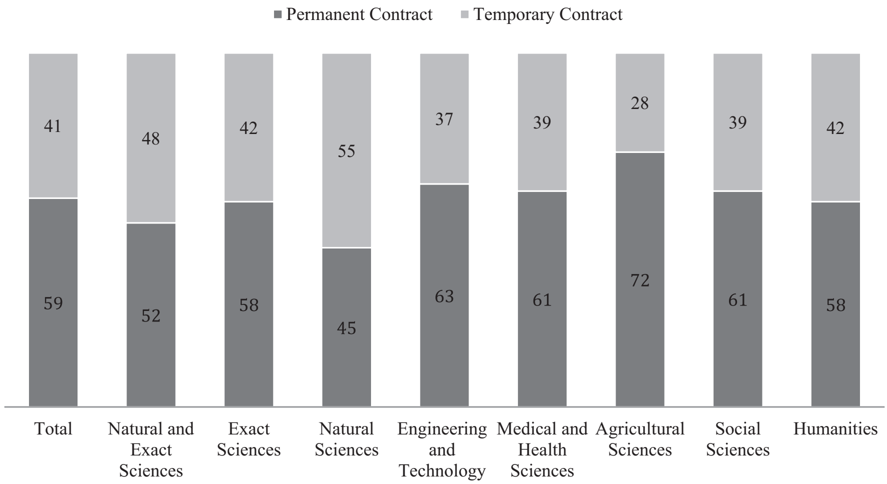


Fig. 15.9 PhDs employed by type of contract and scientific and technological area (discipline) of the PhD. (Source: Cotrim & Duarte (2012))

Portugal, within the European framework for the creation of the knowledge society, evidence fragilities in the national context. In fact, while it is true that these policies allowed a substantial increase in the level of qualifications of the Portuguese population, they also provided for a greater visibility of the national scientific production with the increase in the number of publications. However, such positive aspects were reached at the expense of strong social costs. The social tensions resulting from the precarious working conditions of PhD holders led to legislative interventions to regulate the work conditions of researchers (Decree-Law 57/2016). After a troubled period of political discussions and pressures from the various stakeholders involved, the final legislation focuses on the need to hire PhDs, based on greater independence of HEI from state funding:

> In the context of a well-known demand and great fiscal restraint, the scientific community and academic institutions are also encouraged to co-participate in the development of the country, namely through the creation of consortia, through the stimuli of sharing material resources of nearby institutions and through the raising of revenues by academic and scientific institutions to facilitate the hiring of young doctorates. (Decree-Law 57/2016)

These principles seem to reflect the change in the modes and locus of knowledge production in the national scientific system, which may be seen as reconfigurations in the way researchers are professionally seen and consequently treated.

The analysis of the employment situation of doctorate holders reveals that despite the incentives to increase their employment in the business sector, they are mostly concentrated in HEIs, even with a slight upward trend in employment in enterprises and nonprofit institutions (DGEEC, 2012). As a result, unemployment among PhD holders increased alongside the phenomena of brain drain (Carvalho & Diogo, 2018b; Delicado & de Almeida Alves, 2013; Gomes, 2015). For those who stayed in the country, the national inquiry to the working conditions of PhD holders also reveals that there was an increase in the precariousness of working conditions (DGEEC, 2017). Although relevant differences among disciplinary areas exist, it seems that the trends of having a degradation in working conditions, terms of appointment, and remuneration as verified in other countries (Altbach, 2000; Musselin, 2009; Carvalho, 2018; Carvalho & Diogo, 2018b) also exist in Portugal.

More recent political initiatives can also be interpreted in the frame of the European incentives to implement the so-called knowledge society. To the existent R&D units, new categories were introduced as the collaborative laboratories and the technological interface centers. Both are organizational structures that integrate public and private, profit and nonprofit institutions; however, the collaborative laboratories are funded specifically to produce knowledge with economic, social, and cultural impact. On its Web page, FCT specifies that “Collaborative Laboratories must consist of at least one company and one R&D unit associated with a higher education institution, funded by FCT, and may result from a technology interface center that already has this partnership structure” (FCT, 2019). The emergence of these new structures tends to stimulate the co-creation, co-diffusion, and social appropriation of knowledge. They can also be seen as an instrument to stimulate new modes of knowledge production in the Portuguese scientific system.

Conclusions

The narratives on knowledge society and especially on knowledge economy put a growing pressure on HEIs—in all parts of the world—to change. This is particularly evident in the EU context since the Europe 2020 strategy selected innovation as one of the seven flagships for promoting European integration; by strengthening the knowledge base, the EU expects to reduce differentiation between countries. Within this context, different state members have developed political and administrative initiatives to turn their own societies more knowledge oriented as it has happened in Portugal. In this chapter, an attempt has been made to specify and analyze the way science and technology policies have been evolving in Portugal to respond to European demands.

The scientific system in Portugal is relatively recent. Although Portugal has one of the oldest higher education systems in Europe, only recently did research become the focus of public policy concern. The Europeanization of science and technology policies since the beginning of the new millennium is translated in the support to increase the number of trained researchers as well as the number of research outputs and in attempts to separate the scientific system from the higher education system. These attempts are reflected in initiatives such as the evaluation of the R&D units, which emphasize the development of new modes of knowledge production; in the financial incentives conceded to enterprises to invest in R&D expenditure; and in the emergence of new research units, collaborative laboratories, capable of co-creating scientific and technological knowledge, particularly for the business world. The new millennium sets not only the national commitment to the Lisbon Strategy but also the growing concern with the training of more qualified individuals, as well as with the issues of control and evaluation of the national scientific system where the state remains the main actor and regulator of the country's R&D policies. Indeed, the financial and human efforts made to develop incentives and policies for more and better scientific employment were largely broken by the financial crisis of 2011, as highlighted throughout this chapter.

Although the increase in the number of PhD holders is a positive outcome of the national scientific and technological policies, with impact being an increase in the number of publications, the scientific capacity of the country is still mainly sustained in the higher education system.

The absence of a real scientific system has a strong impact on the existent imbalance in PhD graduates' labor market. In the development paths of the national higher education system and especially in the advancement of the R&D system, it is also necessary to take into account the role of performance evaluation exercises in the systems, the penetration of new perspectives on interpreting science in Portugal, highly emphasizing quantitative production metrics, which, in turn, have been shaping (some would even say *perverting*) the way to do science and disseminating it. Portugal is currently facing the paradox of the development and consolidation of its scientific system, with innovation policies that question the purpose of training PhDs without a plan or expectations of including them in the national scientific system. In a system strongly dependent on higher education, especially in public higher education, it is paramount to rethink ways of promoting scientific employment and to translate it into innovation and economic development, effectively involving the business fabric in this national effort.

One should remember that obtaining a PhD is no longer exclusively associated with the academic career. Although the research career goes back to the 1970s, the existence of researchers was residual and confined to the sphere of higher education. However, the increase in PhD holders in line with the definition of policies, linking scientific knowledge to innovation, development, and economic competitiveness, translates into what can be considered as a top-down creation of a new professional group—the researchers. The creation of this group promotes a greater social division of labor as the traditional roles of teaching and research are separated. Researchers are responsible *only* for the development of research, preferentially applied, with an impact on economic development. In addition, political incentives have been continuously tried in order to move the locus of knowledge production to the economic domain. It is important to analyze—and this book and chapter represent a contribution in that sense—the reality of other countries to understand how European science and innovation policies can contribute to the creation of a fruitful environment promoting the emergence of a new professional group. It is also important to inquire about the potential consequences of this dualism of the academic career for the scientific and higher education systems.

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Teresa Carvalho is an Associate professor with agregação (Habilitation) at the University of Aveiro, Portugal. She is the Vice-dean of the Department of Social, Political and Territorial Sciences, the Director of the PhD program in Public Policies, and member of the Board of CIPES (Center for Research in Higher Education Policies). She has been a member of the Executive Committee of the ESA – European Sociological Association – since 2017. She was also a member of the executive committee of RC52 Sociology of Professional Groups of International Sociological Association (ISA). Her research focus is on governance and new public management, academic profession, and gender in higher education.

Sara Diogo is an invited Assistant Professor at the University of Aveiro (Portugal) and a Post-Doc Fellow at GOVCOPP – Governance, Competitiveness and Public Policies Unit. She is also a Researcher at CIPES – Research Centre on Higher Education Policies. She did a joint-PhD in the University of Aveiro and in the Finnish Institute for Educational Research at the University of Jyväskylä in Finland, comparing policy changes in Portuguese and Finnish higher education systems. Her research focuses on comparative higher education, more specifically, on higher education policy, governance, internationalisation, gender aspects, and international cooperation for development.

Rui Santiago (1953–2015) was an associate professor with *Agregação* at the University of Aveiro and a senior researcher at Centre for Research in Higher Education Policies (CIPES). He was the Dean of the Department of Social, Political and Territorial Sciences and Vice-President of the Portuguese Society of Education Sciences. His main research interests were public reforms, higher education governance and management, and the academic profession. He published numerous book chapters and articles in international journals. He was also the co-editor of the books: *The Changing Dynamics of Higher Education Middle Management* (2010), *Non-University Higher Education in Europe* (2008) and *Professionalism, Managerialism and Reform in Higher Education and the Health services* (2015).

Chapter 16
The Role of Finnish Higher Education in the Innovation and Research System

Timo Aarrevaara and Ville Pietiläinen

Abstract This chapter introduces the Finnish higher education system as part of the national research, development, and innovation system and international development of the knowledge economy. The two sectors of higher education are universities and universities of applied sciences. They act very similarly within the national research system, but both systems have their own strengths regarding research infrastructure, national tasks, stakeholder engagement, and research funding. Higher education institutions and their academic staff are key players in the innovation system, and this chapter presents a change in their operating environment during four reform stages of the Finnish higher education system since 1990. The two Finnish Higher education sectors have different career paths for work in the academy.

Keywords Innovation policy · Academic profession · Higher education · Doctoral education · Academic careers

Introduction

This chapter introduces the Finnish higher education system as part of the national research and development (R&D) system and the international development of the knowledge economy. Finnish higher education comprises two sectors: universities and universities of applied sciences. Although these institutions have a different scope in research, development, and innovation (RDI) and education, they act similarly within the national research system. Each sector has its own strengths regarding research infrastructure, national tasks, stakeholder engagement, and research funding, but dynamic governance and the mobility of research staff between the higher education sectors and between higher education and industry are limited.

T. Aarrevaara (✉) · V. Pietiläinen
Faculty of Social Sciences, University of Lapland, Rovaniemi, Finland
e-mail: timo.aarrevaara@ulapland.fi; ville.pietilainen@ulapland.fi

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Higher education has an international role to educate new generations of researchers, and within Finnish society, the need for PhD education is obvious. This chapter presents discussion about the role of higher education in a knowledge-based society from the perspective of covering all disciplines in the universities and universities of applied sciences: natural sciences, health sciences, and humanities. The scope of this chapter is a comparison between Finland and northern European reference countries; in parts of the chapter, the emphasis is on the Finnish system as the available statistical data and country-specific characteristics related to the topic vary.

Research Intensive Innovation System

Finland is a northern European country with a relatively small population of 5.5 million people. Forestry, agriculture, and mining are a significant part of Finnish industry, but the economic importance of raw materials is not enough to sustain a welfare society. Therefore, the country invests in knowledge, high-quality education, and industry. As in all Nordic countries, Finnish society is stable and based on welfare principles in society with a comprehensive, fee-free education system, and strong public investment in health and social services. In a political sense, Finland has been a member of the European Union since 1995 and has the Euro as its currency. Finnish industry includes paper mills, pulp factories, foodstuffs, chemicals, textiles, clothing, shipbuilding, and many other fields. Finnish industry includes globally competitive sectors such as information technology and the computer game industry. Foreign and domestic companies respect a stable society and good governance. According to Transparency International, Finland has one of the lowest levels of corruption in the world and is ranked highly in the World Economic Forum (Transparency International, 2019) global competitiveness index in higher education and training.

As per data from Statistics Finland (2019b), about 75,000 people are employed in RDI that builds the innovation system — that is, in research and product development — of which less than one-quarter work in universities and universities of applied sciences. In 2018, 38,700 employees worked in RDI positions in industry, of whom 7% had completed a doctoral degree. The universities employed 30,300 people in teaching and RDI positions, 36% of whom had a doctorate. There were 7100 people working in RDI positions in public sector research institutes and research units, 32% of whom had a doctorate. The figures quoted also include personnel assisting in research tasks.

Under these conditions, Finland's innovation policy is based on the idea of long-term sustainable development; the goal of the innovation policy is the extensive utilization of innovation and the results produced in society. This means cross-sectoral cooperation between economic actors and strong public and private investment in information technology.

To enable a wide distribution of well-being in society, innovation is the actors' strategic goal after conditions for economic renewal and innovation. The key actors in Finland's innovation policy are national, regional, and local, including funding agencies, industry, higher education institutions, and research centers (Laasonen et al., 2020).

At different times, higher education has been reformed from different starting points. There have been four reform stages of the Finnish higher education system since 1990: regional policies in the early 1990s, Europeanization between 1995 and 2007, structural reforms between 2007 and 2013, and the conditions of decreasing resources 2013–2018. In the 1990s, innovation policy was largely based on the idea of a regional innovation system, in which regional universities played a significant role. Regional-based innovation policy was supported by Finland's accession to the European Union in 1995, when the regional councils were given a role as the EU's funding authority and thus a significant role in defining innovation policy goals. In 2008, an economic recession began, the lasting effects of which have weakened the flow of resources provided to higher education, especially after 2013. Since then, the structural reforms including universities' separation from the state administration, higher education mergers, and intraorganizational departmental mergers had been implemented, and public financial incentives implementation of reforms were weak (Fabrini, 2016; Pinheiro, 2014; Kohtamäki, 2019).

With the separation of universities from the state administration in 2010, it has also permanently changed the status of the academic profession from being members of the civil service to becoming private contracts (Aarrevaara et al., 2009). The economic basis has changed, which is reflected in the content of the work and the management culture. The differentiation of the academic labor market and working conditions in Finland has led to a phenomenon in which the proportion of fixed-term jobs is higher than in the main reference countries.

The Finnish innovation system and particularly higher education sector is heavily publicly funded. However, there has been a reversal of this perspective, and the emphasis of the regional innovation system has been replaced by European Union (EU) and global perspectives. The EU will also continue to build its innovation perspective *Research and Innovation Strategies for Smart Specialization* (RIS3) on regional smart specialization strategies. The strategies for regions in EU membership countries are aimed at structural transformation in the economy by a policy mix of regional actions in RIS3 (Magro & Wilson, 2019). At the core of RIS3 are actions in which research organizations have a role as generators of new knowledge, and industry has a role of exploiting and generating new knowledge (Kangas & Aarrevaara, 2020; Mazzarol et al., 2016). The system is based on the cooperation of a range of actors and cross-sectoral cooperation between industry, research organizations, and government. Most of the regional actors are small companies and, in sparsely populated areas, micro-sized rather than large enterprises. The emphasis on small companies is a peculiarity of the Finnish innovation system as small companies play as much of a role in solving global problems as large companies and research organizations.

In the twenty-first century, Finland's national innovation system has been based on a set of policies in which innovation is defined as a set of measures presented by many actors and across a range of time perspectives (Koski et al., 2019). Finland's goal in innovation policy is to be a competitive developer of new technology and innovations, a quick adopter, and as a relatively small global actor, the best in implementing innovation. In this framework, Finnish higher education institutions are actors in the national innovation system in knowledge clusters and ecosystems, and their role is in strengthening regional ecosystems and interregional cooperation. The administrative division of these innovation systems are national, regional (subnational), or local by nature (Rinkinen & Harmaakorpi, 2018). In policy action, this means strategic development programs that build knowledge clusters and ecosystems, strengthening regional ecosystems, interregional cooperation between research ecosystem actors, and enhancing higher education institutions' regional engagement (Cai et al., 2020).

There have been many reports on the Finnish innovation system in various comparative studies, and a large number of evaluations of various policy measures have also been carried out on the theme. Their message has been critical. For example, the OECD report from 2019 has highlighted the lack of a vision in national research and innovation policies for addressing major societal challenges. Such a road map has been drawn up for "public science," a term that is becoming increasingly popular in describing research that is conducted with the public and by the Innovation Council with the aim of making Finland the most attractive experimental and innovation environment in the world to contribute to knowledge production. Extensive reforms in publicly funded research have been implemented in Finland, including mergers of publicly funded research institutes, establishment of strategic research, and government research investment (Haila et al., 2018). The reform of research institutes and changes to the funding formula have been parallel with higher education reforms (Aniluoto, 2020). The core of the research institute and funding reform of 2013 was to restructure the system of research institutes, to improve societal impact, to support knowledge-based decision-making and research, to deepen cooperation between research institutes and universities, and to establish new funding instruments to support these goals (Haila et al., 2018). To understand these changes in innovation policy, it is also necessary to examine key reference countries, in particular Norway and Sweden. Norway is a clear basis for comparison in Finland's innovation policy due to its size and its arctic policy emphases. Sweden, on the other hand, shares the starting points for well-being with Finland in much the same way as its public policies lie behind the significance of innovation policies (Torregrosa et al., 2017).

In Fig. 16.1, the OECD 28 (the OECD 25 up to 2003) is based on Germany's strong economy, which did not suffer the recession of 2008 like most European countries. Finland suffered from a long recession from 2008 until 2016, and the consequence of recession was a decrease in public funding for research, development, and innovation. The reasons are in structural reforms described earlier in this paper and decreased Finnish national funding for innovation policies; the increased R&D intensity of other countries is also relevant. In Fig. 16.2, trends in this investment have been summarized. Finland's R&D intensity has decreased significantly relative to Norway and Sweden but also relative to the rest of the EU and the OECD average.

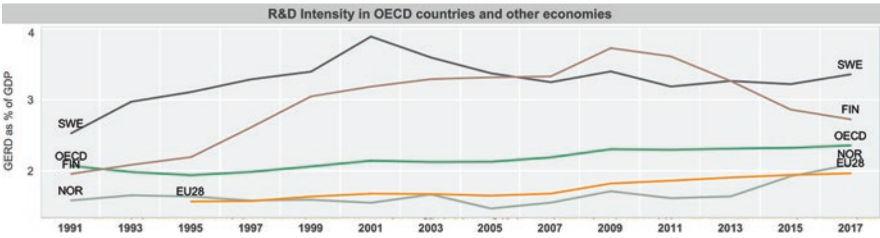

Fig. 16.1 Gross domestic expenditure on research and development (GERD) in three Nordic countries, OECD and EU average. (Source: Based on OECD Main Science and Technology Indicators Database (OECD, 2020))

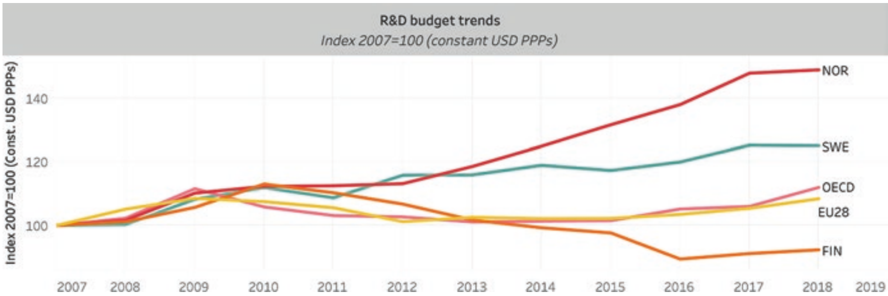

Fig. 16.2 Budget trends for RDI in EU28, OECD, and three Nordic countries. (Source: Based on OECD Main Science and Technology Indicators Database (OECD, 2020))

The Finnish economy has not fully recovered from this 10-year recession, and the decline in the resources of the innovation system has not yet been corrected. This does not bode well for the start of the international recession likely to result from the Covid-19 virus in the 2020s as the Finnish research system is economically vulnerable compared to Norway and Sweden. As Fig. 16.2 indicates, public funding in the RDI sector in Finland had already decreased before the 2020 crisis, unlike in Norway and Sweden.

Figure 16.2 clearly indicates the differences in the development of RDI investment in Finland, Sweden, and Norway during the 2010s. The figure presents budget allocations as the amounts that governments allocate for R&D rather than actual expenditure reported by R&D performers. By the end of the first decade of the twenty-first century, these three countries were growing slightly regarding budget trends for the innovation system. The Norwegian funding has grown rapidly since then, and Sweden has also been following this growth path. The Nordic countries differ in innovation investment, but they are also united by a broad public sector and related publicly funded services. Norway has not spent as much of its oil revenue on maintaining the public service structure as it has on the stability and growth of the innovation system. Sweden and Norway also have their own national currencies through which they have supported their export industry, whereas Finland adopted the Euro as its currency.

The Higher Education System as Part of the Knowledge Economy and R&D Expenditure

As discussed in the first chapter of this volume, the knowledge society can be considered to encompass several characteristics associated with globalization (Delanty, 2001). In Finland, the state's role as a gatekeeper for knowledge and production is becoming weaker because knowledge production is widely distributed in society. Finnish development of the knowledge society has also faced a more even distribution and utilization in society. The Finnish innovation system, emphasizing digitalization, sustainable logistics, cleantech, bio-based economy, and participative health care (Koski et al., 2019), has also faced a demand for relevance in society for scholarly knowledge and its credible production. In Finland, this development has meant a change in the role of institutions that produce and manage information. Knowledge society-based reviews also provide a tool for understanding national interests and the rationale and importance of national higher education systems.

The knowledge economy is a concept close to the knowledge society that looks at changes in work from the perspectives of division, efficiency, and change in the division of labor (Drahos & Braithwaite, 2017). During the period covered by this paper (1990–2018), Finland has had ambitious programs that have promoted the goals of the nation and the economic system, as well as the attractiveness of research and education institutions. In the twenty-first century, Finland has based its social development largely on the principles of the knowledge society; the innovation system with research and development functions has developed favorably during the twenty-first century. This development has been reversed in the 2010s, and the discontinuity of higher education and research in the knowledge society is evident. In particular, the changes that have taken place during the twenty-first century have changed its relationship with the knowledge society.

R&D expenditure is a fundamental indicator of the investments in the knowledge economy. At the start of the 2010s, the Finnish higher education system appeared in the international debate as an example of stable growth and societal impact. During that time period, higher education institutions increased their R&D expenditure as the other publicly funded sector's R&D expenditure remained at the same level (see Fig. 16.3). However, RDI investments have increased most significantly in the private sector, especially in industry. The investment and use of knowledge in industry is different from universities and public research institutes. This is explained by the fact that research in export-driven industries has not been as vulnerable to the economic downturn as the heavily publicly funded universities.

Finland had an unprecedented recession throughout the early 1990s, but this is not reflected in R&D expenditure, and all sectors of society grew throughout the

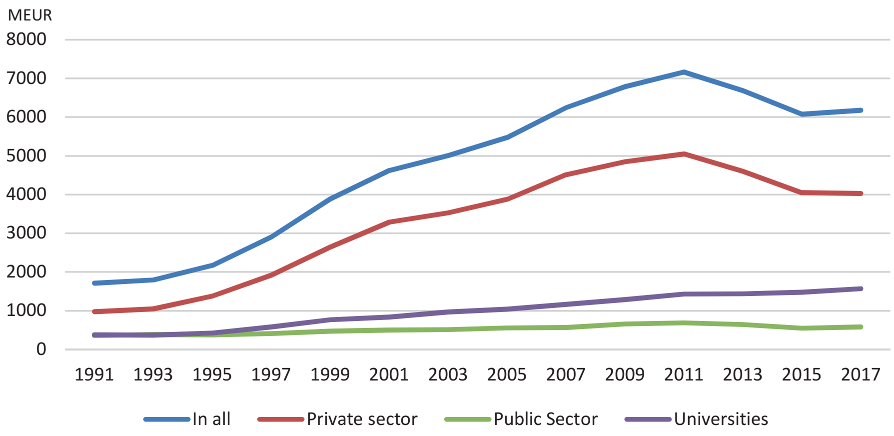

Fig. 16.3 Total R&D expenditure per sector in Euros. (Source: Statistics Finland, 2019a)

period. The recession of 2008 differs substantially from the recession in the early 1990s. The volume of funding for universities is around €1.7 billion and has remained at the same level for the last five years. Figure 16.3 illustrates this trajectory. However, the R&D downtrend appears to be moderating, and the private sector still invests heavily on R&D compared to the higher education and publicly funded sector. In this context, the importance of the knowledge society is manifested by the government as the phenomena of the knowledge economy, internationalization, and, more broadly, the theme of globalization, as well as the importance of markets and higher education. Although the global trends in the theme are strong, they are manifested in different ways in the participating countries, and universal change trends do not necessarily have direct consequences for the functioning and professional status of higher education institutions (Trowler, 1998; Leisyte, 2011).

The Role of the Profession and Academic Careers in Higher Education Institutions

Changes in the academic profession, its position in society, and uncertainty about the position of higher education institutions are themes for which international comparisons are possible. Until now, the academic profession has been attached mainly to the kudos provided by research-based education. Massification in higher education explains the potential that has developed in the Finnish RDI system over the last 30 years.

As per Statistics Finland (2020), the number of students attending university in 1990 was about 113,000, which at the time covered all higher education students in Finland. In 2018, there were 153,000 university students and another 142,000 students at universities of applied sciences (Statistics Finland, 2020). The massification and, more broadly, knowledge and the expansion of higher education have meant that higher education institutions can no longer ensure a lifelong knowledge base tied to the field (Abbott, 1988) (Fig. 16.4).

According to Donald Light's (1974) definition, the academic profession plays a key role in the recruitment of people to undertake academic assignments and the training of those selected for them. It also evaluates the suitability of its members, is responsible for the quality of work, is held in high esteem, and bases its activities on complex knowledge. The definition of the academic profession in Finland includes that portion of the research profession which operates under an employment contract of at least 25% full-time equivalent (FTE) in universities and universities of applied sciences. These include research, teaching, and external activities. Examples include cooperation with private and public companies, in-house training modules, and media presentations.

As in most reference countries, Finnish universities have deployed a national career path model based on the principles outlined by the Ministry of Education and Culture (MoEC, 2008). The path consists of four professional levels: an early career researcher, postdoctoral researcher, university lecturer, and professor. According to the follow-up evaluation (Välimaa et al., 2016), universities have exploited the career path model from two perspectives. First, the model has an evaluation purpose as an academic is aiming to achieve higher professional status (tenure-track). Second, the universities' human resources units have taken advantage of the model to standardize the academic ranks and job titles. The first purpose has specifically served the third-level academic's career opportunities in that professional profile highlights the research and funding function. The second purpose does affect the career path, having a strictly administrative function.

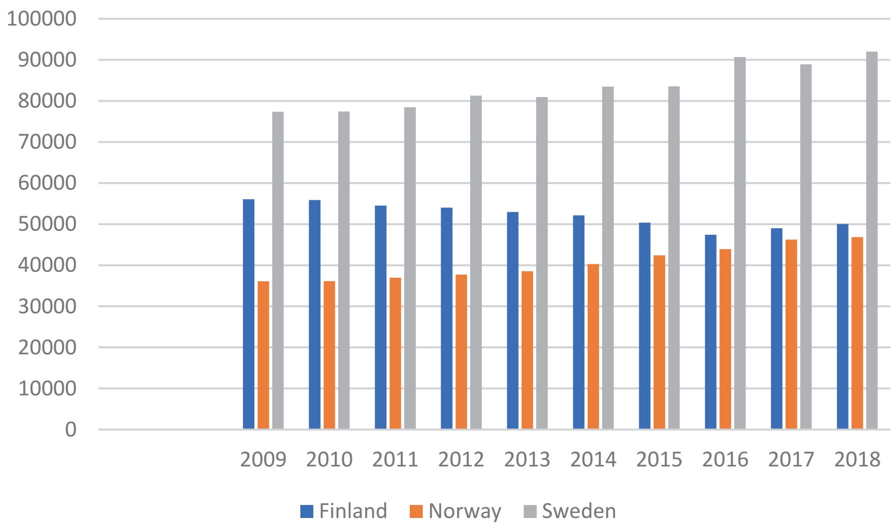

Fig. 16.4 R&D personnel in three Nordic countries. (Source: OECD, 2020)

According to the four-tier career model, access to academic careers requires the accumulation of research kudos. In all stages of the career path, it is necessary to focus also on teaching and societal interaction. This is where the key difference between the universities and universities of applied sciences lies. In universities of applied sciences, scholars enter the field through teaching assignments, and career background requires research experience. In cases of higher posts, a doctoral degree is also required. In universities, attachment to the academic profession is mainly based on the qualifications provided by discipline-based education.

Figure 16.5 illustrates the number of teaching and research staff at universities after the university reform. The first two career levels do not have many permanent vacancies, but there are vacancies from which it is possible to qualify for higher career positions. Those working at the first career level are required to qualify by completing a doctoral degree. Completing a doctorate has therefore become a central component of the early career responsibilities of universities, and this is the main task of the first career level.

All in all, the national career path model has clarified the universities' human resources statistics and academic hierarchy as a concept, but for academics, several defects have arisen from the model. First, the universities to some extent have used the model as an argument for fixed-term employment contracts. According to the Finnish Education Employers (2020), 60% of the academics served under fixed-term contracts in 2019 (doctoral career path contracts excluded). Second, the career path model overemphasizes the research function. According to the Union for University Teachers and Researchers in Finland (YLL), academics with many teaching duties do not have realistic opportunities to access the tenure-track system

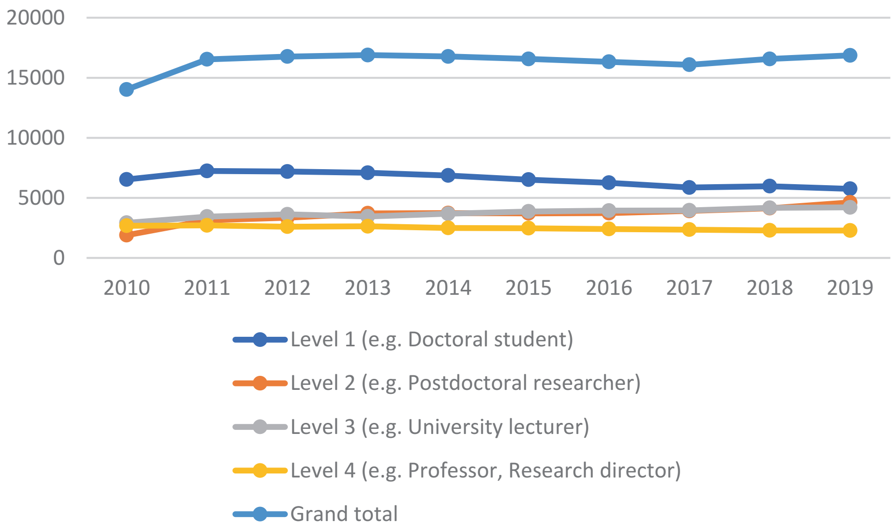

Fig. 16.5 Teaching and research staff at universities (the four-tier career model). (Source: Statistics Finland, 2020)

compared to the research-focused academics. YLL has presented an alternative, balanced career path model between the research and teaching function, but the model does not influence university human resources policies and practices. Third, the criteria for the career path model have become less distinct since its origin.

Along with the established research and publication criteria, the universities have placed a variation of volatile qualifications, such as capabilities to participate in international networking, collecting research funding and conducting administrative tasks (Hautamäki, 2020). As a result, the career path model has not sufficiently reached its academic purpose at the national level. The Ministry of Education and Culture and universities are still actively searching for the optimal benefits from the model.

For the universities of applied sciences, a national career path model has not been formulated even though there are standardized job titles, such as a part-time teacher, lecturer, and principal lecturer. According to the ex post evaluation associated with the universities of applied sciences' reform conducted in 2014–2015 (MoEC, 2018), the quantity of teachers has diminished at the same time as their performance requirements has been on the rise. For instance, teachers' rate of publication has increased by almost 200% within eight years. These statistics might indicate that there has been a productivity leap in the universities of applied sciences.

On the other hand, the ministry's evaluation does not pay direct attention to the potential connection between the reform and changes in the quality of degrees awarded by the universities of applied sciences. Some indications might be that general job satisfaction has decreased among the teachers and that the teachers' experience is that the employer does not take quality issues into account sufficiently even though the students' negative claims about teaching quality have not increased (MoEC, 2018). Accordingly, the performance guidance might have had an impact on a teacher's annual rewards, but there is no evidence on how the direction has more widely affected the teacher's career path.

In summary, the connection between the higher education careers and R&D function is tenuous. In the universities, the commensurate career criteria between the universities would serve as a source of equitable and flexible mobility among academics. In turn, that can be considered to be an essential demand for the R&D function. However, the contemporary trajectory leads in the opposite direction as the universities have created novel and distinct career criteria. In the universities of applied sciences, the role of the R&D function has been strengthened since the educational reform of 2013 described earlier in this chapter (MoEC, 2018). However, the connection between R&D and a teacher's career remains vague as the universities of applied sciences have not so far introduced their shared career path criteria.

Although we have not undertaken a systematic comparison of the knowledge-based societies in Finland, Norway, and Sweden, we have paid attention to the similarities and differences with these obvious reference countries. In Norway and Sweden, the scholarly profession can be defined according to similar principles as in Finland, but the systems are different. In Norway, industry plays a key role in the research ecosystem, and research inputs from universities have not increased in the innovation system. On the other hand, in Sweden, the position of universities was strengthened by legislation in 2008 which secured their financial resources well into the future at the time of this analysis. The opportunity for universities to take on broad social interaction with society was realized more strongly in Sweden than in Norway and Finland, especially during the period from 2008 to 2018.

The status and importance of the academic profession is different in universities and universities of applied sciences and also between disciplines, higher education institutions, and research institutes. Research is a key task in multi-faculty universities with doctoral education in all Nordic countries, but in Finnish universities of applied sciences and Norwegian university colleges, the major responsibility is teaching. These differences are significant because orientation determines attachment to the academic profession.

The changes in the higher education sectors (both universities and universities of applied sciences) are tied to the development of Finnish publicly funded structures and services and international trends. The developments in the 2000s have allowed the Finnish higher education institutions to influence volume factors, higher education priorities, and societal impact simultaneously. However, the untapped potential lies more between the two higher education sectors than within their internal development.

For the academic profession, key issues in higher education reform are institutional autonomy and academic freedom to choose research themes, theories, methods, and forums for publishing research results. Freedom of research is guaranteed by the Constitution and the University Act (2009), but governance is in part an even more important factor influencing academic freedom. The national publication forum with the ranking of journals, publishers, and conferences has quickly been adopted as a part of the funding formula between the government and universities.

Higher education institutions benefit from European Union funding instruments for public and private partnerships. The European Union's main RDI funding program is Horizon 2020 for 2014–2020. By October 2020, a total of 1320 million Euros (MEUR) had been granted to Finland, of which about two-thirds was granted to research institutes and universities. Universities were the largest single beneficiary of this funding with a share of around 522 MEUR. Other forms of funding for the innovation system are the European Regional Development Fund (ERDF) and the European Social Fund (ESF). External funding is significant, but it also brings an external interest to university research. This has a consequence for the accountability of higher education institutions, and the institutions in society have become part of the internal governance of higher education institutions. For example, representatives from outside universities now make up 40% or more of Finnish University boards. The importance of stakeholders has extended to areas that were previously core tasks of the profession. These are the tasks of education, and research planning, alongside regulation, budget control, and information control and practices, has been developed to expand participation in the higher education system. An example of this in Finland is the establishment of the Strategic Research Council (SRC), which in addition to traditional academic evaluation has also seen the evaluation of the societal interaction plans of research projects (Aarrevaara & Pulkkinen, 2016). There has been a remarkable change in the Finnish research system that SRC, as one key research funding instrument, also considers the importance of societal interaction alongside academic criteria. These essentially research-related tasks have expanded the knowledge base of the academic profession into the tasks of the academic community.

All these developments have also changed the task of scholarly profession. In evidence-based decision-making, there is an obvious need for evidence-based and open knowledge, which when combined with social interaction provides a tested knowledge base for policy making. Although trends in higher education development are international, dissatisfaction with the working conditions of the academic profession is evident.

Access to Higher Education

In addition to research and societal interaction, and social betterment, the tasks of universities and universities of applied sciences also include providing education. Teaching is part of the identity of the academic profession, and the emphasis on the role of teaching in higher education separates them from research institutes. The degree-oriented education of students is also a key societal impact of higher education institutions, and it also largely determines the growth and contraction trends of higher education institutions.

About half an age-cohort passes each Finnish matriculation examination, which is a major pathway to higher education. Also, a postsecondary vocational degree or a minimum three-year vocational qualification provides general eligibility for entry to programs offered by universities and universities of applied sciences. This eligibility is given by equivalent foreign qualifications requiring usually at least 12 years of school education. Higher education institutions also admit applicants who have completed relevant study in open university or open university of applied sciences programs or have otherwise demonstrated that they have the necessary skills and knowledge to complete a higher education program.

In Finland, education is valued highly by policy makers, and its tuition fee-free nature is considered to be an essential principle of the welfare state in society. Therefore, all education leading to the degree is tuition fee-free for citizens of the European Union and the European Economic Area. The system is expensive because in a country of about 5.5 million people, more than 250,000 students are continuously studying for a first or second “Bolognian” cycle higher education degree. However, this is worthwhile as it is well established that well-being can only be based on renewable knowledge and skills.

Degrees play an even more notable role during the upcoming higher education budget period in 2021–2024. The ministry has emphasized a general qualification examination path for the applicants that have recently passed the matriculation examination or a postsecondary vocational degree and a continuing (lifelong) learning path for the applicants that are more experienced or aiming at reeducation. As a consequence, the ministry has also increased the lifelong learning proportion of the total budget from 5–9% for the universities of applied sciences and from 2–5% for the universities. According to the ministry's interim report, a lifelong learning objective must be supported by a stand-alone strategy until 2030 (MoEC, 2019a).

Lifelong learning mainly consists of open higher education study and discrete courses although the ministry has included some novel elements in the budget described as a professional specialization for postgraduates. The new educational form is established between a completed higher education degree and continuing professional development for the students who have acquired some workforce experience. The proposition associated with the professional specialization programs is that they do not compete with the existing higher education in-house training courses or commercial training modules. According to a recent evaluation report (Rauhala & Urponen, 2019), the universities have already supplied 30 professional specialization programs, and the universities of applied sciences 31, and both education sectors are preparing several seminal plans.

Lifelong learning, implemented in cooperation between universities and the workforce, implements the renewal of competence and skills in society that are important. As an example, open university is one ministry funding instrument for lifelong learning. Universities of applied sciences also accept applicants who have completed upper secondary education or vocational education and training. Eligibility for the second cycle, or master's degrees, awarded by the university of applied sciences requires a relevant first cycle degree and at least three years of relevant work experience.

All in all, both the labor market and the students have considered professional specialization programs as a promising solution for the demands of changing work and competence needs. However, the plans have still accomplished a rather unpretentious level of conspicuousness and turnout, serving mainly highly regulated professions, such as specializing psychologies or social workers (Rauhala & Urponen, 2019). For the more extensive deployment, the generalist fields should also adopt the idea of professional specialization and provide their distinct programs.

So who is educating the students in higher education? It is necessary to understand the work of the academic profession in the context and the effects of the changes in the operating environment of higher education institutions. Changes in the profession, its position in society, and uncertainty about the position of higher education institutions are themes through which international comparison based on APIKS data is possible.

Although general work conditions at universities and universities of applied sciences have deteriorated according to many studies, higher education still has a strong position in Finnish society. Its autonomy is based on the financial, administrative, and scientific procedures reinforced by national regulation, but the operating environment certainly has conflicting expectations about the role of higher education institutions. The decade-long deterioration between 2008 and 2017 in the economic conditions of higher education has fundamentally changed the general work conditions of the academic profession (Pinheiro et al., 2014; Fumasoli & Huisman, 2013).

Higher education institutions sign a 4-year contract for funding with the Ministry of Education and Culture based on a funding formula, and there is annual monitoring of the performance of higher education institutes for performance funding (Aarrevaara et al., 2018). Only three higher education institutions in Finland have no agreement under the ministry. They are the National Defense University under the Ministry of Defense, the Police University College under Ministry of the Interior, and the Åland University of Applied Sciences under Landskapsregering ("regional government"). Higher education institutions implement the ministry performance agreement through internal allocation. These allocation models do not directly implement the agreement but also include the institutions' own strategic guidelines.

The reward-based salary system for teaching and research personnel at the universities is based on two components. The first of these is the job-specific demand component, which is based on the assessment of work demand category and job title. The second is an individual's performance, which is evaluated in review meetings about personal performance, considering the teaching load, research outcomes, efforts for the university community, and the impact on society. The trade unions are represented on the university-level committee to give statements about the review discussion between supervisors and employers, and the university leadership confirms this result.

Postgraduate Study as a Key to Scholarly Profession

The Finnish universities and universities of applied sciences offer first and second cycle degrees (bachelor's and master's), and all universities offer postgraduate degrees (licentiate and doctoral degrees). The number of doctoral graduates has increased significantly over the last 20 years due to the national doctoral school system established in 1994, abolished in 2010 in the context of university reform. The national system has been replaced by university-specific doctoral schools, which on the one hand has professionalized the completion of doctoral degrees but on the other hand has deprived opportunities for discipline-based national and international graduate schools. New candidates' entry into the system is more difficult than before. The doctoral degree retains its attractiveness as it is the key degree in the knowledge society for the scholarly profession. A doctorate is also required as a qualification requirement for research and key professions in publicly funded positions.

According to the Finnish Education Statistics portal (Vipunen, 2019), doctoral graduates worked in universities (37%), other publicly funded organizations (35%), and companies (28%) in 2019. The companies contain significant potential for the PhD holders and the innovation system. According to the OECD (2017), Finland has not sufficiently managed to connect the doctoral capabilities with the needs of the industry. As a response, Finland has increased business and work-based modules in the doctoral programs. These novel business elements might change the profile of doctoral graduates in the future. For example, compared to other European countries, the postgraduate student's median age is high in Finland (MoEC, 2019b). Both the academic (a four-tier career model) and business paths emphasize young doctoral graduates. Accordingly, the universities and the innovation system might need more specific doctoral programs and distinct objectives for the doctoral candidates in the future.

Licentiate degree is another key graduate degree between the master and doctoral degree. In the early 2000s, the number of licentiate degrees was about two-thirds of the number of doctoral degrees. Finnish universities still offer first and second cycle degrees (bachelor's and master's) and postgraduate degrees (licentiate and doctoral degrees). The licentiate degree had earlier been a qualification for the positions of assistant professor and principal lecturer and had also been valued in some sections of the workforce. However, under the Bologna system, this degree no longer exists, and its role in university performance management is negligible. Prior to the transition to a three-tier degree system, a licentiate degree was a "license" prior to a doctorate with an independent thesis. Now, its importance in labor markets and in the degree system is negligible, and almost all candidates complete a doctorate without having done a licentiate degree. The licentiate degree is still an undergraduate degree in medicine, where no two-tier master's degree is completed after a one-tier bachelor's degree.

Conclusions

The changes in the higher education sectors have been related to the development of Finnish publicly funded activities and international trends, the core of which is the secession of universities and universities of applied sciences from the umbrella of state organization and the formation of an independent legal personality as higher education institutions. Over the last 30 years, Finnish higher education reforms have been implemented in four stages as part of the reform of the innovation system. The regional policy perspective dominated the development in the early 1990s, when the growth in student numbers and regional tasks took place primarily through the establishment of universities of applied sciences. Membership of the European Union fundamentally changed the field as the emphasis on regional policy was partly replaced by the emphasis on internationality. In higher education, this was particularly evident in the growth of international research funding, staff and student mobility, and international programs. The economic regression of 2008 triggered structural reforms that led to large-scale university mergers and changes in the formal status of higher education institutions. Since 2013, the innovation system has been dominated by research institute reform and related innovation policy priorities.

At the heart of the reforms so far, there have been structural reforms in the higher education sectors allowing individual institutions to influence student volume factors, higher education priorities, and societal impact simultaneously. However, untapped opportunities lie more between the two higher education sectors than within their internal development.

Although Finland is a small country, specialization in innovation system is sometimes strict. According to this chapter, the universities' career path model still has the following flaws: only some academics have access to the model, the model overemphasizes the research function, some universities have exploited the model as a reason for fixed-term employment contracts, and the criteria for the model have become blurry since its origin. The universities of applied sciences are still waiting for their contiguous career ladders. From the unified higher education perspective, consistent career models can be considered essential for both the universities and universities of applied sciences. Research institutes are increasingly cooperating with one another, universities and universities of applied sciences are becoming more international, and there is a strong demand for the scholarly analysis and knowledge they produce. Academic staff in universities are still pursuing careers through research, and those in universities of applied sciences through teaching; work assignments and time management are also built accordingly. However, mobility between the universities and university of applied sciences is low.

The APIKS results for 2018 indicate that those whose tasks focus on research are primarily selected for the academic career. The Finnish APIKS data seem to differ from the main reference countries in that those working in the fourth career stage of full professors teach more in Finland than those working in the early stages of their careers. This is because in the first two career stages, there are a lot of researchers working on projects and doctoral students who teach little or not at all in the early years of their academic career.

However, the consequence for the higher education system is a high unemployment rate for doctoral graduates compared to other relevant countries (OECD, 2017). In 2018, 4% of newly graduated doctors were unemployed, and 86% employed (Statistics Finland, 2019a). A potential trajectory for the future might be separate paths for postgraduate students who are aiming at an academic career (the first career stage), business career, and other positions. Nevertheless, these directions should still fulfill the doctoral dissertation criteria to sustain academic quality. Another potential view is a clear cut on the quantity of postgraduate students, on the one hand, and a strict learning path for the students, on the other.

Universities are still pursuing careers through research, and universities of applied sciences through teaching — work assignments and the use of time are also structured accordingly. Mobility between institutions in the scholarly profession is still too low. The opportunities for opening up career paths have not been exploited in the reforms of the research system, and mobility within the research system is not yet widespread.

For the last few decades, Finland has been a society built on professional sectors in which some professions including the scholarly profession have played a significant role in building the welfare society. At the core of the performance of the higher education institutions, there is cooperation between actors, and the effectiveness of operations is a key determinant of resource allocation defined in government funding formula for universities and universities of applied sciences. The innovation system of the 2020s has strong legitimacy in Finland and has a guiding effect on the formation of academic profession. For the last few decades, higher education institutions have sought their role in the innovation system of the 2020s, and this construction is strongly driven by funding instruments. The starting point for European governance guides universities to a more strategic and innovative approach. On the other hand, academic funding and publication forums guide the production of high scholarly quality. In the coming years, within the scope of comparative research, the APIKS survey will open up the starting points on which the innovation system and especially universities can implement the utilization and effectiveness of information.

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Timo Aarrevaara is a Professor of Public Management at the University of Lapland, and Principal Investigator of the research team of Professions in Arctic Societies. He has professional experience in public administration as well as in research and teaching. He is chair of the APIKS coordinators group.

Ville Pietiläinen is senior university lecturer of leadership psychology at the Faculty of Social Sciences, University of Lapland. His research interests are entwined with both education policy and leadership issues. The key research questions revolve around complexity, supportive leadership roles, co-creative space, and interaction dynamics. His professional background derives from public administration and human resource management. He has served as secretary general at the Finnish National Education Evaluation Council and conducted many system evaluations, process consultations and audits.

Chapter 17
The Interplay of Higher Education, Research, and Innovation in Sweden

Stefan Lundborg and Lars Geschwind

Abstract In this chapter, we analyze the key policies in research, development, and innovation (RDI) and the role of the higher education sector in Sweden. The chapter begins with a policy overview of RDI, followed by a discussion of the innovation capacity and research performance of Sweden and an analysis of the role of higher education in RDI. After describing its distinctive historical context, we present some key characteristics of the Swedish higher education system and academic profession. Finally, we formulate the functions and challenges of the Swedish system.

Keywords Innovation policy · Research funding · Higher education · Doctoral studies · History of higher education

Introduction

Sweden is a Nordic country of around ten million people. It has been a full member of the EU since 1995. Like the other Nordic countries, Sweden has taken steps toward a knowledge economy with a strong focus on innovation and technology. Since the early 1990s, the Swedish economy has seen stable growth with only minor dips, although the global financial crisis that began in 2007–2008 had negative effects on investment into research and development (R&D). This growth has been the primary driver of increased research spending, which measured as a percentage of GDP has remained relatively flat after a slight downturn at the start of the twenty-first century. It is worth noting that even this stagnant level is high by global standards; Sweden's average R&D investment far surpasses the OECD (Organisation for Economic Co-operation and Development) average over the last 30 years

S. Lundborg (✉) · L. Geschwind
KTH Royal Institute of Technology, Stockholm, Sweden
e-mail: slundbo@kth.se; larsges@kth.se

T. Aarrevaara et al. (eds.), *Universities in the Knowledge Society*, The Changing Academy – The Changing Academic Profession in International Comparative Perspective 22, https://doi.org/10.1007/978-3-030-76579-8_17

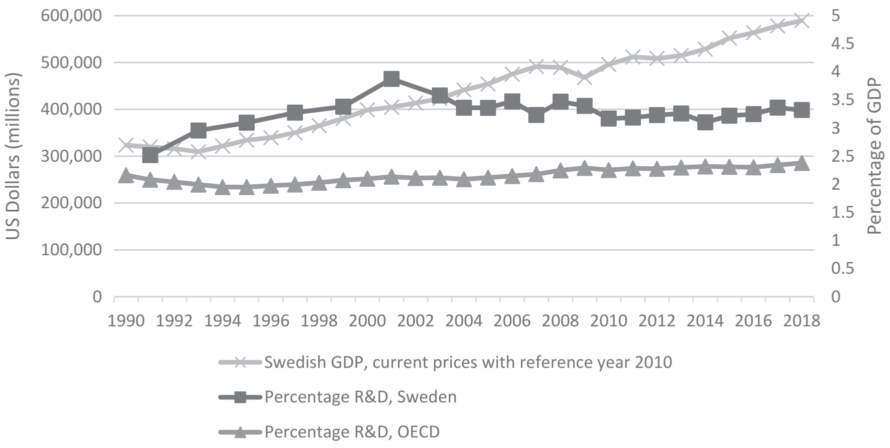

Fig. 17.1 GDP in Sweden 1990–2019, constant prices with reference year 2010, in relation to R&D spending as a percentage of GDP. (Source: OECD (2020b); World Bank (2020))

(Fig. 17.1). About 25% of R&D expenditure in Sweden comes from government sources, which is roughly on par with the OECD levels (OECD, 2020a).

This chapter provides an overview of policy reforms in the Swedish system of RDI and discusses the policy impacts on system performance. It also describes the role of the higher education sector and concludes by presenting the current challenges faced by the Swedish system.

Research, Development, and Innovation in Sweden

Policies and Strategies

Sweden's national policies and strategies for research, development, and innovation (RDI) date to the 1940s. During World War II, in which Sweden remained neutral, state committees were formed to organize a modern RDI system. This was partly due to the economic crisis of the 1930s, which caused a decline in resources and the quality of higher education.

The experiences from World War II showed the potential societal benefits of research and innovation, and the Swedish prime minister formed a government committee on research policy in 1962 composed of active researchers from the humanities and the natural, technical, and social sciences. Simultaneously, large investments were provided to regional authorities for conducting clinical research, and national policy areas such as housing and agriculture were adapted to make use of scientific advances. Public research institutions were expanded, and funding bodies working in tandem with research-intensive enterprises – largely in medicine and technology – were also developed (Wetterberg, 2010). In addition, the university sector established itself as the chief producer of public research efforts (SOU 1975:26).

The next great leap in Swedish RDI policy came in 1972 with the appointment of a research council committee, which laid out an ambitious plan for policy reform that included the establishment of a new funding body to support research of societal importance and to facilitate cooperation between existing bodies (SOU 1975:26). Crucially, the committee also suggested that the government propose a unified bill, once during each parliamentary term, to set the future direction of R&D policy – these are now known as "research bills" (SOU 1977:52). These policies led to greater cohesion in Sweden's RDI efforts, further entrenching the emerging knowledge economy. It also stimulated greater focus on the university sector as both a producer and distributor of new knowledge based on its key functions of research and teaching.

The next major reform came in 1977 with the consolidation of all postsecondary education into the university sector. This change led to a massive expansion in the number of higher education institutions in Sweden, and the mergers of municipal and regional institutions primarily focused on teacher and nursing education. Sweden was divided into six educational regions, each of which was to have one university and at least one university college. In the division between the two types of institutions, research and PhD education remained university matters; however, this caused a deficiency within the teaching-research nexus for professional education that remains an issue today (SOU 2015:70).

The next step in the consolidation of research efforts in the higher education sector was taken in 1990, when an agreement was reached regarding medical training and research (ALF). Medical research was to be carried out at regional healthcare facilities in formal collaboration with universities, generating a significant interconnectedness between healthcare development and university research (prop. 1989/90:90).

The higher education system was again reformed in 1993 with a new funding system. Universities and university colleges were largely free to determine their own operations within the confines of available funding (Prop. 1992/93a:169). The main exception remained PhD education, the regulation of which was only gradually loosened using an application process that reached its peak as recently as 2019 when the last university college was given the right to award third-cycle degrees (UKÄ, 2020a).

Throughout most of the twentieth century in Sweden, the Social Democratic Party held a more or less hegemonic position. In the mid-1970s, the party began working on *employee funds*, with a portion of private profits intended to be put into funds (controlled by trade unions) and used to buy shares in listed companies, with the aim of gradually transferring ownership and control of these companies to workers. This ended up having a seismic effect on Swedish research funding when the process foundered in 1991 after the Social Democrats briefly lost power. The new government, conservative in outlook, immediately abolished the employee funds, and most of their accumulated resources were set aside for research (Prop. 1991/92:92).

In 1993, two new research foundations – the Swedish Foundation for Strategic Research (SSF) and the Swedish Foundation for Strategic Environmental Research (Mistra) – were formed, and the existing foundation of Riksbankens Jubileumsfond (RJ) was further capitalized. The total amount of capital was roughly 10 billion Swedish crowns which, adjusted for inflation, corresponds to about 1.4 billion euros today (Prop. 1992/93b:171). They were further joined by additional foundations in 1994 comprising the Swedish Foundation for International Cooperation in Research and Higher Education (STINT), the Knowledge Foundation (KKS), the Swedish Foundation for Care and Allergy Research (Vårdalstiftelsen), the Foundation for Baltic and East European Studies (Östersjöstiftelsen), and the International Institute for Industrial Environmental Economics (IIIEE). These additional foundations were capitalized with roughly 8 billion Swedish crowns – 1.1 billion euros in today's value (Prop. 1993/94:177). In 1994, the last vestiges of the employee funds were used to transform Chalmers University of Technology and Jönköping University from public authorities to foundations, introducing a new type of higher education institution to the system (Prop. 1992/93c:231).

Additional reforms of the funding landscape would take place in the following years with changes in balance between research councils, funding authorities, and the new foundations, as well as the scuttling of some bodies and the establishment of others. No reform had such far-reaching effects on the landscape as a whole until 2001, when the current research councils were established. The newly established councils were comprised of the Swedish Research Council (VR), the Swedish Innovation Agency (Vinnova), the Swedish Research Council for Sustainable Development (Formas), and what would become the Swedish Research Council for Health, Working Life, and Welfare (Forte) (Prop. 1999/2000:81). Together, these four organizations contributed roughly 11 billion Swedish crowns in research funding during 2017 alone (Statistics Sweden, 2020a).

In 2011, the movement toward greater autonomy for higher education which started with the 1993 reforms was greatly furthered by the so-called *autonomy reform*, removing a large portion of the regulation regarding the internal governance of institutions – especially regulation mandating mechanisms of collegial governance, such as faculty boards. In practice, most higher education institutions have maintained some elements of the previously regulated structures, but as these structures are now voluntary, the room for action on the part of central university management has been markedly increased (2014/15, RFR5).

As of 2020, the increased autonomy for higher education is hanging in the balance; a government commission recently suggested changes that could either strengthen or rein in the autonomy depending on the implementation. Perhaps chief among these suggestions was a funding reform, where universities would be free to regulate their own balance between research and education activities and the enactment of a system of performance agreements between the higher education institution and the ministry in a model similar to those of Finland, Denmark, and the Netherlands (SOU, 2019:6). The government has not as yet assumed a clear position in relation to these suggestions.

Guiding many of these developments since the late 1970s have been the aforementioned research bills, produced every three or four years. Besides the major reforms introduced, these bills have also controlled the flow of government resources directed toward research and, by extension, both innovation and higher education. After an initial focus on strengthening the university sector as well as industrial research in general, eventually the focus turned toward excellence in research and, in more recent years, toward collaboration and societal utility.

Analysis of RDI in Sweden

Sweden is, despite its modest size, almost invariably described as a leader in international innovation, but it is faced with challenges. The European Innovation Scoreboard of 2020 names Sweden one of five *Innovation Leaders*. The country narrowly maintained its lead in this select group, owing to top or near-top performance in eight out of the ten innovation dimensions that comprise the index. The two exceptions concern the presence of *innovators* and the *sales impacts* of innovations – both being clear examples of outcome dimensions that contrast with the indicators regarding conditions for innovation, where Sweden performs better (European Commission, 2020). This is consistent with the findings of the Research and Innovation Observatory's *RIO Country Report 2017: Sweden*, which found Sweden to be in a robust position but faced with important challenges in ensuring a stronger linkage between research and innovation, reducing its dependence on a small number of multinational companies for its R&D expenditure, and sustaining high quality within the public research base (European Commission, 2018). All of these challenges clearly point toward difficulties with ensuring that favorable conditions for innovation also lead to innovation in practice.

A similar pattern can be seen regarding research, where Sweden has historically performed strongly; as shown by the 2016 OECD Compendium of Bibliometric Science Indicators, Sweden was one of the top performers, measured by both publications per million inhabitants and frequency of highly cited publications (Fig. 17.2). The Swedish Research Barometer 2019 likewise concluded that performance was strong with regard to expenditure, staffing, and publication volume but adds that performance – although strong – is significantly weaker regarding citation impact (Swedish Research Council, 2019). Again, this points to a system where all the right conditions appear to be in place but where it has been difficult to transform ambitious policy efforts into practical performance in terms of output and impact. The Swedish RDI system performs *fine*, but such an evaluation departs sharply from its *excellent* conditions.

This has been a long-standing issue for the Swedish value chain of research and innovation, sometimes called *the Swedish paradox*, with large investments in R&D having scant effect on system output (Bitard et al., 2008). This problem is therefore in no way unknown to policy analysts or the powers that be, which could serve to explain the shift in research bills first toward excellence and then collaboration.

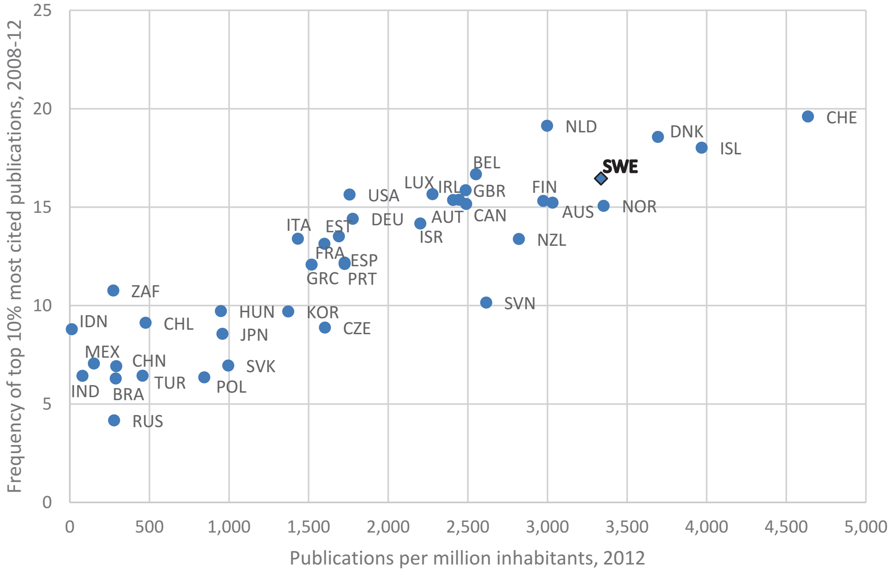

Fig. 17.2 Publications per million inhabitants 2012 in relation to frequency of top 10% most cited publications 2008–2012. (Source: OECD (2016))

First, an attempt to build a strong foundation of excellent research is undertaken. Then we try to make sure that this research is strongly linked to the innovators of society at large. Fundamentally, the two approaches represent different views of how value is created. On one hand, value is obtained by letting the brightest talents grow as much as they possibly can so that the rest may follow; on the other, the idea is that all talents grow best when they grow together.

This raises the question of what room these talents are given to grow within the confines of the Swedish system, which returns us to the country's higher education sector.

The Role of Higher Education for Research, Development, and Innovation in Sweden

The position of the Swedish higher education system appears to be strong in an international comparison. The attainment level of tertiary education among 25- to 34-year-olds is 48%, compared to the OECD average of 45% (OECD, 2020c), with as many as 15 researchers per 1000 employed compared to the much lower OECD total of 9 per 1000 (OECD, 2020d).

The specific configuration of the Swedish RDI system means that the conditions of higher education institutions have several direct effects on the general innovation

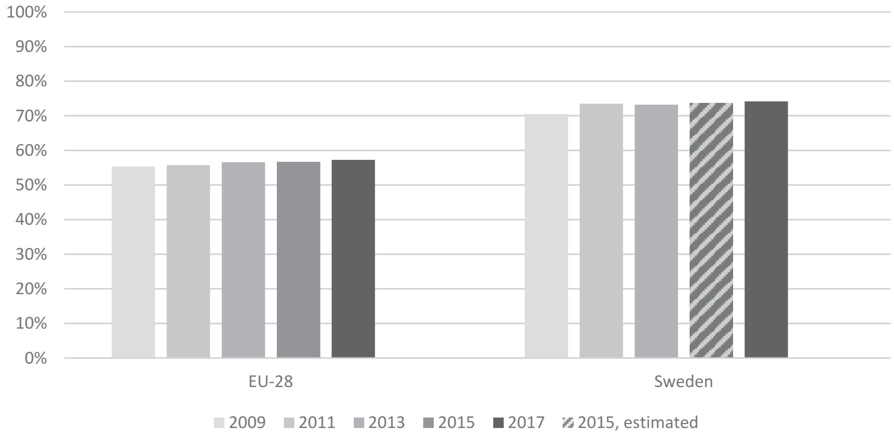

Fig. 17.3 Level of government R&D spending directed at higher education institutions as performers, every other year 2009–2017. Swedish figures for 2015 estimated based on adjacent measuring points due to lack of data. (Source: Eurostat (2020))

capacity of other sectors of society. This is partially based on the fact that more than 70% of government spending on R&D has been steadily directed toward higher education institutions, a significantly higher level than that of the EU as a whole (Fig. 17.3).

Two other examples of this reliance on higher education institutions are found in the holding companies and innovation offices, found at the universities and some university colleges.

The holding companies were introduced in 1994 and tasked with generating closer ties between the higher education institutions and private businesses by allowing the universities to participate in new types of collaborations – such as business incubators – and stimulate the flow of personnel between the sectors. The companies are themselves fully owned by a university or university college and capitalized by the government, partly when established and partly through an annual capital injection. The function of the holding companies as a construct is twofold: First, they allow higher education institutions to act in the market economy in a way that their status as public authorities or foundations would normally prohibit. Second, they provide a way to maintain orderly control of their market-like activities under a single umbrella; the university owns a company, which in turn owns multiple other companies, rather than the university directly managing the ownership of the others. The set of holding companies has been expanded at various points, generating a total of 18 holding companies fully owned by Swedish higher education institutions, 17 of which are government authorities. Among the government-owned companies, the collected turnover in 2018 amounted to roughly 40 million euros (RiR 2020:4).

The innovation offices were instituted through the research bill of 2008, with the aim of working toward *making use of research carried out at university* (prop.

2008/09:50). In accordance with this, an innovation office can now be found at each university in Sweden, with some having a special responsibility to support nearby university colleges toward the same ends. The innovation offices are integrated administrative functions of their respective university that work to encourage commercialization of innovative ideas from their personnel and students through, for instance, establishment of such enterprises or patents that the holding companies might invest in. The line between the innovation offices and the holding companies is often blurred, with common interests in government-supported idea banks, for example, meant to facilitate the commercialization of ideas sprung from the activities at the higher education institutions.

It is clear that the fundamental idea of the Swedish RDI system is to make universities *one-stop shops* for the entire value chain. They educate the workforce through providing the vast majority of all tertiary education in the country (UKÄ, 2020b), produce the knowledge that fuels the education via a dominant position in research activities (Geschwind, 2017), and are meant to facilitate the transformation of this knowledge into workable implementation and economic growth as *key innovators* (Lidhard & Petrusson, 2012). As with previous examples regarding the Swedish discrepancy between performance in indicators measuring conditions and outcomes, respectively, this idea has so far not been entirely successful. A part of this is attributable to dubious results on the innovation front (RiR 2020:4), but during the consultation process for the research bill of 2020, several actors – one university included – also noted clear issues with the division of labor between various parties within the research landscape. Such issues included the responsibilities of the comparatively small sector of research institutes as well as what was deemed as fairly hidden or neglected roles of private businesses and non-university government authorities (Geschwind & Lundborg, 2020).

Characteristics of the Swedish Higher Education System

Historical Context

Sweden got its first higher education institution in 1477 with the founding of Uppsala University, followed by Lund University in 1666. Other universities in Stockholm and Gothenburg followed during the nineteenth century, initially styled as university colleges, accompanied by the advent of specialized universities such as the Karolinska Institutet, Chalmers University of Technology, and the KTH Royal Institute of Technology. During the twentieth century, further universities and university colleges were established in waves, during the 1960s, 1970s, and 1990s.

The driving forces behind the establishment of Swedish higher education institutions have varied depending on the time period and type of institution in question. The first universities were established as educational institutions dedicated to general governmental and theological competence, whereas the specialized universities of the nineteenth century were meant to cater to more instrumental needs. The Karolinska Institutet, for instance, was founded to improve the capability of Swedish field medicine and surgery as a result of less than stellar performance during the Finnish war of 1808–1809 against Russia. The expansions of the twentieth century were largely motivated by regional policy and growth efforts, as well as the aforementioned attempt to form a more cohesive and unitary system of higher education. The historical legacy of each higher education institution has important implications for their respective positions within the system as their original purposes have, to a large extent, acted as driving forces for both their own development and the government's approach toward them (Jernberg, 2017).

A significant contributing factor to this historical embeddedness lies in the way that the higher education institutions are governed, with most instructions being given as blanket missions for the entire sector through laws, ordinances, and shared appropriation directions. This means that there are few active measures working against path dependencies, even when no individual policy efforts actively entrench the historical legacies. The foundation of this current system of governance was laid in the previously mentioned higher education reform of 1993, with a move from a centrally planned system to a market-like structure where the higher education institutions compete against one another for students. Each registered student is, up to a point, worth a certain sum of funding from the government depending on what they are studying, and the government primarily steers the direction of higher education through the balance between the funding categories as well as earmarked funding bounties toward certain types of education. Coupled with the expansive system of funding bodies for research activities, this means that higher education institutions tend to become more entrenched in their positions over time – they direct their development efforts toward areas where they are already strong and therefore are most likely to succeed in a competitive market (Lundborg & Wikström, 2017).

The divisor between universities and university colleges has long been a staple of the systemic policy debate regarding higher education, but particularly so after the aforementioned reform in 1977, where the number of university colleges increased quickly and heavily. For a time during the 1990s and early 2000s, it was possible for a university college to apply for the status of university and, with it, the general ability to carry out third-cycle education. Three university colleges – Karlstad University, Örebro University, and Växjö University (now Linnaeus University) – were eventually successful in meeting the set criteria, with a fourth (Mid Sweden University) being deemed by the government likely to meet the criteria a few years down the line. Within the span of a few years, all four were granted university status. Shortly thereafter, the door to university status was closed by the government as part of the policy focus on excellence – further institutional upgrades would thin out the supply of resources for the existing universities. Recently, the door has been opened once more, with the upgrade of Malmö University in 2018, and the announcement in 2020 that Mälardalen University would likewise be upgraded starting in 2022 – once again for reasons explicitly tied to regional policy demands (Government Offices of Sweden, 2020).

The prevailing focus on excellence during the start of the twenty-first century did not only lead to the end of the university status application system; a series of institutional mergers were undertaken to generate the critical mass deemed necessary for the creation of truly world-class universities. The Stockholm Institute of Education was merged with Stockholm University, Växjö University and Kalmar University were merged to create the aforementioned Linnaeus University, and somewhat recently, Gotland University was merged with Uppsala University while three arts colleges were merged to create the Stockholm University of the Arts (Geschwind, 2017). However, with the decline in focus on excellence and the emerging focus on collaboration, innovation, and regional growth, this type of consolidation has ground to a halt. Three multicampus higher education institutions (Dalarna University, Blekinge Institute of Technology, and Örebro University) have in recent years, by their own initiative, attempted to merge their campuses – so far unsuccessfully, due to protests from the ministry based on the ambition to maintain a broadly distributed regional presence of higher education institutions.

The common theme throughout most of this history has been some form of political utility; if a problem has needed solving, the solution has fairly often turned out to be the expansion of higher education, sometimes followed by mergers or status upgrades in order to consolidate the sector and keep it from becoming disordered. Although the rate of expansion for the number of institutions themselves has slowed, the basic policy idea has remained. This is illustrated in part by continuing expansion of higher education, particularly during times of economic crisis, but also by an enduring tendency to make use of the capacity of higher education as well as university research to solve various policy issues that do not necessarily fall into the traditional scope of the sector (Sörlin, 1996; Sundqvist, 2010).

Structural Characteristics

As of 2020, there are 48 higher education institutions in Sweden. Of these, 17 have university status while the remainder are considered university colleges, though the English translation of their names generally leave out the college part. Thirty-one institutions, including all but two of the universities, are also public authorities, carrying out the vast majority of all higher education. A further 14 are considered *independent higher education providers*, which tend to be very small businesses admitting only a handful of students each year. The remaining three institutions, two of which are universities, are run as private foundations.

The Swedish higher education system is course based, meaning that students register to study on individual courses rather than a comprehensive education. Higher education institutions may package these courses into programs to make course selection easier for the students, as well as to increase the marketability of their educational offerings; whether the courses taken are part of a program or not has no fundamental impact on what degree the student becomes eligible for. Since the introduction of the Bologna degree system, the number of local programs leading to bachelor and master's degrees has increased. In addition to general degrees, there are professional programs with their own national degree requirements and regulations (e.g., nursing, engineering, and teaching).

The course-based system has consequences for the administrative process of higher education, one of which being that degrees are not automatically awarded upon completion of studies. Instead, the student must actively apply for a degree when he or she feels that the requirements are met – something that not all students do, as employers rarely ask for a degree certificate. The result is that there is no accurate way of measuring the *output* of the Swedish educational system as the number of degrees awarded does not correspond to the number of educational processes finished, and the number of courses completed does not provide any information on whether the studies were carried out until completion or if the student stopped halfway.

The course-based system also means that a large number of Swedish students are not studying full-time. Instead, they may take a single course every now and then, particularly later in life during vacation periods, and thus either remain in the system for many years or show up several times with long gaps in between. While complicating statistical endeavors, in theory this should be a positive trait for lifelong learning and, in turn, development and innovation. In total, 410,288 individuals were registered on a course during the academic year of 2018/2019, which corresponds to 300,542 when converted to full-time equivalent (FTE). As many as 67,928 FTE students were registered on freestanding courses rather than programs. The number of FTE for completed courses was notably lower at 250,706, meaning that roughly 83% of all students managed to complete the courses they had registered for (Fig. 17.4). This number is significantly lower for the freestanding courses at 63%. This has been a hotly debated issue since the current system of higher education was implemented in 1993, primarily because this number impacts the funding of the higher education institutions, supposedly inhibiting efforts dedicated toward lifelong learning.

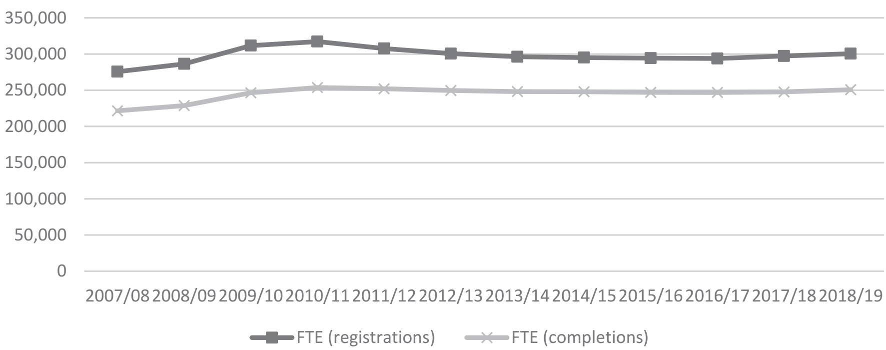

Fig. 17.4 Full-time equivalents (FTE) for course registrations and course completions in Sweden between the academic years of 2007/2008 and 2018/2019. (Source: UKÄ (2020c))

The Swedish higher education sector is often broadly divided into six groups of institutions: comprehensive established universities, specialized universities, new universities, university colleges, arts colleges, and independent providers. Fundamentally, these groups all share the same regulated role in the system; every higher education institution is expected to carry out both research and education, to contribute to the provision of competence and lifelong learning, both curiosity-driven research and applied research, and so on. Their instructions differ only marginally through some specific tasks, such as Uppsala University's instruction to carry out education in a number of less commonly spoken languages. The vast majority of goals and missions are common to all higher education institutions.

However, the different types of higher education institutions differ on two important and interrelated counts. The first is that they – as also indicated by the overview of the historical context – share common historical legacies within each group and therefore some structural characteristics with regard to their institutional profiles and focuses (Stensaker & Benner, 2013). The comprehensive universities carry out education and research activities across more or less the entire range of disciplines, being catch-all institutions, providing knowledge in bulk. The specialized universities focus on one particular area of research and education, such as technology, medicine, or economics. The new universities are frequently described as smaller versions of the comprehensive universities, attempting to maintain a corresponding spread of disciplines but with fewer personnel, a smaller volume of activity (e.g., research), and less funding, within each. University colleges primarily undertake regionally motivated education and research, with emphasis on the educational activities, although some have made strides toward more nationally oriented roles and grow increasingly similar to the new universities. Meanwhile, arts colleges mainly carry out education and some research, primarily within the arts, and to a lesser extent teacher training connected to the arts (SOU, 2015:70). Finally, the independent providers are small private organizations given authority to offer a small selection of educational programs primarily directed toward healthcare and theology (UKÄ, 2018).

The second way that higher education institutions differ is in their funding conditions, which differ sharply between the categories and have a limiting effect on their size and focus with regard to education and research. This is because all funding in the Swedish system is classified unequivocally as dedicated to *either* research or teaching – never both (Fig. 17.5).

As Fig. 17.5 shows, the comprehensive universities and specialized universities are heavily focused on research, whereas the other categories are heavily focused on teaching – characteristics built-in by what types of activities they receive funding for. This is in part the result of the aforementioned historical legacy since the lion's share of government funding for a particular year is distributed based on the previous year's distribution, but it is also a result of the system of open competition for research funding from private and public funding bodies, where the established and specialized universities tend to be significantly more successful than the other categories.

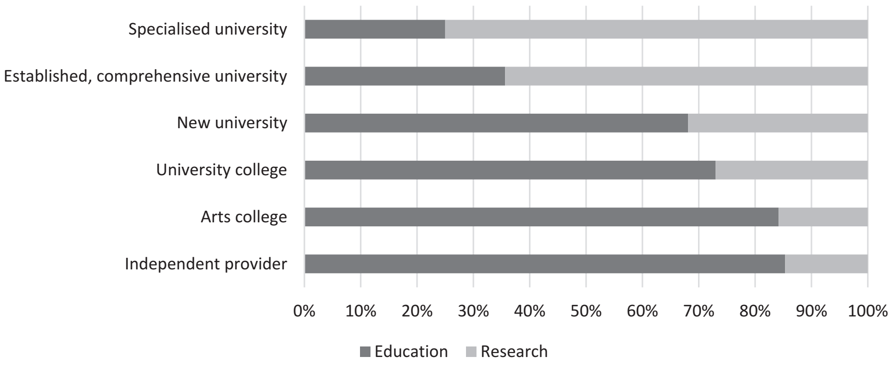

Fig. 17.5 Proportion of funding dedicated toward teaching and research, respectively, in 2019, per type of higher education institution. (Source: UKÄ (2020c))

Studies have shown that a significant reason for this is the institutional capacity that the older universities have had the opportunity and resources to build over time, generating a feedback loop where the prevailing pattern of resource distribution recreates itself: Older universities get more research funding because their research is well funded and, therefore, also probably stronger (Sandström, 2015). Newer universities and colleges in turn get a proportionally larger share of educational funding because the majority of their activity comprises education. Because education and research are subject to different funding schemes, this also tends to drive institutional profiles in different directions depending on whether a particular environment is research-focused or teaching-focused, counterintuitively weakening the teaching-research nexus in a system where the same type of institution is the dominant provider of both (Lundborg, 2017).

Academic Careers

Swedish higher education institutions employed a total of 78,106 people in 2019 (UKÄ, 2020b), which works out as 62,877 FTE. Of these, 41,665 were classified as academic staff. This includes around 10,000 third-cycle students as the norm in Sweden is that they are employed as PhD students at the institution where they are carrying out their studies. The Swedish system has no fees for doctoral students; instead, there is a funding requirement mandating that a higher education institution can only admit students into third-cycle education if they can be offered employment or other conditions of equal standard. The second case is applied highly restrictively, with the most common alternative to employment as a PhD student being some other sort of employment at a higher education institution or another organization where third-cycle studies may be undertaken during work hours. Alternative forms of funding, such as grants and stipends, have been increasingly rare since the reform in 1998 focusing on improved conditions for third-cycle students (Geschwind, 2018).

In 2019, roughly 64% of all third-cycle students were employed as PhD students. Roughly 5% had some other sort of employment at a higher education institution. Usually, these students also hold positions as lecturers. Another 6% funded their studies through stipends, and the same amount lacked any standardized form of funding, which is most often due to their earlier funding running out. The remainder of the students held employment at a business or authority where their employer agreed to set aside a minimum of 50% of the time in their schedule for participating in third-cycle studies (UKÄ, 2020c).

Academic staff are generally divided into six types of positions, PhD students being one. The other five positions consist of lecturers (normally teachers without PhD degrees), career development positions (research associates, postdocs, associate senior lecturers), senior lecturers, full professors, and "other academic staff" made up of nonstandardized positions, such as researchers. In addition, a common career step between senior lecturer and full professor is *docent,* a title which most closely corresponds to the British *reader*. These are not employment positions as such but rather a certificate of recognition from a particular higher education institution that your academic competence has surpassed the level of a regular senior lecturer. As these are unregulated recognitions from individual institutions, there are no national statistics cataloguing the readers of the country.

The norm for the terms of employment of Swedish academic staff is heavily influenced by the corresponding norms of the labor market in general, where most personnel are tenured and employed full-time. Exceptions are found primarily with the career development positions and other academic staff, who tend to be subject to short-term employment contracts often dependent on the availability of external funding. In the case of the career development positions, this is highly deliberate, the idea being that academics who hold these positions are supposed to move on to more senior, tenured positions after they have achieved sufficient qualifications. PhD students are a special case in that their employment, by definition, only lasts for the duration of their nominal study time. Despite the norm of full-time tenures, short-term contracts are significantly more common within the higher education sector than in other areas of society, even among the categories of staff that are normally tenured, with 15% being on such contracts in 2018 (UKÄ, 2019).

Only the steps of PhD student to senior lecturer to reader to full professor are traditional parts of the academic career ladder, whereas the career development positions – intended to form a step immediately prior to the position of senior lecturer – are a somewhat new and underused addition. Other academic staff occupy a nondescript and peculiar position in the hierarchy, in that they hold a diverse collection of positions that normally do not provide adequate opportunities to build a competitive set of qualifications – mostly because they tend to be strictly research positions, and the normal ladder requires educational qualifications in order to move forward. Lecturers occupy a position next to, rather than within, the career ladder because many academics never hold this position during their careers – and many of those who do never move on from it. This is because the position of lecturer is normally reserved for staff without PhD degrees, but the academic career is often started by being employed directly as a PhD student, after which the next move is to a career development position or a position as senior lecturer.

The total number of academic staff, expressed as FTE, has risen more or less steadily since the turn of the century, with the largest expansion being found among the career development positions. In 2019, this group was almost four times as big as it had been in 2001, owing to focused national efforts to develop improved academic career paths for academic staff, particularly early-stage academics. The latest major national policy adjustment in this area was made as recently as in 2017, when associate senior lecturers were given the regulated right to be tried for promotion to senior lecturers (Fig. 17.6).

The gender balance between different academic positions has long been a hotly debated issue in Swedish higher education policy, primarily due to a significant imbalance among full professors. In 2019, the portion of men was 70%. Conversely, there was a moderate imbalance in the opposite direction among lecturers – the most junior type of staff – with 41% being male. In order to rectify this imbalance, since 1997, higher education institutions have been given tasks in the yearly appropriation directions from the government to increase the proportion of women among newly recruited professors. Despite this, the progress has so far been modest (UKÄ, 2020d).

Salaries for academic staff in Sweden are generally respectable. The average monthly salary for a full professor in 2019 was 67,300 Swedish crowns (SEK), which amounts to about 6,460 euros. This can be compared to the overall average salary of Swedish workers of 34,000 SEK. While there is a significant difference between the two figures, they are not worlds apart – this is because Sweden

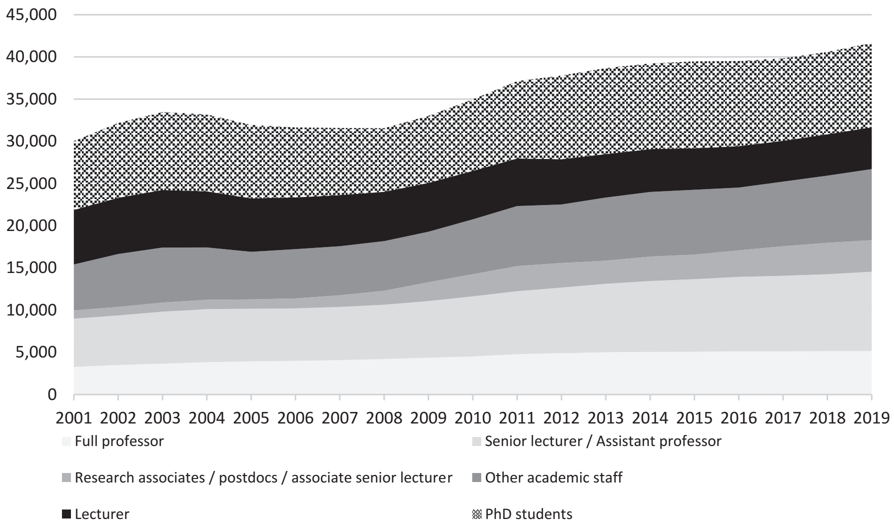

Fig. 17.6 Number of FTE employed at higher education institutions in Sweden 2001–2019 ordered by academic position. (Source: UKÄ (2020b))

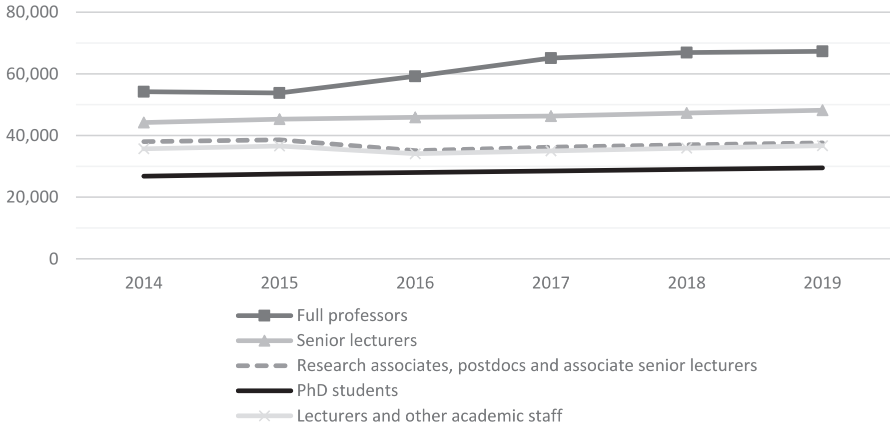

Fig. 17.7 Average monthly salaries of Swedish academic staff in Swedish crowns before taxes 2014–2019. (Source: Statistics Sweden (2020b))

generally has very narrow wage distribution (OECD, 2020e). Accordingly, the wage levels of other groups of academic staff are close, with senior lecturers earning on average 48,200 SEK in 2019, with lecturers, other academic staff, and career development positions all earning around 36,700 SEK. The salary levels of professors have increased during the last few years, whereas the levels for more junior staff have generally decreased (Fig. 17.7).

Worth noting is that the salary levels for PhD students have been very stable, which is due to the fact that their wages are set according to a different model than the rest. Whereas most academic staff negotiate their salaries individually with the employer, the norm for employed PhD students is that they are salaried according to a collectively predetermined ladder. Generally, they receive a predetermined raise whenever they reach a particular milestone in their education – such as reaching the halfway point, completing all coursework, getting awarded a degree of licentiate, or similar. At no point does their salary approach that of the other groups of academic staff, which means that employed PhD students are generally in the early stages of their career development rather than having shifted into such a position after amassing working experience in other positions.

Conclusion

During the last thirty years, the Swedish system has seen extensive reform, particularly regarding the governance of higher education and the landscape of research funding but also significant shifts in the values prioritized by government programs. The reform of higher education in 1993 meant a shift from a focus on consolidation and central planning to institutional autonomy and competition. The aftermath of the employee funds meant a radical expansion and redirection within the funding landscape with the advent of several important research foundations that have lasted well past their initially envisioned expiration dates. This was balanced somewhat later by the introduction of a set of public research councils that fundamentally remain the same to this day. Behind this development has been – compared to the Swedish norm from the twentieth century – frequent shifts in the parliamentary balance of power and hence political administrations with differing priorities moving from emphasis on research excellence to stimulating collaboration, utility, and innovation.

The result is a system for research, development, and innovation that is generally considered strong from an international perspective. This is in part due to historically strong performance rather than recent successes, as well as a history of consistent economic growth that has made it possible to maintain a comparatively high level of RDI investment. Efforts to increase the rate of transformation from research findings into useful innovation have been less than successful, and there is a well-established gap between the seemingly advantageous conditions of the system and its less than stellar – although still respectable – performance when it comes to output. This gap calls into question whether it will be possible for the country to remain at the forefront of international competition without some sort of change of direction.

The Swedish system heavily relies on its higher education institutions to act as a hub for RDI activities. They are expected to provide competence through education, knowledge through research, and innovation through collaboration activities and business incubation via holding companies and innovation offices. Conversely, the research institute sector is comparatively small from an international perspective, and research policy primarily approaches the business sector in relation to their collaboration with universities and university colleges. This means that what happens in higher education has broad ramifications on society as a whole, particularly regarding the generation and proliferation of knowledge.

Firstly, the unified system of tertiary education means that any activities requiring skilled labor rely heavily on the ability of higher education institutions to accurately identify and respond to those requirements. Secondly, the allocation of government research funding primarily – albeit sometimes indirectly through funding bodies – to higher education institutions means that efforts to find new answers to social and technical challenges rely heavily on standards of academic quality. Thirdly, the focus on collaboration activities at higher education institutions as a primary driver of innovation relies on the ability to generate working interfaces between those that define the needs and those that define the solutions. These aspects together rely on a system of higher education that is internally cohesive; institutions must ensure proper links between their different roles in the value chain. If activities within education, research, and innovation are not coordinated with each other, the value of having them all under one roof is lost. At the same time, higher education institutions must be finely attuned to the needs of their surroundings as different regions and sectors face different problems. Each higher education institution must perform a function that is universal in principle but unique in practice.

The institutions should, in theory at least, manage to accomplish the strong cohesion required by the universal principle. The teaching-research nexus, for instance, should improve by having both activities carried out at the same place by the same people. This assumption is underlined by the regulated quality standards, where higher education institutions must also maintain active research capabilities within their areas of education in order to maintain the power to award degrees and are expected to also uphold direct links between this research and their education activities (Geschwind & Broström, 2015).

This interconnection between teaching and research should in turn also aid the interplay between knowledge production, knowledge proliferation, and knowledge utilization. In practice, however, there are few signs that the activities are very connected at all – instead, there are vast differences in focuses between different higher education institutions, on one hand, and between different environments within these institutions, on the other. The differences primarily take the form of imbalances between research and teaching activities, where the norm is for a particular environment, or even institution, to be much stronger in one than the other. This is particularly true for environments focused on professional education. These environments tend to suffer from a lack of senior academic personnel, being lopsided toward lecturers without PhD education, as well as a dearth of research funding when compared to funding dedicated toward teaching.

The causes of this type of imbalance seem to be twofold. One is the unequivocal classification of all funding as being dedicated toward either research or teaching but never both. This means that further research cannot be carried out when the research funding has run out, even though large amounts of teaching funds remain, and vice versa. The other is that the resource distribution systems for teaching and research are built on different principles, meaning that institutional focus on one type of activity tends to strengthen over time – it is easier to get further funding in an area in which you are already a strong performer than in one in which you have little experience.

This means that the strong internal cohesion between teaching, research, and innovation that is required and expected by the system tends to go unrealized in practice as different institutions and different environments within them become geared primarily toward one or possibly two of the three. As a result, a seemingly unified system of higher education develops a stronger degree of variation than the regulation implies, yet the conditions of the system remain tied to the assumption that any given university or university college will be able to fill all three roles of educational institution, research provider, and innovation engine. Efforts to strengthen this chain where it is perceived as weakest are readily apparent in policy initiatives such as the research bills, but the recurring shifts between fundamentally different perspectives on what actually needs to improve – excellence versus collaboration being the chief examples – may serve to hinder progress.

Sweden appears to have all the trappings of an RDI success story – a good business climate, strong finances, a well-educated population, and a very healthy number of researchers chipping away at the veil of the unknown. Yet something still appears to be missing, and there is scant agreement on precisely what it is and how it relates to the rest of the system.

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Stefan Lundborg is a PhD candidate in technology and learning at KTH Royal Institute of Technology, as well as the chief internal auditor of Örebro University. He has a background in political science, and his research interests are focused on the governance of higher education. His thesis deals with the room for strategic action at higher education institutions in Sweden in light of an expanding flora of expectations and stakeholders for the sector.

Lars Geschwind is Professor in Engineering Education Policy and Management, and coordinator of the research group HEOS (Higher Education Organization Studies) at KTH Royal Institute of Technology, Stockholm. His main research interests are higher education policy, institutional governance, academic leadership, and management and academic work. He is currently involved in a number of projects focusing on change processes in higher education institutions including, for example, governance and steering, quality assurance, academic careers, and partnership with industry. Most studies include a comparative component and a historical perspective.

Chapter 18
University, Research, and Innovation in Argentina: A Winding Road to the Knowledge Society

Mónica Marquina and Lucas Luchilo

Abstract This chapter aims to provide an overview of the relation between university, national research, and innovation in Argentina from a historical perspective. As an emerging country, the relation between industry and the production of knowledge is relatively weak. Research and innovation efforts have historically been achieved through national policies; however, these efforts were largely interrupted by de facto governments and economic crises. This chapter addresses some basic R&D indicators and also offers a review of the process that has led to the current institutionalization of the country's scientific and innovation system. The role of the university in these relations is further examined. Key features of the Argentine higher education system are described, such as high enrollment and low graduation rates, the creation of new universities, and the large proportion of part-time teachers. Finally, some conclusions are raised regarding the importance of innovation as an imperative of R&D policies and university research in light of the insufficient dynamism of the industry and the weak incentives to foster a close relation between knowledge production and the development of the country.

Keywords Academic career path · Public funding · Research policy · Scientific production · Argentina

M. Marquina (✉)
Interdisciplinary Nucleus of Training and Studies for Educational Development (NIFEDE), National Scientific and Technical Research Council (CONICET), Universidad Nacional de Tres de Febrero, Buenos Aires, Argentina
e-mail: mmarquina@untref.edu.ar

L. Luchilo
Center for the Study of Science, Development, and Higher Education (REDES), Universidad de la Ciudad Autónoma de Buenos Aires, Buenos Aires, Argentina

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Introduction

In recent years, the concepts of *knowledge economy* and *knowledge society* have increasingly become institutionalized in political discourse and public policy forums such as the European Union, the World Bank (WB), the Organization for Economic Co-Operation and Development (OECD), and the United Nations Educational, Scientific, and Cultural Organization (UNESCO). A large section of specialized literature confirms the existence of a new paradigm of knowledge production (Gibbons et al., 1994; Ziman, 2000) that revolves around the kind of knowledge required by developed capitalist societies and the grounds for implementation of that knowledge.

There are currently two contrasting views of knowledge production. On the one hand, there is the traditional approach, based on the idea that the dynamics of production and the dissemination of knowledge are primarily an endogenous phenomenon. This type of knowledge production, dominant in established universities, is driven by autonomous academics who subject themselves only to the control and regulation of their peers. On the other hand, there is the contemporary approach, which highlights the need to link production and dissemination of knowledge in universities and research centers with short-term social and productive demands, establishing their transfer and commercialization capabilities as criteria for validity and reliability (Santiago & Carvalho, 2015).

These transformations and debates on how to conceive of knowledge in our current society have promoted international changes in research and forced higher education systems to respond to newer demands. Thus, brand-new spaces are promoted, as well as funding policies and mechanisms within the framework of the new public management (Austin & Jones, 2016). Likewise, universities are urged to comply with a new provision for direct contribution to socioeconomic development, which gained relevance in developed countries during the 1980s (Cortés, 2006; Etzkowitz, 1998; Etzkowitz & Leydesdorff, 2000; Lee, 1996; Meyer-Krahmer & Schmoch, 1998; Siegel et al., 2004).

These issues began to slowly emerge in developing countries over recent decades, coalescing with local traditions and histories related to the development processes of science and technology, both inside and outside the university sphere. This chapter attempts to examine the state of knowledge production in Argentina through a focus upon its main academic fields. It also seeks to provide a perspective on the steps that the country has taken to build relations between the universities; the national science, technology, and innovation system; and the production sector, as well as to appraise how closely Argentina follows the trends and theoretical debates taking place in developed countries.

The System of Science, Technology, and Innovation in Argentina

Funding, Staff, and Scientific Production: Basic Indicators

In order to define the system of science, technology, and innovation in Argentina, we should begin by introducing some indicators of funding, staff, and scientific production. In 2017, Argentina spent around 5000 million dollars (PPP) on research and development (R&D), representing a 0.55% of its gross domestic product (GDP). This percentage is low by international standards but exceeds that of most Latin American countries, with the exception of Brazil. As in the rest of Latin America, R&D spending has grown exponentially since the early 2000s due to a cycle of high export prices and the general expansion of public expenditure. Since 2010, however, this has tended to stagnate or decrease.

In addition, the composition of R&D spending by funding sector shows an increasing influence of public funding, which went from 62.9% in 2007 to 72.6% in 2015. Distribution of expenditure by sector of performance requires an international comparison since it contrasts with other countries in and outside the region (Fig. 18.1). The comparative data show that R&D expenditure in Argentina has relied heavily on the public sector, while investment from business (24.9%) or the higher education sector (25.9%) has been relatively lower than in other countries.

The distribution of researchers by employment sector reveals a similar pattern. The rate of researchers employed in business is rather low (8%), whereas that of

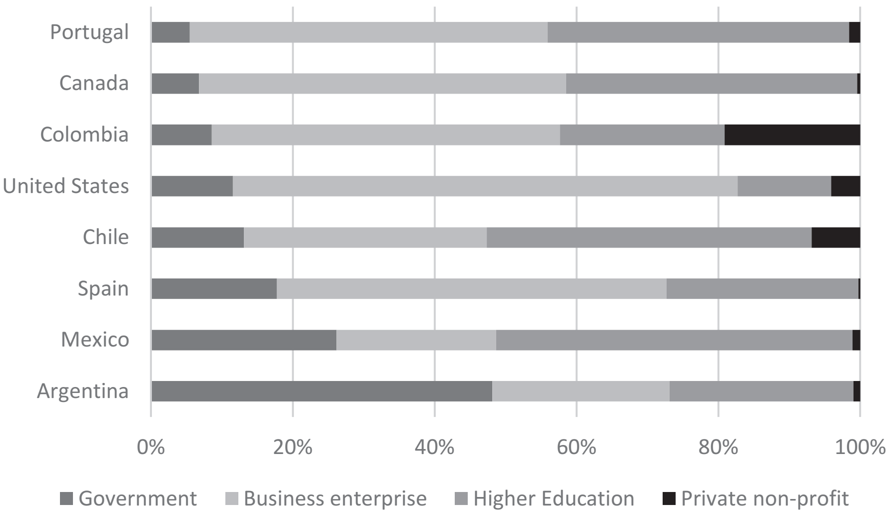

Fig. 18.1 Gross domestic expenditure on R&D by sector of performance, selected countries (2017 or last year available). (Source: Red Iberoamericana de Indicadores de Ciencia y Tecnología (RICYT, 2019))

researchers employed in the public sector reaches 51%. The weight of the public sector in R&D funding and allocation of researchers is a peculiar characteristic of Argentine academic research, which is carried out in universities—largely public—and the Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET, National Scientific and Technical Research Council). This body encompasses a wide range of research institutes, with over 10,000 researchers and 12,000 fellows. A large percentage of researchers and the totality of fellows work in joint university centers. Researchers are university teachers, usually working part-time. The CONICET greatly influences the career path of those academics wishing to advance in their profession: it decides who gains access to a career in scientific research, pays salaries, and has its own hierarchical structure of decision-making. As a result, a significant section of research fellows in public universities have a double employee status—university and CONICET—whereby identity and relation with the latter prevails.

The integration of women into the body of researchers differs from the prevailing pattern in OECD countries. The ratio of women is 53% of the total number of researchers, against a global average of 28.8% and a Latin American mean of 45.4% (RICYT, 2018; UNESCO, 2018). Nevertheless, a glass ceiling exists in what pertains to the access of women to positions of managerial responsibility. At a general demographic level, a better balance has been achieved in recent years among different age groups, with a rise in the ratio of young and middle-aged researchers, reaching 60% in 2007 and 71% in 2019 (CONICET, 2020).[1] As regards scientific production, researchers working at Argentine scientific institutions published 11,698 articles in journals cataloged in the Science Citation Index in 2017. That figure represented a 41% increase on the number of articles published in 2008. In this same time span, between 2008 and 2017, Brazil, Chile, Colombia, and Mexico boosted production at higher rates, as can be observed in Fig. 18.2.

Institutional Organization of the Scientific and Technological System in Argentina

The institutional foundations of the scientific and technological system in Argentina were established in the mid-1950s[2] by administrations that promoted a comprehensive reform of the country's research and development model, inspired by European

[1] For a detailed analysis of these figures, please refer to CONICET, "Investigadores por Año y Rango de Edad 2007/2019," "Personal de Apoyo por Año y Rango de Edad 2007/2009," and "Personal Administrativo por Año y Rango de Edad 2007/2009," accessed August 28, 2020, https://cifras.conicet.gov.ar/publica/detalle-tags/5

[2] In the 1930s, however, the work of Bernardo Houssay—Nobel Prize in Physiology in 1947 and a key figure in the development of science—had already set forth the creation of the Argentine Association for the Advancement of Science with government support, to endorse a fellowships and grants program (Barrios Medina & Paladini, 1989; Feld, 2015). Another prior effort, in this

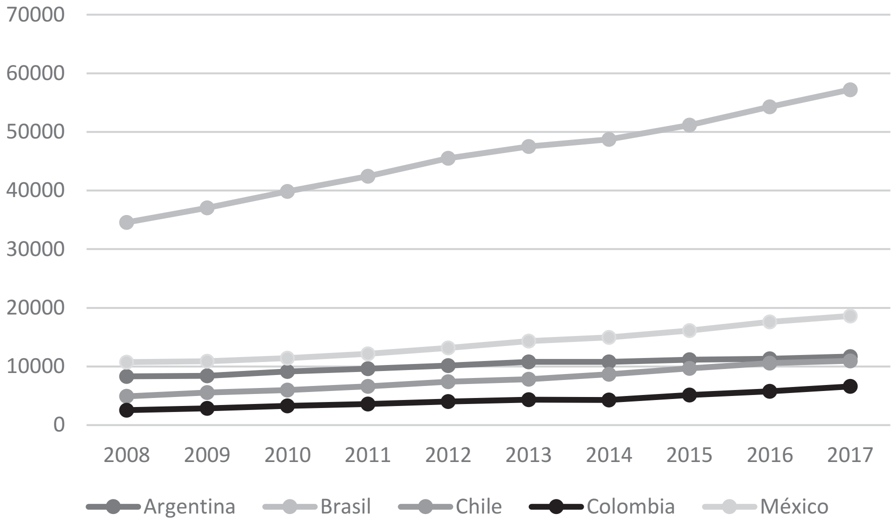

Fig. 18.2 Publications in Science Citation Index, selected Latin American countries (2008–2017). (Source: RICYT (2018))

and American experiences. This process has been described as the "transfer of institutional models," in which UNESCO and the Organization of American States played a significant role (Albornoz, 2007; Oteiza, 1992).

This process of institutionalization occurred in a national and regional framework dominated by developmentalism, the main objective of which was to close the productivity gap between the industrial and agrarian sectors in Latin American countries and those belonging to the central economies. This explains the establishment of the Instituto Nacional de Tecnología Agropecuaria (INTA, National Agricultural Technology Institute) and the Instituto Nacional de Tecnología Industrial (INTI, National Industrial Technology Institute) (Bisang, 1995; Nun, 1995). Other bodies centered on specific fields—nuclear science, marine biology, space, water, and defense—were also created or strengthened.

Academic research efforts at the time focused on the inclusion of research in public universities as a significant activity and on the creation of the CONICET. The primary university innovation was the introduction of full-time professorship, a career path that included obligatory research. As a result, there was a major rise in the number of faculty members engaged in academic activities on a full-time basis at universities. In 1958, the CONICET was founded with the aim of "promoting, coordinating, and guiding research in the field of pure and applied sciences" (Poder Ejecutivo Nacional, 1958). While originally conceived as an academic research

case with geopolitical motivations, was the support for nuclear development by President Juan Domingo Perón (Mariscotti, 2016).

promotion body, in the mid-1960s, the CONICET began to undertake a research performance function.

Since 1966, Argentine research development has witnessed the ups and downs of local politics, de facto governments, and brief democratic administrations. In that year alone, 1300 academics and researchers left their positions at the Universidad de Buenos Aires (UBA) (Luchilo, 2007), with their resignations prompted by military interventions. The disruption of the university research growth cycle triggered a progressive distancing between the CONICET and universities. This trend was reinforced in 1973 with the creation of a scientific research career ladder at the CONICET, which has since become the main employer of researchers, and with the establishment of a hundred institutes that depended upon it (Aristimuño & Aguiar, 2015; Bekerman, 2009).

The restoration of democracy in 1983 brought about a break with these trends and a closer relation between universities and the CONICET (Vasen, 2012). Similarly, new programs were launched with the aim of setting priorities for research (Vaccarezza, 1994) and promoting closer ties with the productive sector.

In the 1990s, a neoliberal and modernizing government carried out an ambitious reform plan, and one of its main pillars was research policy. The Program of Incentives to Teachers-Researchers in National Universities—influenced by the Mexican national system of researchers—set a performance payment for teachers who engaged in research activities.[3] Institutional innovations were adopted during that decade in a process of "bureaucratic modernization" (Albornoz & Gordon, 2011) or "conservative modernization" (Bekerman, 2016). The creation of the Agencia Nacional de Promoción Científica y Tecnológica (ANPCyT, National Agency for Science and Technology Promotion), based on two funding instruments directed at supporting research and promoting innovation activities, is one of such cases.

In 2001, the Science, Technology, and Innovation Act (Law No. 25467) was passed, which provided an organic framework for the national scientific and technological field. Since 2004, there has been a sustained growth of financial and human resources in the scientific and technological system. The CONICET was the main beneficiary of this expansion process, triplicating its staff and number of fellows in less than a decade. In contrast, universities witnessed a different dynamic, with many adopting policies that did not sufficiently stress academic research (Unzué & Emiliozzi, 2017). And yet the increase in grants at the CONICET—and, to a lesser degree, the ANPCyT—allowed for an accelerated growth in doctorates.

Since the late 1990s, a series of plans have been laid out to provide general guidelines for the implementation of R&D policies. For instance, the National Plan of Science and Technology (1998–2000) introduced the idea of a national innovation system (SNI) as a means to organize the focus of public policy. The Bicentennial Plan 2006–2010 (Plan Bicentenario) adopted the use of investment goals and human resources based on indicators, following the steps of the European Union. The

[3] We refer to the implications of this program for academia in subsequent sections.

National Science, Technology, and Innovation Plan 2020 (Argentina Innovadora) was centered on the application of R&D in productive sectors, in particular biotechnology, information technologies, and nanotechnology.

The linkage of national science and technology policies with the WB and the Inter-American Development Bank (IDB), especially since the mid-1990s, has played a major role in policy guidance for the country's science and technology sector, such is the case of a large segment of the ANPCyT's budget which is granted by the IDB (Aguiar et al., 2015).

Universities and Innovation Policies

Institutional Initiatives

The idea that universities must contribute to innovation in economy beyond the education of professionals or the provision of codified knowledge began to gain ground in Argentine universities around the mid-1980s. The establishment of the UBA's Technology Transfer Agreements Office became the first relevant institutional effort to implement a debate over the role of research and researchers in university relations with the productive sector (Vasen, 2012). This office regulated some of the most important aspects of this initiative, such as the amount of time that teachers could spend on knowledge transfer activities, the additional remuneration they could receive, or the allocation of resources from technological agreements. This sought to formalize and dynamize the management of services offered to businesses and public bodies, which researches had been carrying out informally.

Based on this precedent, in 1991, the UBA established the firm UBATEC along with the Municipality of the City of Buenos Aires, the Argentine Industrial Union, and the General Economic Confederation—an academic actor, a state organization, and two business chambers (Vasen, 2012). In the same period, the Universidad Nacional del Litoral (National University of the Litoral) created the Centro para la Transferencia de los Resultados de la Investigación (CETRI, Center for the Transfer of Research Results)—probably the most successful Argentine experience in the field of university and industry linkage—with the assistance of INGENIO, a joint research institute of the Universitat Politècnica de València (Vallejos, 2010).

In the tradition of the university reform of 1918,[4] the relation between university and society was based on the idea of university extension (Romero, 1986). Although in some universities knowledge transfer and service programs remained within the

[4] The 1918 university reform, known as the "Córdoba Reform," was a movement led by students from the Universidad Nacional de Córdoba against a clerical university model, averse to new ideas in higher education. This effort, which had an impact throughout Latin America, introduced the ideas of university cogovernance (composed of teachers, students, and graduates) and university autonomy as basic principles for the functioning of the university in relation to the government. The interaction between university and society became a strong pillar for the movement, giving

realm of university extension, this concept began to be restricted to activities directed toward vulnerable social sectors, whereas the idea of transfer was applied to projects destined specifically for business. Moreover, in contrast to university extension, technological linkage increasingly appeared as the outcome of research.

It is worth noting certain ambiguity in the terminology used in Argentina and, generally, in Latin America. Several formulas are often adopted such as "university-industry relations," "university-industry cooperation," "technology transfer and linkage," "transfer of research results," "linkage between university and industry," or "relation to the socioeconomic environment" (Versino et al., 2010; OCTS & RICYT, 2017). In turn, terms such as "commercialization of research" or "valorization of research results," quite frequent in American or European contexts and referring explicitly to a search of economic advantage, do not tend to be used in the region.

Recent efforts to establish a common conceptual framework have yielded initiatives such as the *Manual iberoamericano de indicadores de vinculación de la universidad con el entorno socioeconómico* [*Latin American Handbook of Linkage Indicators Between University and the Socioeconomic Environment*] (RICYT, 2017), with the participation of the Red de Vinculación Tecnológica de las Universidades Nacionales Argentinas (RedVITEC, Argentine National Universities' Technological Liaison Network). This network is a sign of the legitimacy and institutional leverage that knowledge transfer has been achieving in the field, but this does not necessarily mean it has been successful in every case. The establishment of knowledge transfer offices in some universities—with the aid of strong government incentives—acted as a blueprint for other institutions.

National Policies

During the 1990s, the main regulations and instruments for innovation policies were laid out. Law No. 23877 for the promotion and encouragement of technological innovation aimed at reaching a greater linkage between science, technology, and production through financial instruments such as a tax-credit quota, credits at a subsidized rate, and a new organizational figure, the *Technology Liaison Unit* (TLU). Since then, several TLUs have been established, many of them operating in universities.

The creation of the ANPCyT brought a change in the relation between the scientific and technological system and industry. The Fondo Tecnológico Argentino (FONTAR, Argentine Technological Fund) encompassed direct credit lines to industrial and technological linkage projects. Opening these lines of credit represented a significant incentive to linkage in the country (Del Bello, 2014).

way to the creation of newspapers and radio stations, as well as the spread of culture across its sphere of influence.

A major feature of the Argentine system is that the main instruments of encouragement to innovation revolved around the then Secretariat of Science, Technology, and Productive Innovation. Instruments of encouragement to small- and medium-sized companies or industrial promotion plans of a territorial base remain under the umbrella of the Ministry of Industry, unconcerned by the innovative content of the activities promoted. In other words, the adoption of an innovation policy did not form part of the central core of economic and industrial policies but rather focused on a relatively marginal sphere, at least as far as business was concerned (Del Bello, 2014; Aguiar et al., 2015).

There are historical and structural reasons that explain this specific feature. The creation of the ANPCyT was the outcome of an initiative by a small group of technocrats in a context of a predominant neoliberal economic direction, rather reluctant toward industrial policies (Aguiar et al., 2015). On the other hand, the characteristics of Argentine business and the proclivities of its leadership were unsympathetic toward the development of R&D and innovation activities. And yet the ANPCyT's funding windows had a good reception among a particular segment of the business sector.

Since 2007, new funds and mechanisms have been put in place. Some of them have been used for the promotion of partnership projects, whereas others have been directed toward specific sectors, with different tools such as the Fondo Fiduciario de Promoción de la Industria del Software (FONSOFT, Software Industry Promotion Trust Fund) and the Fondo Argentino Sectorial (FONARSEC, Argentine Sector Fund), in addition to WB funding (Angelelli, 2011).

For universities, and TLUs in particular, these instruments had a major impact and largely redefined their focus of action. Even though linkage was mostly seen as a bilateral relation between universities and industry, these two actors found common ground and associated together to obtain public funding, prompted by the increase in innovation policies and ANPCyT partnership programs at the time (Universidad Nacional de Quilmes, 2015).

Informal Linkage

Despite the importance and visibility of formal linkage, academics carry out most of this activity informally and often unintentionally. This is acknowledged both in the international arena and in Argentina (D'Este & Patel, 2007; Estébanez, 2004). Their activities include the participation in professional partnerships and specialized meetings, as well as informal exchanges with the private sector or the government; consultancy to public, private, and nongovernmental institutions; the creation of technical documents; a role in scholarly networks; academic mobility between sectors; and courses and lectures.

Assessing the importance of informal linkage proves difficult owing to the absence of records in knowledge transfer offices from which to systematize data and build indicators. However, some assessments based on innovation surveys are available (D'Este & Patel, 2007). In the Argentine case, informal relations are an essential element in the initial stages of projects that are eventually brought to fruition (Universidad Nacional de Quilmes, 2015).

Higher Education in Argentina

The current higher education system in Argentina has been shaped in accordance with the Higher Education Act (Law No. 24521). Argentina's higher education system is composed of the university and the nonuniversity subsystems, with a larger enrollment rate in the university sector. Since the higher education reform in 1918, the public university in Argentina has made a steady growth, currently concentrating close to 80% of enrollment, which exceeds by far the enrollment rates in other Latin American public universities. The public university sector has also developed the ideas of autonomy and cogovernance between teachers, students, and graduates as distinctive features of its system development. It has a greater prestige in society based on an open admission system and a tuition-free policy. Yet the nonuniversity sector has less than one-third of the total Argentine higher education enrollment rate, despite its institutions being greater in number. It has usually been regarded as a "second choice" for students when they are not able to enter public universities. These institutions commit to the training of teachers and technicians without research contribution, and their financing is dependent on provincial governments, with most of their teaching staff being hired on an hourly basis (Table 18.1).

The university subsystem—which will be our focus from here on—has experienced a sustained expansion in recent decades. Unlike the general growth trend in the Latin American private sector, university expansion in Argentina has its roots in the creation of public universities at a national level and, to a lesser extent, the development of the private sector. The attempts at institutional differentiation carried out in the 1990s were unsuccessful, despite foreseeing the creation of *university institutes* that distinguish themselves from universities by committing to a single area of knowledge. The provincial university sector has not fared better either even though its figure was contemplated in the 1995 Higher Education Act (Fig. 18.3).

University institutions tend to vary according to size. In the private sector, 76.2% of universities are, for the most part, small (up to 10,000 students), and 22.2% are

Table 18.1 Composition of the higher education system in Argentina, institutions, and students per subsystem and sector (2017 or last available data)

	Public sector		Private sector	
	Institutions	Students	Institutions	Students
University subsystem	67	1,640,405	63	430,865
Nonuniversity subsystem	1046	599,998	1193	302,318
Total	1113	2,119,795	1256	721,940

Source: Secretaría de Políticas Universitarias (SPU, 2020) and Dirección Nacional de Información y Estadística de la Calidad Educativa (DNIEE, 2017)

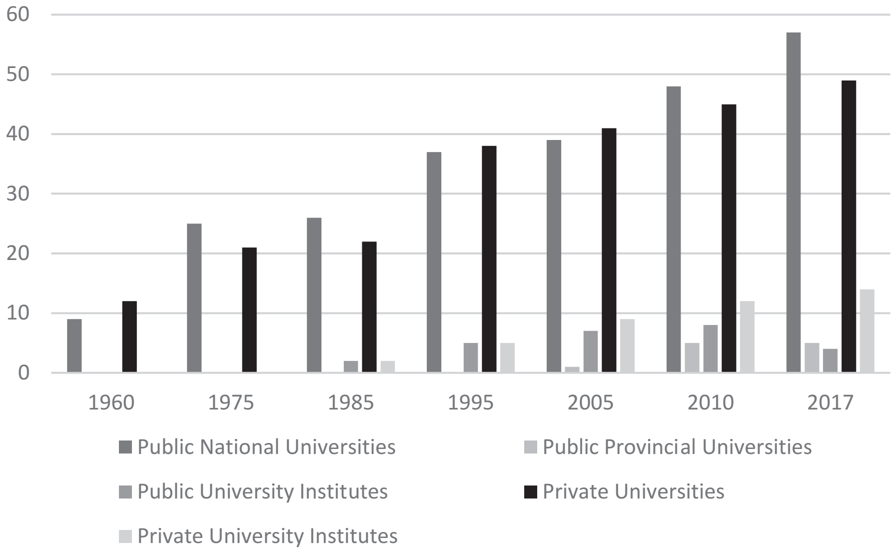

Fig. 18.3 Institutional expansion of the Argentine university subsystem (1960–2017). Based on institution type. (Source: Haberfeld et al. (2018))

medium-sized (up to 50,000). In the public sector, however, 35.5% of universities are small, 51.6% are medium-sized, and 12.9% are large (more than 50,000 students, the Universidad de Buenos Aires being the largest, with close to 300,000 students enrolled) (SPU, 2020).

In recent years, this institutional growth has been occurring at a faster rate than enrollment. In the 2005–2017 period, the number of public university institutions increased more than 40%, whereas the number of students in that sector rose slightly higher than 17%. In contrast, the number of institutions in the private university system rose by 26%, but enrollment increased to a more accelerated pace by 62.83% (Haberfeld et al., 2018). In this sense, the slowdown in enrollment growth seems to show that a higher public investment on human resources or capital has not translated into a proportional growth in the number of students (Fig. 18.4).

Out of the total undergraduate students in 2019, 37.3% were enrolled in Social Sciences, 20.8% in Applied Sciences, 19.3% in the Humanities, 19.2% in Health Sciences, and barely 2.5% in Basic Sciences (SPU, 2020). A large section of the student population (73.9%) is aged between 19 and 29, with women constituting a majority within this segment—not only as a whole (58.1%) but also as first-year students (58.4%) and graduate students (61.2%) (SPU, 2020).

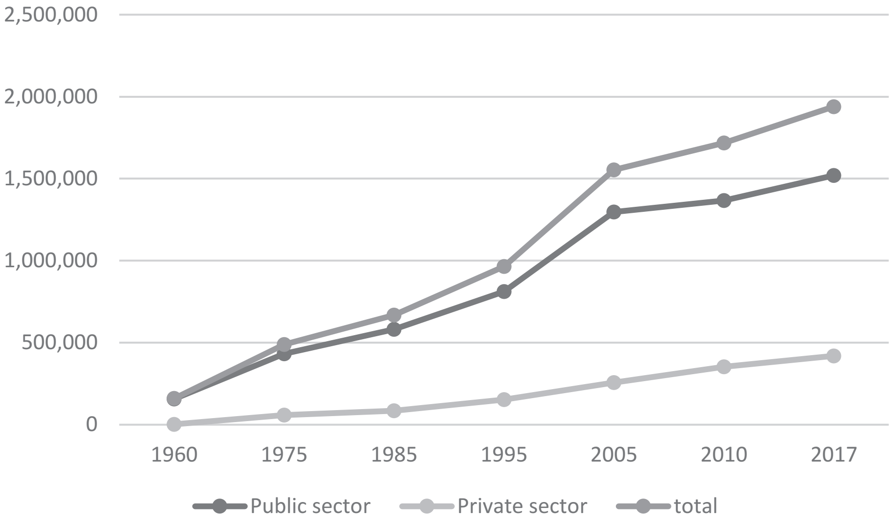

Fig. 18.4 Evolution of university enrollment by sector (1960–2017). (Source: Haberfeld et al. (2018))

The Argentine Academic Profession

The first universities in Argentina were established with the primary aim of training professionals within a Napoleonic Model.[5] This explains the incidence of university professors almost exclusively focused on teaching from the start of their careers while largely engaging in other liberal professions, particularly law. A specific space oriented toward academia within the university began to blossom in the 1960s in accordance with policies addressing the development of science and technology. This contributed to the establishment of new regulations for academic work, such as access to faculty positions through an open selection process and the possibility of full-time commitment to academic teaching and research. These new guidelines allowed for a generational renewal of the faculty that merged teaching with research, securing pertinent funding for the development of scientific work in universities (Buchbinder, 2005). Yet institutional disruptions and their effect on academia may help explain the establishment of the profession, especially between the mid-1960s and the fall of the de facto government in 1983. Those years left their mark with the exclusion, exile, disappearance, and censorship of university teachers.

With the restoration of democracy in 1983, a new period began, which could be characterized as one of unplanned expansion of the university faculty. The student enrollment boom, an outcome of a demand held back for over two decades of restrictive university policies, required a major growth in faculty, in particular

[5]The Universidad Nacional de Córdoba (National University of Córdoba) was founded in 1613, and the Universidad de Buenos Aires (University of Buenos Aires) in 1821.

within public universities. According to some scholars, this form of constitution and expansion of the Argentine academic market undermined a possible harmonious development that could have safeguarded the specific features of the academic profession (Chiroleu, 2003). The decade of 1982–1992 reveals a doubling of teaching contracts although with a prevalence of part-time appointments as a sort of response to the rise in enrollment.

In the following decade, the worldwide wave of reforms sweeping the region reached the country amid a deep economic crisis. A revamping of the higher education system began, with funding from the WB, coupled with a global trend with an emphasis on efficiency, productivity, and evaluation, that altered the demands of academic work. Policies applied to the university sector carried the implicit influence of a model of the academic profession derived from developed countries, marked by a demand for a high level of postgraduate education and the advancement of teaching and research activities. Different incentives and regulations were implemented in this scenario, which outlined a blueprint for academic work that was limited to specific disciplines. The development of postgraduate courses gained momentum, along with the establishment of a national system of university evaluation and accreditation, an incentives scheme for research destined to the figure of the teacher-researcher, as well as other measures based on the possibility of access to competitive funding. On the other hand, peer review systems for the evaluation of teaching, research projects, and grants promoted the establishment of new academic segments that, in practice, act as academic elites, allocating resources and prestige in an academic profession that is increasingly fragmented (Marquina, 2013).

These regulations have remained in place and have been reinforced since the 1990s. As we have seen, research and innovation support policies were notably endorsed by the CONICET, which provided a sphere of development for a career in scientific research to a larger extent than before. This sphere, which simultaneously differentiated itself from the university system as promoter of research careers, began to place most of its researchers in universities for the development of scientific activities. Thus, the groups of researchers whose work relies on both the CONICET and the university now coexist within these institutions.

One of the main characteristics of Argentine universities is the large number of part-time faculty. In the private sector, most of the contracts are part-time, and there is not much information available to thoroughly assess more specific cases. In the public sector, however, there has been a prevalence of close to two-thirds of part-time teachers (10 h per week) and a tendency toward growth of these numbers in recent years. The main occupation for most of these teachers is outside the university although some may engage informally in research (Marquina & Fernández Lamarra, 2008). The final third is distributed among full-time teachers (40 h per week) and those working 50% of a full-time position (25 h per week), both of whom are concentrated in the higher echelons. In 2019, distribution was as follows: 68% were part-time, 18% were working half of a full-time position, and 11% were full-time (SPU, 2020) (Fig. 18.5).

Over the last decade, the faculty's composition has evened out as regards the presence of men and women. While in 1998 men exceeded women by almost ten

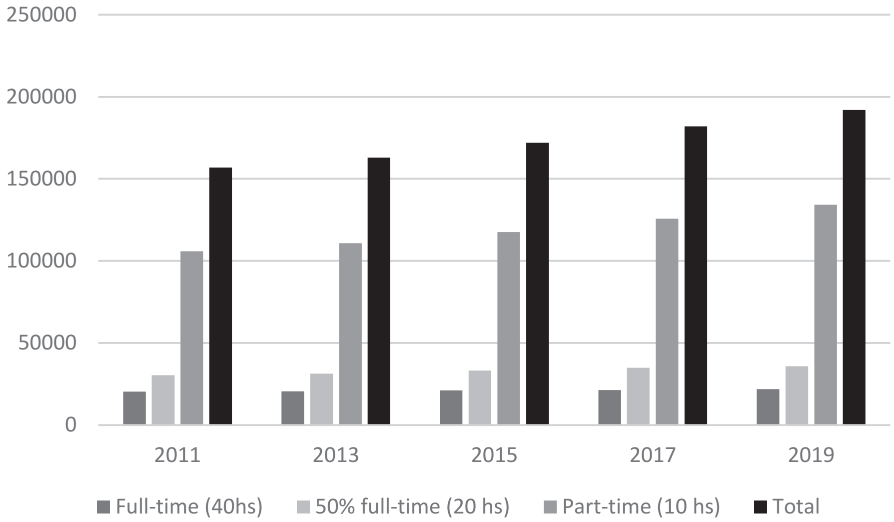

Fig. 18.5 Composition of university faculty per time dedicated to academic work (2011–2019). (Source: Author's chart based on statistical yearbooks (SPU, 2015, 2020))

percentage points, in 2019, women and men evened out at 50% each. Nevertheless, the uneven distribution of activity by gender can be observed further with the introduction of other variables. Since 1998, women have been slightly concentrated in more full-time positions than their male counterparts, currently exceeding men by 5 percentage points (54.7% to 45.3%) (SPU, 2020). Yet when analyzing distribution by hierarchy, men comprise the largest number of chairs (38.5% for men against 61.5% for women) (SPU, 2020), an uneven distribution of power if one considers the pyramidal organizational structure of the Argentine chair system. This also accounts for the aforementioned glass ceiling for science and technology positions.

In contrast to other countries around the world and the region, holding a postgraduate degree is not a major feature of Argentine academics. Barely 21% hold a postgraduate degree, of which only 13% is a doctorate (SPU, 2020).[6] Furthermore, by examining the boom in postgraduate education, a direct result of the modernizing agenda of the 1990s, we were able to confirm that more than 80% of academics obtained their postgraduate degrees after 1990, and more than half (50%) of those have done so after 2000 (Marquina et al. 2017).

The Argentine academic profession is strongly hierarchical. The chair system is the most common type of organization of academic work prevailing in universities, especially in more traditional institutions, in which the largest number of students

[6] It is important to note that undergraduate degrees are not the same as bachelor's degrees. Undergraduate courses last between five and six years, have an integrated curriculum, and provide students with qualifying degrees for professional practice.

are concentrated.[7] Each teacher, from auxiliary teachers (assistant professors and heads of practical works and tutorials) to professors (adjuncts, associates, and heads of chairs), participate in the university chair by engaging in different tasks assigned according to rank. Full professors are heads of chairs and have the right to design the syllabus and give lectures (theory classes), usually large scale, whereas assistant professors and heads of practical work tend to carry out laboratory functions or class work with small groups of students.

In general, access to these positions is decided through an "open selection process through competitive examinations and interviews" ("concurso público de antecedentes y oposición") in which the institution issues an open call for an available position, and the selection is made by an evaluating committee composed of peers in similar or higher hierarchical positions. This competitive evaluation of teachers grants the status of *regular* to whomever obtains the position, and the selected professional enjoys stability, with a career performance evaluation mechanism for permanence. By contrast, for the promotion to a higher position, a new call for an open selection process must be made. This means that the teacher cannot be removed—except under extreme circumstances—and has acquired "university citizenship" which allows them to choose, and be selected for, positions in university governance as representatives of the academic personnel. Therefore, the complexity of this selection process lies in its twofold impact: the quality of the academic activity and its implications for institutional policies (Marquina, 2009).

Another characteristic feature of university teaching in Argentina is the low level of salaries. Although the university system as a whole allocates more than 85% of its budget to staff expenditures and, over the last decade, teacher remuneration has risen in relation to previous decades, current teacher salaries continue to be low. In a study of academic salaries, Altbach et al. (2012) examined the situation in Argentina, comparing it with a group of fifteen countries and ranking it antepenultimate above India and China in relation to both the first and highest career salaries. Despite this scenario and the limited resources available for research, if compared with international levels, most of the academic production in the country takes place in public universities and represents more than two-thirds of published articles.

An incentive mechanism for teacher-researchers was adopted in the 1990s, involving an additional payment for high performance. Paradoxically, while this program is still in place, the monetary incentive it offers is rather symbolic, providing instead a different type of benefit—of prevalence or advancement within a system of researcher categories—in accordance with productivity parameters similar to the ones used worldwide. Currently, 12.8% of university teachers in Argentina take part in this incentive program (SPU, 2017).

As a final note, it is worth mentioning the extent to which university extension, community engagement, and knowledge transfer to society are present in the academic profession. Between 2006 and 2019, in addition to the aforementioned

[7] The group of the five largest universities, which retain a traditional organizational model (Buenos Aires, Córdoba, La Plata, Rosario, and Tecnológica Nacional), comprises 46.20% of students from public universities (SPU, 2017).

ANPCyT programs, the Secretariat of University Policies (SPU) promoted a set of actions destined to strengthening the relation between the university and the community (Chiroleu & Marquina, 2015). These actions entailed competitive calls for projects submissions under the direction of teachers. Although the funding granted was limited and meant for an annual development, it helped sponsor joint activities between universities and society. However, these types of competitive funds have not been systematized or empirically studied, and thus, it is not possible yet to engage in an analysis of academic participation in similar initiatives.

Conclusions

This chapter examined the evolution and current status of knowledge production in Argentina through a focus on the development of innovation systems and with a special emphasis on governmental and higher education efforts. To do so, it has been necessary to take into account the trajectory of university capabilities through time, the characteristics of the productive systems, and the regulations and incentives of institutional and public policies. The reviewed scenario reveals a solid heterogeneity in a context of insufficient innovative dynamism. The good performance of the emergent agricultural bioeconomy within the industry and, to a lesser degree, of knowledge-based services stands in contrast with a majority of low productivity sectors. The origin of this insufficiency is usually sought in business and university culture or in the weakness of incentives to foster engagement. Notwithstanding these interpretations, it is undeniable that the combination of stagnation and macroeconomic instability that has characterized the country's recent history has been a background condition of significant importance.

Also, university performance evinces a marked diversity, often within the institutions themselves. In fact, university authorities have recognized the need for universities to establish relations and activities destined to contribute to business innovation and have established specific areas for the promotion of these relations. National policies in the realm of science, technology, and innovation have also encouraged initiatives of this kind.

Nevertheless, a significant gap exists between these approaches and the performance of universities. Performance is doubtless conditioned by the context we have examined. Yet there are universities—or university departments—that, under similar circumstances, have increased their capabilities to attend to the needs of the productive fabric, whereas others have failed to do so completely.

The analysis of the development of the academic profession in Argentina deserves a special mention, in particular with regard to this book and the project it entails. A determining feature of our characterization is its profound fragmentation. On the one hand, there is a minority group of academics that participates in the world academic order, has links with international peers, publishes in world-renowned journals, and devotes the majority of its activity to research and teaching. This group possesses a strong prevalence toward endogenous knowledge production as "knowledge for knowledge's sake" and occupies the most prestigious ranks in the profession, such as hierarchical positions in degree courses, evaluating committees, and higher categorization levels. Many of them work under a dual reporting relation with both the CONICET and the university, or they are beneficiaries of significant subsidies granted by the ANPCyT for their research teams. This group encompasses barely 20% of the total number of academics working in the university system in the country, and it is largely distributed among a variety of basic and applied fields.

For its part, the vast remaining majority of academics is rather local, both in their scholarly relations and the publications for which they write, if they do so at all. This majority is primarily focused on teaching due to their partial dedication to academic activity. They develop their academic work as complementary to their main activity, outside the university, whether in the industry, the public administration, or other societal organizations. This group represents close to 80% of the total academic population in the country that is currently active within the university system.

These groups can potentially establish links with society through the development of their academic activity. In the case of those teachers whose main activity is concentrated within the industry, this would be possible only if these academics were interested in the application of research to development and innovation or if institutional and governmental funding mechanisms aimed at the transfer of knowledge to industry and society were available. On the other hand, in the case of teachers with positions in the public sector or societal organizations, should their own complementary activity be related to academic work, it could then place them as agents in the organization of engagement between the university and society, with great potential for the achievement of a social function or third mission, which today represents an essential tool in the knowledge society.

Evidence compiled from the data collected by the Academic Profession in the Knowledge Society (APIKS) project regarding the state of Argentine academia will be of fundamental importance. Are governmental policies focused on external engagement enough motivation to displace traditional academics from their laboratories or libraries? What are institutions doing in this regard? Or are these merely individual options that each academic might take based on their specific interests and expertise?

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Monica Marquina is an independent researcher with the National Council of Science and Technology (CONICET), with a workplace at National University of Tres de Febrero (UNTREF) where she also is a graduate professor focusing on university quality assurance, the academic profession, higher education policy and management, and the democratization of higher education. She is Professor at University of Buenos Aires (UBA) in educational policy and comparative education. She has a PhD in higher education (Universidad de Palermo, Argentina) and a master's in higher education administration (Boston College, USA). She is part of the Board of Directors of the National Commission of Evaluation and University Accreditation (CONEAU of Argentina), a position proposed by the National Parliament. She has written several books in her research fields as well as articles in national and international journals.

Lucas Luchilo is the head of the School of Education and Human Development at the University of the City of Buenos Aires. He is also a professor at the University of Buenos Aires. He works as a researcher and consultant on the fields of Science Policy and Higher Education. He served as Undersecretary of Institutional Evaluation at the Ministry of Science, Technology and Innovation and as Chief of Staff for the Minister of Education from Argentina. He has a teacher's degree in History and a master's degree in Science and Technology Policy from the University of Buenos Aires and has been Director of the Center of Studies on Science, Development and Higher Education REDES, a research center affiliated to the National Council of Science and Technology (CONICET). He has written several books, book chapters and articles on his fields of expertise.

Chapter 19
The Development of the Research Capabilities of Chilean Faculty

Daniela Véliz and Sergio Celis

Abstract Over the past 30 years, Chilean faculty's progress in terms of size, academic training, and research productivity has been outstanding. In the last decade, the number of faculty in Chilean higher education increased by about 40%, and the number of them holding doctorate degrees doubled. This progress has occurred in the context of multiple national initiatives and policies attempting to migrate the country from an economy based on the exploitation of natural resources to one based on knowledge and innovation. This chapter describes these changes and explores the challenges and opportunities for faculty members in the emerging Chilean knowledge economy and its innovation system. In particular, we discuss issues and new demands surrounding faculty's research work. This building of research capabilities includes modernizing doctoral education, increasing the participation of women in leadership positions and STEM fields, navigating internationalization, and meeting new demands for outreach with industry and society.

Keywords Academic profession · Research collaboration · Outreach · Professionalization · Chile

D. Véliz (✉)
School of Education, Pontificia Universidad Católica de Chile, Macul, Chile
e-mail: dvelizc@uc.cl

S. Celis
School of Engineering and Science, FCFM, Universidad de Chile, Santiago, Chile
e-mail: scelis@uchile.cl

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The Development of the Research Capabilities of Chilean Faculty

The Chilean higher education system has undergone substantial transformation over the past century. The rapid growth in higher education enrollment has been one of the forces driving these transformations, resulting in an increased demand for faculty. As indicated by Brunner (2015), the enrollment expansion has also contributed to the rapid professionalization of faculty in Chile through the increase in full-time appointments and dedication to institutional resources to support research activities. Although most Chilean faculty still lag in academic training and research productivity compared with faculty in developed countries, their progress in these areas over the past 30 years has been outstanding (Bernasconi, 2006; Berrios, 2015). The number of faculty in Chilean higher education increased by 38% between 2009 and 2019, from 62,548 to 86,332 (Servicio de Información de Educación Superior [SIES], 2009; 2019a). Similarly, the last decade has seen a sizable expansion in the number of Chilean faculty holding doctorate degrees, with this number doubling between 2009 and 2019, from 5703 to 12,021 (SIES, 2009; 2019a). Table 19.1 shows the 2019 composition of academics by educational level and gender.

Universities and their faculty members also comprise much of the country's research workforce. Santelices (2015) estimated that about 65% of all Chilean researchers work at universities, most of them as faculty members. Overall, Red de Indicadores de Ciencia y Tecnología (RICYT, n.d.) estimated there to be about 14,200 researchers in Chile in 2016. Most Chilean researchers work in engineering and technology (34%) and biological, mathematical, and physical sciences (29%), with only 19% employed in the humanities and social sciences. Faculty research productivity has also increased in the past decade, and Chile ranks first in Latin America according to the number of publications per capita (SCImago Journals cited by Santelices, 2015). The rapid growth and professionalization of Chilean faculty have required a seemingly fast adaptation of higher education institutions, which has occurred from new protocols for hiring and promotion, as well as the training of doctoral students. Simultaneously, Chilean institutions are being powerfully shaped by the new knowledge economy through myriad policies and incentives, as well as pressure from the research community and the public.

Table 19.1 Academics by education level and gender: Head count 2019

Level of education	Female	Male	Total
Doctorate	4046	7975	12,021
Master	11,031	12,669	23,700
Medical specialty	1976	2918	4894
Professional	18,290	20,352	38,642
Bachelor	1838	2052	3890
Associate	811	1394	2205
Without degree	401	579	980

Source: Author's own elaboration based on information from SIES (2019a)

In this chapter, we explore the challenges and opportunities emerging for Chilean faculty members in this new, higher education landscape. We begin with an overview of Chile's knowledge economy and national innovation system, in which universities are key actors. We then describe the professionalization of Chilean faculty over the past several decades. To conclude, we discuss the most critical challenges and opportunities regarding the building of research capabilities for the Chilean professoriate, which include modernizing doctoral education, increasing the participation of women in leadership positions and STEM fields in particular, navigating internationalization, and meeting new demands for outreach with industry and society.

The National Knowledge and Innovation System

Chile has launched several initiatives and policies over the past two decades to migrate from an economy based on the exploitation of natural resources to one based on knowledge and innovation. This national effort is represented in growing institutionalization at the governmental level. In 2005, the National Council for Innovation and Competitiveness (CNCTCID, 2019) was launched and became, to some extent, the first public initiative that included leaders from the research world as well as industry and the public sector. The council's focus has evolved over the past 15 years, shifting from its original emphasis on innovation as an engine for economic growth to innovation for sustainable and inclusive development (CNCTCID, 2019). A milestone in this process was the establishment of the new Ministry of Science, Technology, Knowledge, and Innovation in 2018 (MINCIENCIA). Dr. Andrés Couve, a renowned researcher in the medical school at the Universidad de Chile (UCH), was appointed as its first minister. MINCIENCIA's mission is to design strategies to consolidate and guide the national system for science, technology, and innovation (MINCIENCIA, n.d.). According to the Global Innovation Index (GII) 2019, which measures the quality of governmental innovation across 80 indicators, Chile is ranked first in Latin America, followed by Costa Rica (2nd) and Mexico (3rd) (GII, 2019).

Despite the achievements described above, Chile's investment in research and development remains remarkably low, representing about 0.4% of the gross domestic product (GDP) (CNCTCID, 2019) (Table 19.2), and a long-term strategy for the knowledge economy remains under development. Nevertheless, there is growing awareness in Chile that a national innovation ecosystem is arising. As a new national strategy for science and innovation continues to be defined, two main groups of public sector actors have dominated this emerging system: universities and innovative business enterprises.

Table 19.2 Trends in Chile's overall R&D investment, 2007–2017

Year	% of GDP
2007	0.31
2008	0.37
2009	0.35
2010	0.33
2011	0.35
2012	0.36
2013	0.39
2014	0.38
2015	0.38
2016	0.37
2017	0.36

Source: Author's own elaboration based on information from OECD (2020)

Table 19.3 Chronological expansion of higher education in Chile

	1980	1990	2000	2010	2019
HEIS´	8	302	240	176	150
Student enrollment	118.978	249.482	451.129	938.154	1.194.310

Source: Author's own elaboration based on information from Bernasconi (2004), SIES (2019b), and Zapata and Tejeda (2016)

The University System

In total, the higher education system in Chile comprises 143 public and private institutions. Sixty of these are universities, and while they all have nonprofit status by law, only 18 are state-owned. In addition to universities, the current higher education system includes 39 professional institutes that offer four-year, profession-oriented programs. Lastly, 47 technical training centers offer two-year educational programs. These institutes and technical training centers are mostly private organizations and can be established as both for- and nonprofit institutions. Chile has a highly privatized higher education system that has expanded considerably in the past two decades, which in turn has led to the need for more faculty (Table 19.3).

Scholars have proposed various ways of defining a "research university" in Chile (Muñoz & Blanco, 2013; Reyes & Rosso, 2013; Torres & Zenteno, 2011). Torres and Zenteno (2011) classified Chilean universities according to research and teaching outputs, such as the number of Institute for Scientific Information (ISI) publications published in the last year, the number of doctoral programs offered, the number of government grants (FONDECYT, the main source of funding for scholars in

Chile) awarded in the last year, and the amount of money awarded through these grants. In contrast, Muñoz and Blanco (2013) take into account research output, size, composition (e.g., student demographics), and accreditation status, among other variables. They define research universities as having a high number of postgraduate programs, with at least 26% of all students enrolled in a master's program and 46% of all students enrolled in a doctoral program.

Lastly, Reyes and Rosso (2013) have proposed a university classification system of four distinct groups. The first group comprises universities with doctoral and intensive research programs (eight institutions) that offer seven or more accredited doctorates in three or more different areas of knowledge. The second group includes universities with doctoral programs in selective areas and research activity (19) that offer fewer than seven accredited doctoral programs in less than three subject areas. The third group consists of teaching universities with research outreach (11) whose faculty collectively publish about 40 research articles a year in internationally indexed journals. The fourth group comprises teaching universities (7) that do not offer accredited doctorates and produce less than 10 research articles a year in internationally indexed journals. The number of universities described above correspond to data from 2018.

The Innovation and Entrepreneurial System

Despite progress in the local innovation and entrepreneurial ecosystem, the research and development activities in private Chilean enterprises have remained stagnant over the last decade (CNCTCID, 2019). The low number of researchers working in industry illustrates this reality. Overall, in 2017, Chile had about 3200 researchers (full-time equivalent), which represents approximately 1.04 researchers working on research and innovation per 1000 inhabitants—one of the lowest rates among OECD countries (CNCTCID, 2019). Moreover, only about 4% of doctoral degree holders work in the private industry (CNCTCID, 2019). This low percentage has contributed to the development of public and university policies to equip doctoral students with more significant and fruitful link to industry (Walczak et al., 2017).

These numbers and percentages suggest that Chile has not yet fully embraced innovation although there have been some bright spots. In 2010, the government launched the "Start-up Chile" program, which funded 1000 ventures from all around the world in its first five years (Gonzalez-Uribe and Leatherbee, 2017). In 2012, the Corporación de Fomento Productivo (CORFO), a governmental agency, launched the "Una Nueva Ingeniería para el 2030" (Ingeniería 2030, "A New Engineering for 2030") program. Its primary purpose was to strengthen the capacities of engineering schools in the areas of applied research, development, and technology transfer, as well as innovation and entrepreneurship. Ingeniería 2030 granted approximately US$60 million in six years to 10 engineering schools, which allowed them to fund new initiatives to encourage and support entrepreneurship. Ingeniería 2030 also resulted in the creation of several fabrication labs, coworking spaces, and start-up accelerators across engineering schools. Even though Ingeniería 2030 attracted the interest of faculty members, their active involvement is still a significant challenge to the program's sustainability (Sociedad Chilena de Educación en Ingeniería [SOCHEDI], 2020). Programs and initiatives like Start-up Chile and Ingeniería 2030 are helping to create a collective perception of Chile as possessing an emergent and vibrant innovation and entrepreneurship system, in which faculty members are called to play a key role. Some indicators show moderate progress; patent applications increased by 74% in the last decade (2009–2019), from 2244 to 3902, and four universities were among the top 10 Chilean organizations that obtained patents in 2019 (Instituto Nacional de Propiedad Industrial [INAPI], 2020).

The Contemporary Chilean Professoriate

The professionalization of Chile's university faculty took place in the 1990s after Chile's return to democratic governance and was driven in part by the massification of the national higher education system (Bernasconi, 2006). In addition to the proliferation of students and higher education institutions in Chile, both the state and the universities themselves implemented internationalization strategies and policies. In doing so, they contributed to the development of a university model that emphasized the research productivity of faculty members with doctorates, which has become the new national norm.

While slow compared with European countries and the United States, the professionalization of Chilean faculty has been noteworthy. The professionalization described by Jencks and Riesman (1977) in their book *The Academic Revolution* documents the transformation of faculty into independent experts trained to conduct research usually through a doctoral program and with full-time dedication to their academic activities, generating knowledge based on the standards established by their peers. Thus, the Chilean professoriate has moved from a teaching focus toward research-centered activity. Bernasconi (2006) indicates that a new type of faculty emerged in Chile in the 1990s, whose typical member was an "entrepreneurial" professor who is "a highly competent, productive, dedicated researcher and teacher, who manages to make good science and a good living out of doing things professors did not do fifteen year ago" (p. 194).

While the Chilean professoriate has experienced strong growth over the last two decades, both in terms of quantity and academic preparation, this growth has occurred with high levels of geographic concentration (Fig. 19.1). More than half (54%) of faculty members with doctoral degrees are concentrated in Santiago, the capital city. The percentage of faculty with doctoral degrees rises to 75% when the geographical regions are expanded to include Valparaíso and Bío-Bío, the other two largest metropolitan areas in Chile (SIES, 2019a).

Although this chapter focuses on full-time faculty at research universities, it is important to acknowledge the value of part-time faculty at these institutions, who represent about 75% of the faculty in the higher education system (Berrios, 2015).

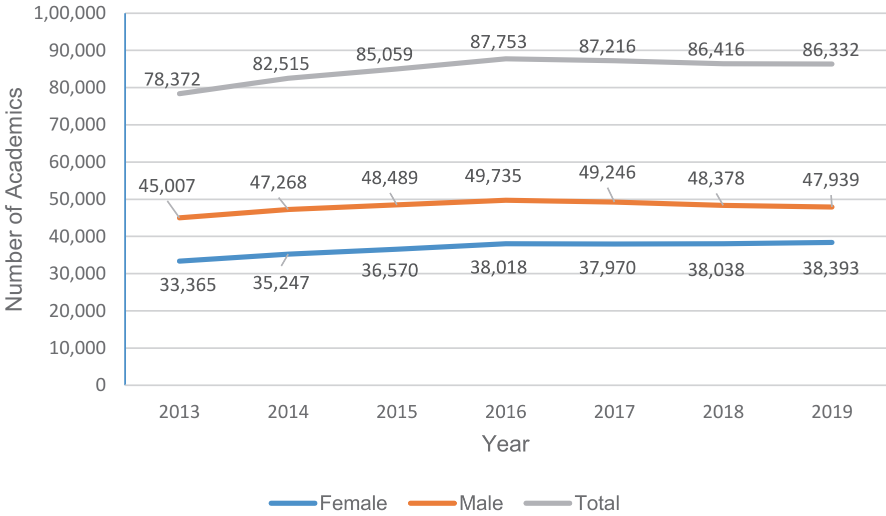

Fig. 19.1 Number of academic. Head count. *Note.* The evolution of academics head count in Chile from 2013 to 2019 by gender. (Author's own elaboration based on information from SIES (2019a))

According to Berrios (2015), this group of faculty reflects a distinctive Latin American profile. Part-time faculty are, in general, professionally successful individuals with full-time jobs outside the academic world. They engage primarily in teaching activities as a way of giving back to their alma mater. For instance, Chilean engineering schools have a strong cadre of practitioners who interact with students and connect them with the national industry.

The Chilean Faculty and Research and Development

According to Santelices (2015), between 60 and 65% of researchers in Chile work at universities. To place these numbers in a Latin American context, in terms of number of researchers per million inhabitants, Chile ranks below Argentina, Uruguay, and Brazil. As mentioned above, researchers in Chile work predominantly in STEM fields, with less than 20% of researchers working in the social sciences and humanities (RICYT, n.d.). In terms of academic preparation, there is also a significant gap between faculty in STEM and other disciplines. For instance, at UCH, more than 95% of the approximately 220 faculty in physical science and mathematics hold doctoral degrees compared to the institutional average of 36%.

Chile's per capita funding for science and technology is also lower than that of Argentina, Uruguay, and Brazil. However, resources for science have increased substantially in the last decade in Chile. For instance, national investment in science and technology increased from US$400 million to US$900 million between 2005 and 2012 (Santelices, 2015). Most of this funding comes from the state, in particular from the National Commission for Scientific and Technological Research (CONICYT), recently renamed the National Agency for Research and Development (ANID).

In terms of research productivity, the number of publications per capita increased 250% between 2000 and 2012. Chile ranks first in the number of publications per capita in the Latin American region (SCImago Journals cited by Santelices, 2015). Most research publications produced in Chile occur in the natural sciences (51%), medical and health science (22%), engineering and technology (12%), social sciences (8%), agricultural sciences (5%), and humanities (2%) (ANID, 2019). UCH and the Pontificia Universidad Católica de Chile (PUC) are responsible for half (50%) of all publications generated by faculty in Chile. When the top five research universities are included, together these seven institutions represent 75% of all publications generated by faculty.

Chile barely registers in global rankings of research productivity, with only two Chilean universities appearing on the 2020 QS worldwide university ranking, coming in the 100–200 group. Although Chile has the best universities the country can afford, they are not considered “world class” as their research capacities lag behind research institutions in developed nations, including other prestigious universities in Latin America, such as Brazil’s University of Campinas (Bernasconi, 2014). Within the leading Chilean institutions, typical research outputs (publications, number of PhD students) vary dramatically across disciplines. The research outputs of STEM programs increasingly resemble those of the best universities in Latin America and certain prestigious international research universities (CONICYT, 2012a).

As the numbers above indicate, Chilean faculty members’ research activity has changed and grown dynamically. This period has brought multiple challenges and opportunities for faculty members. However, there is little research about Chilean faculty members’ working conditions and the effects of the rapid change they have experienced. In the next section, we explore themes present in national and international debates about faculty research and development, with a particular focus on faculty in STEM fields. This list of themes is neither exhaustive nor hierarchically organized but allows for a greater examination of the academic profession in Chilean universities.

Challenges and Opportunities

Doctoral Education

Like Chilean higher education in general, graduate education in Chile has experienced dramatic growth over the past twenty years. The total number of doctoral degree holders in Chile is not clear; though the last census (2018) reported 29,901 people with doctorates living in Chile, this number is likely not trustworthy as it is self-reported. More reliable data show that in 2019, 12,021 faculty members in Chilean universities held doctoral degrees (SIES, 2019a).

When discussing Chilean doctoral students, it is necessary to distinguish between two types: those studying at a Chilean university and those studying abroad. According to national data, doctoral programs in Chile enrolled 6048 students during the 2019 academic year (SIES, 2019a). Disaggregation of the data shows an unequal distribution in doctoral student enrollment according to discipline, with the majority of these students enrolled in the natural, biological, mathematical, and physical sciences (33%), followed by engineering and technology (20%) and the social sciences (12%).

The number of Chilean graduate students abroad has also increased in the past two decades. To generate a comprehensive policy for graduate studies, the Chilean government created the "Becas Chile" (Scholarships Chile) program in 2008, which currently constitutes the primary program in the country allowing students to pursue graduate education abroad (master and doctoral programs). The number of scholarships awarded to students enrolled in master's and doctoral programs abroad has steadily increased over time; 2000 scholarships were awarded between 2003 and 2007 compared to more than 5000 between 2008 and 2012. Currently, Becas Chile is supporting 1386 doctoral scholarship recipients, most of whom are enrolled in programs in the United Kingdom (440), Spain (283), and the United States (217) (CONICYT, 2020).

As in most Latin American countries, the vast majority of doctoral degree holders in Chile are employed in academia, with a low proportion of doctorates working in industry and the public sector. A possible reason for this trend is that Chile invests little in research and development (0.4% of its GDP) compared to other OECD countries. In this context, an interesting phenomenon is the emergence of scientific groups and networks with the characteristics of social movements (Frickel & Gross, 2005), which have pushed the government for a greater emphasis on science and technology in the nation. For instance, in 2008, the Asociación Nacional de Investigadores de Postgrado (National Association of Graduate Researchers) was established to influence public policies on science and technology and improve graduate education. Its actions range from public seminars and open letters to the media to street demonstrations. Similarly, the movement "More Science for Chile," launched in 2010 and inspired by the 1980s "Save British Science" movement, seeks to promote investment in and public attention to science and technology.

Over the last decade, the national accreditation system has positively influenced the process of the quality assurance of doctoral programs, particularly in STEM fields (Celis & Véliz, 2017). A strict standard for faculty members' productivity is one of the critical features of this process. Faculty members who are part of a doctoral degree program must publish a certain number of papers in indexed journals, usually within a five-year window. The number and type of publications are established by different disciplinary committees. Recently, some disciplinary committees have also considered licenses and patents as well as publication output (Celis & Véliz, 2020). While the accreditation system has given graduate programs greater visibility within Latin America (Celis & Véliz, 2017), it has also created some constraints that need to be addressed. For instance, to some extent, the process penalizes programs with multidisciplinary orientations, yet multidisciplinary work is needed to equip graduates with a problem-solving mindset (Celis & Véliz, 2020). The quality assurance process should also encourage new ways of engaging in internationalization, such as with dual degree programs (Celis & Véliz, 2020) and a stronger orientation toward industry and innovation (Walczak et al., 2017).

Gender: Women in the Sciences

The growing awareness about the participation of Chilean women in STEM fields is a recent phenomenon. While progress has certainly been made, there remains more to do. During the 2019 academic year, women accounted for 53% of undergraduate enrollment (SIES, 2019b) and 50% of graduate enrollment (SIES, 2019b). Even though women comprise an increasing share of higher education enrollment, they are still concentrated in particular fields, such as education (75%), health science (74%), and the social sciences (67%). In contrast, in 2019, women represented only 19% of all technology students (SIES, 2019b) and only 22% of students graduating from STEM programs at Chilean universities (SIES, 2019c). Hence, though most data show a predominance of female participation in higher education from enrollment to retention and graduation, it is crucial to examine the data carefully as there are still significant differences in women's participation across disciplines.

Over the past few years, Chilean institutions have increased their efforts to boost the representation and retention of women in STEM careers. Since 2013, several leading engineering schools, particularly at the university level, have developed programs to combat gender inequality. One of the most notable has been spearheaded by the Faculty of Physical Sciences and Mathematics at UCH. The Priority Gender Program (PEG), an affirmative action-type admission initiative, increased the percentage of woman enrolled in the university's undergraduate degree programs from 20 to 30% between 2014 and 2019 (Bastarrica et al., 2018). In addition, because in 2014 women represented only about 15% of all faculty members, the Faculty of Physical Sciences and Mathematics at UCH implemented a program that provides full scholarships for doctoral education abroad to talented women on the condition that the awardee returns to work at the university after graduation. PUC has similarly implemented a program called Women for Engineering. This program focuses, both internally (with its students and school) and externally (with future students, mainly from high school), on generating change at the cultural and operational levels to be more inclusive of, attractive to, and motivating for women students (School of Engineering PUC, 2015).

A recent study conducted in a research-oriented university in Chile has also revealed that women academics in engineering careers continue to confront gender stereotypes held by their colleagues, have fewer seats on decision-making committees, and occupy lower ranks of the academic hierarchy (Paredes-Walker, 2020). Higher education institutions and governments have made some effort to implement family-friendly practices for women academics, such as initiatives that stop the tenure clock for women who have children. However, the sexism that exists in Chile continues to inform the perceptions of women academics, such that they still feel "lucky" when their partner helps in the rearing of their children (Paredes-Walker, 2020). Beyond STEM-related fields, women in Chile experience gender issues in terms of research participation and in higher education in general, posing a serious challenge to their abilities to generate new knowledge (Acuna, 2016).

At the government level, ANID (former CONICYT) has been working on an institutional policy for gender equality since 2012 to encourage women's participation in STEM fields and decrease the gender gap in scientific activity. Some ideas that ANID has considered include the extension of research projects during maternity leave, the equitable measurement of scientific productivity, and a monthly allowance for childcare. The initiatives seem to be working as over the past 13 years, women's participation in ANID research programs has increased from 27% in 2001 to 4% in 2014 (CONICYT, 2015). Nevertheless, data show that the gender gap persists as women advance in their research careers. Although ANID and universities have played an important role in reducing the gender gap in STEM fields in Chile, there is still much to be done to incentivize women's participation in research careers and support their progress in their chosen fields.

Internationalization

The Chilean higher education system has increased its degree of internationalization across several dimensions, including the number of Chilean faculty at research universities who received their doctoral degrees from a foreign institution (primarily located in North America and Europe) and the number of foreign-born faculty who work in STEM fields in Chile. Among all doctoral degree holders in Chile, more than half received their degrees abroad (CONICYT, 2014). The number of foreign-born faculty in Chile, while growing, remains low; less than 4% of Chilean faculty are foreign-born (SIES, 2019a) though 11% of doctoral degree holders living in Chile are foreign-born (CONICYT, 2014). Prestigious STEM academic units have a greater proportion of international faculty. Foreign-born faculty represented 16% of UCH's Physical Science and Mathematics faculty in 2014 (up from only 5% in 2002) and more than 60% of the postdoctorates in these programs. Similarly, half of PUC's Physics Department faculty are foreign-born.

In terms of international research collaboration, according to bibliographic indicators, STEM faculty in Chile have strong ties with faculty in the United States and Europe. In engineering, the countries that collaborate the most with Chilean faculty are the United States (22%), Germany (10%), France (9%), and Spain (9%) (CONICYT, 2012a). These countries are also the top collaborators in earth and planetary sciences, environmental science, neuroscience, physics, and astronomy. In the last decade, ANID has encouraged international research collaboration through funding programs in partnership with research agencies in other countries.

For instance, the Newton-Picarte Funds supports joint research programs between Chilean and British scientists. Similar initiatives exist with Brazil, Finland, Germany, and the United States.

This internationalization of faculty has had several consequences for the Chilean higher education system. First, it has increased the level of international collaboration, which has a positive impact on the number of publications in international journals and on international reputation (Celis & Kim, 2018). Second, it has opened effective channels of mobility across nations for students and other scholars. Third, through teaching, faculty involved in international initiatives facilitate the creation of globally minded curricula and educational experiences for their students.

Nevertheless, this process of internationalization brings significant challenges to institutions, particularly as it has unfolded in fragments, with no support from national or institutional policies (Matus, 2015). While this is an area that requires substantive further research, we note the following two issues. First, although STEM faculty present greater levels of internationalization than their peers in other disciplines, it is not clear what groups of subdisciplines, institutions, or sociodemographic groups are being marginalized or ill-supported throughout the internationalization process, which may have long-lasting impacts on the country. Second, the professional experiences and working conditions of foreign-born faculty who work in Chilean universities are largely unknown. How are they socialized within departmental and institutional cultures? What access do they have to sources of funding? What are their long-term plans for staying in or leaving the country? These are some of the questions that require further examination.

Outreach: An Emergent Relationship with Industry, Innovation, and Entrepreneurship

Innovation and entrepreneurial indicators—such as licenses, patents, and start-ups—are increasingly assumed to be part of faculty productivity at prestigious research universities. Productivity, in this dimension, remains elusive for Chilean STEM faculty, even at the UCH and PUC. Between 2001 and 2011, universities obtained only 29 patents in Chile, which is less than 2% of the total patents granted in the country (Santelices, 2015). In a study of a network of Ibero-American universities, PUC ranked at the bottom for total expenditure in research, development, innovation, and entrepreneurship (Cruz, 2014). Part of PUC low spending in research and development is a lack of research collaboration with industry (CONICYT, 2012b; Munita and Reyes, 2012). A survey by Olavarría (2012) of new doctoral degree holders in Chile showed that only 9% were involved in programs that had partnerships with industry. In a comparative study of top Chilean and Korean engineering schools, Celis and Kim (2018) found that the percentage of published research coauthored by engineering faculty and industry in Chile is much lower than in Korea. Among other barriers to entrepreneurship, Chilean researchers cite low levels of venture capital and a lack of shared understanding among their colleagues about what entrepreneurship and innovation mean and their relevance within the academic world (CONICYT, 2012b). However, national research universities and the government have initiated large and well-funded programs that attempt to increase technology transfer between the university and its environment, such as Ingeniería 2030.

Social innovation, impact, and relevance are some of the concepts increasingly related to outreach. In October 2019, Chile entered a period of intense social unrest resulting from, among other factors, a perception of vast inequalities and injustice, along with a distrust of all types of institutions. Higher education has also been widely criticized in this context. As a result, various institutions are working to highlight their outreach and the multiple ways they benefit society. Faculty members are similarly being asked about the social good they produce and the impact their work has beyond research publications. We anticipate a growing debate about privilege, inequalities across faculty ranks and institutions, teaching commitments, and alternative ways of measuring academic productivity.

Conclusion

The Chilean higher education system has undergone major transformations. In particular, the growth in enrollment, institutional diversification, internationalization, and professionalization of faculty work have transformed what institutions and society expect from faculty. In this sense, Chilean academia has moved—and was moved—from a focus on teaching to a focus on research. As a result, higher education institutions have hired more faculty members with doctorates, especially at research universities.

Currently, a significant number of faculty at Chilean research universities hold doctoral degrees and occupy positions with a primary focus on research. However, this number is still far from the standard in developed nations and other leading institutions in Latin America. Nevertheless, the Chilean faculty is growing rapidly and with sound indicators of research productivity. Moreover, while the per capita funding for science and technology in Chile is lower than in other countries, such as Argentina, Uruguay, and Brazil, Chile's resources for science have increased substantially in the last decade. In particular, STEM has seen significant change and growth in Chile though there is little research exploring the working conditions of faculty in STEM fields or the effects of the rapid change they have experienced.

In this chapter, we presented some of the opportunities and challenges surrounding research and the professoriate in Chile. Although doctoral education has expanded in terms of the number of students enrolled in national and international programs, the gender distribution of students remains unequal across disciplines, with a low proportion of female students in STEM fields. Consequently, universities, as well as the government, have developed policies to attract more women to these fields. While progress has been made, there is still much to be done in this area. The Chilean higher education system has also increased the internationalization of its faculty, with international collaboration and publishing in international journals becoming increasingly important. However, we are far from understanding the significant institutional challenges resulting from this process of internationalization as there is limited empirical data to explain and describe the dynamics of faculty working in Chilean universities. Lastly, although the Chilean government has initiated large, well-funded programs that attempt to increase technology transfer between universities and their environments, these programs are too new for their possible impact to be fully understood.

Further research is needed to inform and assist stakeholders as they work to improve the conditions of faculty members at Chilean universities. We believe that it is critical to generate empirical data on the issues presented above, allowing scholars and practitioners committed to promoting equality and improving the working conditions of faculty in Chile to understand the challenges and, more importantly, the solutions in our unique context.

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Daniela Véliz is Assistant Professor and Director of Academic Development at the School of Education at the Pontificia Universidad Católica de Chile. Her research interests relate to the academic profession, internationalization, student affairs, and gender. She is one of the founders of the Network of Researchers on Chilean Education (RIECH). She is the current WERA (World Educational Research Association) representative. She holds a Ph.D. in Higher Education and an MA in Student Development, both from the University of Maine.

Sergio Celis is an Assistant Professor in the School of Engineering and Sciences at Universidad de Chile. He conducts research on higher education, with a focus on organizational change, faculty work, and teaching and learning in STEM fields. His primary research interest is in how multiple forces, internal and external to the institution, influence what colleges and universities do. He serves as vice president of the Chilean Society for Engineering Education (Sociedad Chilena de Educación en Ingeniería [SOCHEDI]). Sergio received his professional degree in industrial engineering at Universidad de Chile and his Ph.D. in higher education at the University of Michigan.

Chapter 20
Higher Education, Science, Technology, and Academics in México: At a Crossroads

Etty Haydeé Estévez-Nenninger, Angel Alberto Valdés-Cuervo, Edgar Oswaldo González-Bello, Juan Pablo Durand-Villalobos, Marion Lloyd, Jorge Gregorio Martínez-Stack, and Lizeth Guadalupe Parra-Pérez

Abstract Mexico's systems of higher education and science, technology, and innovation (STI) are characterized by relatively late development and weak performance within the global context. The federal government has recently sought to strengthen the role of higher education institutions as they have historically been at the center of research and innovation. The efforts made have proceeded despite receiving very few financial resources in a country that allocates expenditure on research and development below 0.5% of gross domestic product (GDP). The goal of this chapter was to analyze elements of the current situation in higher education and science, technology, and innovation in Mexico. We underline the recent developments in the production of Mexican scholars: the advancement of the academic profession, reflected in the increment of scientific productivity. However, despite efforts made to reverse underperformance in research and innovation, Mexican competitiveness and innovation are still ranked in a modest position compared with most of its international peers from the Organisation for Economic Co-operation and Development. We conclude that STI, higher education, and academics work as part of a cross-linking of conditions, characteristic of the crossroads where the country is in relation with international tendencies and social dynamics based on knowledge and innovation.

E. H. Estévez-Nenninger (✉) · E. O. González-Bello · J. P. Durand-Villalobos
University of Sonora, Hermosillo, Sonora, Mexico

A. A. Valdés-Cuervo
Technological Institute of Sonora, Cd. Obregón, Sonora, Mexico
e-mail: angel.valdes@itson.edu.mx

M. Lloyd · J. G. Martínez-Stack
National Autonomous University of Mexico, Ciudad de México, Mexico

L. G. Parra-Pérez
Colorado State University, Fort Collins, CO, USA
e-mail: lizeth.parra@colostate.com

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Introduction

Mexico's systems of higher education (HE), science, and technology are characterized by their relatively late development and weak performance within the context of the global knowledge and innovation society. Investment in science and technology (S&T) has largely remained fluctuating around 0.4% of GDP for the past two decades. According to the Special Science, Technology, and Innovation Program (PECiTI by its Spanish acronym), despite the low levels of financing, science and technology activities have increased in terms of the number of indexed publications and the number of PhDs awarded in the natural sciences (e.g., healthcare, agricultural sciences, engineering, and technology) and in the social sciences and humanities (Kent, 2014).

In 2019, Mexico had 30,548 scientists affiliated to the National System of Researchers (SNI by its Spanish acronym) (National Council for Science and Technology [CONACYT, for its Spanish acronym], 2019). This membership implies government recognition of people who are dedicated to producing scientific knowledge and technology, for the high quality of their work. The SNI has contributed to research in Mexico that complies with international standards; in this sense, researchers recognized by the SNI have been said to be the "core of scientific research" in the country (CONACYT, 2014). The number of people dedicated to research activities exceeds the number of researchers recognized by the SNI. According to the CONACYT, in 2012, Mexico had a total of 46,066 researchers: 32.3% worked in the industrial sector, 20.6% in the government, 44.4% in higher education institutions (HEIs), and the remaining 2.7% in the private, nonprofit sector. There were 0.9 researchers per 1000 members of the economically active population (EAP) in 2012; this proportion is far below that of developed countries such as Germany (7.9) or the United Kingdom (8.2) and some Latin American countries. It is estimated that Mexico may not achieve the current proportion of researchers in countries such as Argentina or Turkey, which are predicted to have roughly 2.5 researchers per 1000 EAP for another 20 years (CONACYT, 2014). By 2018, the number of researchers per 1000 members of the economically active population (EAP) had decreased to 0.8 (National Autonomous University of México [UNAM, for its Spanish acronym], 2018).

Unlike most developed countries around the globe, Mexican higher education institutions (HEI) and publicly research centers (PRC) are at the heart of national research and development (R&D) in Mexico. Since 1984, through the establishment of the SNI, the Mexican government has strived to strengthen both HEI and PRC to make them capable of fueling the innovation that the country needs to achieve economic progress. Although the Mexican government promotes national prosperity by supporting new technologies through research development carried out by HEIs and PRCs, it also attempts to convert these institutions to engines of economic growth in their regions. This development, however, has led universities to lose their monopoly on knowledge production as they are increasingly responsive to economic, technological, and industrial needs. As a result, a close interdependency between university, industry-business, and the government has been emphasized. In other words, Mexican government acknowledges that prosperity depends upon the knowledge produced at HEIs; however, scientific production also depends upon both industry needs and the interest of the Mexican government to support scientific research and technological development. The transition toward a knowledge economy has required a profound transformation of HEIs, including a significant economic investment made by the government during the last decade.

This chapter takes stock of the efforts made by Mexico to strengthen R&D as a means to bring prosperity and enhance the quality of life of its citizens. We offer data regarding R&D expenditure over the last two decades, a trend line in R&D expenditure as a percentage of GDP, a trend line in the rate of growth in R&D expenditure, and the expenditure on R&D by sector (government, higher education, industry-business, private/nonprofit). The chapter also presents the structure of the Mexican higher education system and its struggles to advance the knowledge economy. Moreover, in order to understand the efforts made by the country to transit toward a knowledge economy, we briefly explore the effects of a knowledge society on R&D in the country as well as its impact on political participation, societal health, employment, and incomes rates.

Mexico's system of science, technology, and innovation (STI) is constrained by two factors: first, the lack of demand on the part of the industrial sector, which may be partly due to the country's proximity to the United States, and second, to insufficient investment in science, technology, and higher education in general. Unsurprisingly, the Mexican economy is largely based on low-technology companies, which are limited to producing products and services designed and developed abroad. This condition demands little added value in terms of innovation (Scientific and Technological Advisory Forum [FCCyT, for its Spanish acronym], 2006, 2013, 2019).

However, beyond exploiting knowledge competitively for purely economic development, Mexico needs to more broadly diffuse knowledge as a principal strategy for social development and well-being (Gómez-Merino et al., 2017). The Knowledge-Base Society (KBS) should not be only centered on technological advancement but rather must function as a driver of social change (Khan, 2003). Due to its relevance, KBS is a current topic of discussion, especially among social scientists and higher education policymakers across the globe.

The goal of this chapter is to analyze the current state of STI and HE. This text is organized into four sections. First, it analyzes both global trends in higher education and their impact on Mexico. Second, it reflects on the Mexican government's response to these challenges. Third, it leads the reader through the higher education system in Mexico and its transformation over the past two decades. Finally, some suggestions and conclusions are offered as a result of the analysis presented.

Major Drivers and Global Influences on Mexican Higher Education

Over the past few decades, HEIs have undergone major transformations, fueled by the twin forces of neoliberalism and globalization. As a result, a major reduction in government funding and a general decline of the public sphere have promoted the so-called *academic capitalism* (Jessop, 2017; Pusser, 2011). In Mexico, global trends are reflected in an explosion in private-sector providers. Prior to the 1980s, higher education was predominantly provided by the state. However, the growing influence of neoliberal policies around the world, as well as the explosion in demand for tertiary degrees, spurred many governments, including Mexico, to open the door to the private sector.

In Latin America, private higher education institutions recorded an average of 47% of tertiary enrollments, and in several countries, the private share is far larger, namely, Brazil, Chile, Costa Rica, El Salvador, and Peru (Bjarnason et al., 2009). On the contrary, Mexican enrollment in private HE has remained stagnated at 33% over the last decade (Mendoza, 2018). However, the country is a key player in the new phase of private higher education: the for-profit sector. The for-profit market is a big business that made $282 million in 2013 through tuition from its HEIs in Mexico (Millán, 2014).

In addition to the explosion in private-sector providers, public universities are increasingly turning to private sources of funding to make up for the shortfall in government subsidies. In fact, the line between public and private has been blurred in many countries as tuition fees make up an ever-larger share of university budgets. This is particularly true in the United States and Chile. However, even countries with long traditions of public higher education, such as United Kingdom and Canada, have raised tuition fees significantly over the past decade. As a result, students and their families are increasingly relying on public or private loans to pay for college, leading to record levels of student debt. In the United States, the volume of outstanding student loan debt has grown by a factor of 4.5 since 1999 (Quintero, 2012). Mexico is a relative newcomer to student loan market partly because public universities, most of which charge only nominal fees, continue to account for most of tertiary enrollments.

The Competitive Pressure of University Rankings

Another global trend impacting HEIs are international rankings. Governments have seized on the rankings to justify existing higher education reforms or to promote new ones in countries such as France, Spain, Russia, and Malaysia (Ordorika & Lloyd, 2013). Today, governments rely on the rankings to determine where to send scholarship holders abroad (Ordorika & Lloyd, 2013). The most notable of these programs is Brazil's Science without Borders program, which sought to send more than 200,000 students abroad between 2012 and 2017. Other countries with large study abroad programs relying on international rankings are Russia, China, Chile, Ecuador, and Peru.

In Mexico, CONACYT has dramatically increased the number of scholarships for graduate studies in recent years, from a few thousand in the early nineties to 53,225 in 2018. However, a 2.8% decrease in students of was seen in 2017, and only 8% were scholarships abroad (CONACYT, 2018). The Mexican government gives preference to students accepted at highly ranked universities, preferably in Europe, Canada, and the United States. In fact, CONACYT has only signed collaboration agreements with Brazil and Costa Rica for student mobility in Latin America (CONACYT, 2015a). The mobility program, however, gives priority to students studying in the STEM fields as part of the Special Program for Science, Technology, and Innovation (PECiTI).

The Focus on Investment in Science and Technology

The new enthusiasm among policymakers for the science, technology, engineering, and mathematics (STEM) fields has been fueled by the recommendations of international agencies such as the World Bank and the Organisation for Economic Co-operation and Development (OECD). In the past, the OECD has repeatedly underlined the low investment of Mexico in science and technology, which has remained one of the lowest among OECD countries. In response, the Mexican government created dozens of new technological institutes across the country. In 2012, former president Felipe Calderon announced his government had created 140 new universities in 6 years; 120 of those were institutions devoted to the STEM fields: 45 technological institutes, 42 technological universities, and 33 polytechnic universities (Rodríguez-Gómez, 2012). Although further laws established 1% of GDP must be invested in science and technology, the level has hovered at about 0.40% over the past decade.

Trends in Science and Technology Expenditures

Mexico spends less than 1% of its GDP on research and technological development (World Bank, 2018). According to the National Association of Universities and Higher Education Institutions ([ANUIES by its Spanish acronym], 2012), science and technology policies in the country have not been managed efficiently with national development strategies. The association argues that budgets are systematically assigned with a low priority to the sector compared to 2.3% OECD average. Between 1990 and 2017, the average proportion of the GDP allocated to research and development was 0.38%, with a minimum of 0.25% in 1996 and a

Table 20.1 Trends in Mexico's overall R&D investment, 1995–2018

Year	% of GDP
1995	
1996	0.25
1997	0.28
1998	0.31
1999	0.34
2000	0.31
2001	0.32
2002	0.37
2003	0.38
2004	0.39
2005	0.40
2006	0.37
2007	0.43
2008	0.48
2009	0.52
2010	0.53
2011	0.51
2012	0.49
2013	0.43
2014	0.44
2015	0.43
2016	0.39
2017	0.33
2018	0.31

Source: Authors' own elaboration based on information from World Bank (2018) and OECD (2020)

maximum of 0.53% in 2010. Table 20.1 shows the trend line in R&D expenditure as percent of GDP over the last 20 years.

The indicator for gross domestic expenditure on research and experimental development (GERD) captures all spending on R&D carried out within an economy in a year. Amid OECD countries, Mexico had the lowest level of GERD as a percentage of GDP (0.31%) in 2018 between OCDE countries (OECD, 2020). In North America, the United States and Canada spent 2.8% and 1.6% of GDP on R&D, respectively. However, of all the Latin American countries, Mexico spends the most on R&D; over two-thirds of GERD financing comes from the public sector and one-fifth from the private sector. Unsurprisingly, federal universities, along with CONACYT, conduct most of the scientific research in Mexico (Mendoza, 2018). In this regard, in 2016, CONACYT and public education were the sectors which contributed the most to GERD spending, contributing 50% and 25%, respectively.

Expenditure on R&D by Sector (Government, HEIs, Business, Private/Nonprofit)

Since Mexico's R&D intensity was one of the lowest among OECD country members, its government significantly increased its expenditures between 2013 and 2015 (Table 20.2). Although the promotion and development of scientific research in Mexico is a shared responsibility between the Secretary of Public Education (SEP, by its Spanish acronym) and CONACYT, the expenditure from private and nonprofit sources remains insufficient. Unlike most of the countries, in Mexico, R&D mostly depends on the efforts of universities and public research centers. That is, the active economic participation of different sectors (business/industry, private, nonprofit) remains limited. For example, business contributions to research and development stood at just 20% of the total contribution to R&D compared to 40% in Brazil and and 70% in South Korea (Oxford Business Group, 2019). While domestic S&T development continues relying upon governmental efforts, domestic development cannot be raised unless participation from private companies increases. A balance between private and governmental participation must be achieved within the coming years. As a result, the academic community in Mexico has suggested a tax reform aimed at stimulating private investment in S&T (UNAM, 2018). Public institutions and universities continue to play an important role in R&D. Unlike American universities, Mexican universities' investment in R&D comes from the government itself. That is, the state allocates universities a budget that must be spent in S&T development; therefore, this investment is part of what the column "Government" includes as seen in Table 20.2, while the "Higher Education" column reflects the investment of private HEIs and the private sector associated with public HEIs. Expenditures are presented in millions of dollars and include the expenditures by sector (government, higher education, including research institutes, business/industry, private, nonprofit) over the last two decades (Table 20.2).

The ups and downs that are perceived over time in public and private investment has been explained by various specialists on the subject to be the result of the discontinuities of public policies, which have not made it possible to take advantage of existing talent and to take root in S&T in the business sector (Scientific and Technological Advisory Forum, 2019).

Higher Education Institutions and Academic Staff in Mexico

In recent years, the Mexican academic sector increased the number of scientists conducting research activities. This is a result of the unprecedented growth experienced by the HEIs, concerning such aspects as its diversification, the increased number of professors and research areas, the number of students, and the number of study programs offering a scientific training (see Table 20.3).

Table 20.2 Investment on research and development by sector from 1995 to 2015, presented in millions USD (the sum of the breakdowns may be inaccurate due to the unrevised amounts provided by the OECD)

Year	Total	Business enterprise Total expenditure	%	Government Total expenditure	%	Higher education Total expenditure	%	Private nonprofit Total expenditure	%
1995	1941.486	341.379	17.5	1284.937	66.1	130.862	6.7	22.067	11.3
1996	2081.424	404.677	19.4	1390.274	66.8	168.693	8.1	45.517	2.2
1997	2514.179	425.290	16.9	1786.663	71.0	216.194	8.6	22.123	0.9
1998	2923.546	689.367	23.6	1776.320	60.8	234.807	8.0	3.297	0.1
1999	3505.009	826.438	23.6	2147.237	61.3	340.522	9.7	3.776	0.1
2000	3362.821	992.598	29.5	2119.156	63.0	200.850	5.9	19.217	0.6
2001	3634.889	1084.622	29.8	2146.531	59.1	329.158	9.1	28.518	0.8
2002	4171.255	1447.070	34.7	2313.656	55.5	343.529	8.2	34.913	0.8
2003	4401.937	1527.307	34.7	2469.844	56.1	337.128	7.7	34.384	0.8
2004	4778.963	1845.462	38.6	2405.837	50.3	355.816	7.4	37.239	0.8
2005	5346.151	2219.192	41.5	2629.406	49.2	389.850	7.3	49.853	0.9
2006	5462.068	2469.986	45.2	2717.686	49.8	177.333	3.2	7.683	0.1
2007	6670.852	2590.618	38.8	3636.888	54.5	254.224	3.8	110.576	1.7
2008	7785.429	2579.243	33.1	4522.236	58.1	440.953	5.7	124.315	1.6
2009	8459.543	2860.735	33.8	4764.589	56.3	511.930	6.0	199.566	2.4
2010	9291.092	3052.229	32.9	5792.283	62.3	256.381	2.8	146.991	1.6
2011	9775.282	3159.827	32.3	6159.020	63.0	249.170	2.5	151.466	1.5
2012	9798.989	2399.446	24.5	6645.212	67.8	313.671	3.2	405.167	4.1
2013	10296.712	2158.338	20.9	7278.769	70.7	362.546	3.5	456.866	4.4
2014	11586.595	2339.272	20.2	8315.656	71.8	392.938	3.5	495.166	4.3
2015	11901.398	2450.078	20.6	8475.523	71.2	411.551	3.5	518.62	4.4

Adapted from "Gross domestic expenditure on R-D by sector of performance and source of fund" by the OECD (2019)

Table 20.3 Chronological expansion of higher education in Mexico

	Year 1970	1985	1990	2000	2008	2013	2018
HEIs	115	271	372	1416	2397	3017	3291
Enrollment students	225,000	840,000	1,206,100	1,206,100	2,705,190	3,419,391	3,864,995
Academics	25,000	95,799	113,238	220,000	283,818	349,193	397,971

Adapted from Gil-Antón (2009) and Secretary of Public Education (2019)

The Mexican higher education system is complex. It is comprised of seven subsystems: federal, state, research centers, technological and polytechnic, teachers' colleges, private, and other public HEIs which vary by government dependence, source of funding, and specialization in fields of study. Table 20.4 shows the total number of HEIs together with the academics by type of hiring.

Table 20.4 Higher education in Mexico at 2017: Academics by institution type

Type	Total HEIs	Academics			
		Total	Full-time	Part-time	Per hours
Federal universities[a]	142	65,088	25,513	6214	33,361
State universities	56	92,609	34,310	3378	54,921
Technological and polytechnical[b]	309	31,270	8739	509	22,022
Normales (teachers' colleges)	239	11,627	4521	2627	4479
Research centers	24	2110	1928	133	49
Other public HEIs[c]	235	13,050	5463	1603	5984
Private institutions[d]	2140	150,463	12,041	7441	130,981
Total	3145	366,217	92,515	21,905	251,797

Adapted from Mendoza (2018)

[a]Federal, state universities, teachers' college, and research centers depend on public funding. Federal and state universities have autonomy to make most of their decisions regarding institutional governance, faculty or program design, and delivery

[b]Technological and polytechnic institutes depend on government. The government decide on some aspects of their operation

[c]Other public HEIs are funded and managed by other government agencies, such as secretary of justice, agriculture, defense, or health

[d]Private institutions are privately funded; however, their operations require governmental accreditations and authorization

Every subsystem has had a different impact on scientific and technological development in the country. The federal universities are at the center of the higher education research enterprise as they gather 72% of postgraduate programs related to STEM (Cruz & Cruz, 2008). Among the most productive institutions in knowledge transmission and the creation of human resources are the National Autonomous University of México (UNAM), the National Polytechnic Institute (IPN), and the Autonomous University of Mexico (UAM). In fact, these institutions, along with public research centers, manage to concentrate more than 75% of established researchers in the country (Santelices, 2010). Though state public universities have the largest number of full-time professors, the private system has the largest number of academics hired by the hour (Estévez-Nenninger et al., 2020; Gil-Antón, 2009). One-third of students (33%) are enrolled in private institutions, which are part of the largest subsystem. According to the OECD (2019), the 2140 private institutions represent 72% of HEIs in Mexico. Generally, these institutions focus in the field of engineering sciences, biology, and chemistry, as well as medicine and health sciences.

Current Government Policies to Enhance Scholarly Productivity

Over the last decade, Mexico has entrusted its scientific and technologic progress to two main federal programs: CONACYT and SNI. Peña Nieto's administration kept up the oldest instruments of CONACYT, the scholarship program for postgraduate studies. The program absorbed a third of the financing of CONACYT, which makes it the largest program in the country. From 1971 to 2016, CONACYT awarded more than 328,176 scholarships of which 268,112 were granted in domestic universities and 60,064 in international ones. CONACYT, however, acknowledges there is not an established and clear strategy to grant scholarships in strategic areas (CONACYT, 2017).

On the other hand, the SNI has been operating for more than three decades as a device to recognize and certify Mexican scientists who carry out cutting-edge research, publish in specialized journals, and train human resources. The SNI has been effective in attracting new professionals and containing the emigration of Mexican academics to foreign countries. In 1984, it recognized 1396 members, and by 2019, this figure reached 30,549 (CONACYT, 2019). The areas with the highest number of researchers are social sciences and economics, biology, and chemistry; the areas with fewer researchers are biotechnology, agriculture, medicine, and health. The significant increase in number of researchers is reflected on the amount of indexed publications in recent years. From 2008 to 2015, the production of scientific articles in Mexico experienced an average growth rate of 4.92% in relation to the member countries of the OECD. Currently, the country ranks 33rd of the 34 OECD member countries in terms of the Impact Relative to World (IRW), with 0.98 citation impact of the set of publications as a ratio of world average (CONACYT, 2015a).

Moreover, an increment in the number of patent applications by Mexicans during the 2000–2015 period was observed. In the year 2000, of all patents requested, 431 (3.2%) belonged to nationals, a number that climbed to 951 (6.1%) by 2010 and 1364 by 2015 (CONACYT, 2015b). Another indicator of scientific development in the country is that, in 2012, the Global Innovation Index located Mexico in 79th place out of 143 countries and in 72nd place in 2018 (Cornell University et al., 2018).

Researchers and support for research tend to be distributed unequally; of the 28,635 SNI researchers, 31.67% reside in Mexico City, whereas 68.33% reside in different states of the country (CONACYT, 2017). However, the financing of research projects and infrastructure continue to favor institutions with greater scientific maturity and better management and investment capabilities, thus perpetuating territorial differences. A recent initiative is the so-called *Chair Program*, consisting of public positions of an academic nature for young researchers, whose objective is to incorporate more than 3000 doctors in HEIs, centers, and research institutes located in the 32 states of the country (CONACYT, 2014).

The expansion of human resources is essential for the development of the country; CONACYT and SNI allow the formation of human capital and the creation of a base of science and technology activities. These programs allow the acceleration of innovation, as a strategy to achieve competitive advantages within the framework of knowledge-based societies, as it is generated from new products, designs, and services. Further, the federal government is promoting Innovation Incentives Programs (IIP) which aim to link higher education institutes and research centers with the productive sector for the creation, transfer, and exploitation of knowledge. Although these programs have strengthened the exchange and cooperation between the academic, scientific, and corporate sectors (Dutrénit & Arza, 2010), the interaction between these agents is still limited, weak, and irregular, to consolidate a real system of innovation (OECD, 2014). CONACYT acknowledges this condition is the result of both the absence of policies that recognizes the types of companies; the phases of innovation; the link between science, technology, and innovation agents; and the lack of support for innovative technology companies (CONACYT, 2014).

Increasing Fragmentation and Stratification of Academic Workforce

While an increasing contingent of productive scholars and researchers continues to grow, especially at the federal universities and public research centers, the vast majority of academic staff, including those in the private sector and in the technological-oriented institutions, continue to work in a more precarious and less supportive situation. In Mexico, only 36% of professors in public and private sectors hold tenured positions, and the rest are part-time or hourly contracted (ANUIES, 2014). However, public institutions have maintained higher percentages of tenured professors, especially in the research centers, and federal and state universities, in comparison with private HEIs.

There is also a marked segmentation between teachers and researchers, with the latter group deemed as more valuable in its contribution to the knowledge society. In Mexico, the financial difference between both academic groups is particularly extreme. Starting in 1984, with the creation of the SNI, the government linked the salaries of top researchers to their scientific production, measured primarily in terms of the number of publications in peer-reviewed journals. Members of the SNI receive substantial bonuses depending on their levels of production; the system has four levels, with bonuses (extra salaries actually) ranging from $350 to $1600 USD a month in 2019. However, researchers are evaluated accordingly to their production in scholarly journals, with internationally indexed journals in English (of which there are far more in the STEM fields) receiving the highest points. Furthermore, members of the SNI in universities (the program also has members from research institutes and private companies) represent a privileged and tiny minority of university professors.

Mexican Higher Education and Social Improvement

Mexican universities have a broader contribution to the knowledge society by promoting social betterment and civic participation. Historically, universities have been responsible for educating thoughtful citizens who fight against human pandemics like poverty, unemployment, and educational lags. The knowledge society fostered from HEIs has been the imaginary space where intellectual debates take place to encourage societal improvement and social justice in Mexican society. Overall, HEIs have contributed to improving society to the extent that social aspects like political participation, societal health, and employment are improved.

Due to the global economic circumstances, social demands are rising; hence, a more politically active and engaged society must be educated in a knowledge society to serve in a knowledge economy. The interaction in a global economy has led Mexican HEIs to embrace a knowledge society that fosters individuals to interact in civilized life. However, the promotion of a more participative society remains as a pending issue in the political agendas of HEIs. In that regard, data from National Survey on Political Culture and Citizen Practices (ENCUP) (Governing Secretary, 2005) underlines two main reasons. First, Mexico is still immersed in an "inevitably of elites"—in fact, the most critical decision-making process is still dominated by a small stratum of economic and political decision-makers. Second, it seems that politics are less complicated to those who study in private institutions. As a result, the level of interest in politics is also higher among individuals educated in those institution. Figure 20.1 displays the levels of interest in politics in people who have not attended higher education and on those who have attended higher education in public and private institution (Fig. 20.1).

The efforts made in campuses across the country seem to be more fruitful in terms of societal health and quality of life. According to the OECD (2019), Mexico has made important progress over the last decade in terms of quality of life of Mexicans. Among the most significant signs of improvement are in indicators such as income, education, jobs, and health. The better life report (OECD, 2017)

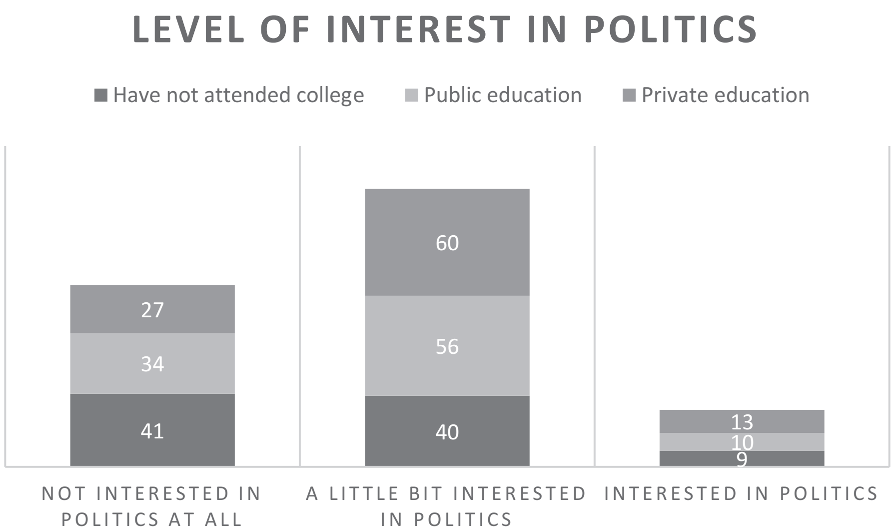

Fig. 20.1 Graphic shows the level of interest in politics of Mexican citizens. The graphic distinguishes the level of interest among those who have not attend college at all and those who have attended public and private universities. (ENCUP, 2005)

indicates college attendance has exponentially grown in Mexico. Between 2007 and 2017, graduation rates increased from 16% to 23%, which is still below the OECD average of 44%. The average household net-adjusted income per capita remain at 13,891 USD per year, which is considerably lower than the OECD average (30,563 USD). In Mexico, 37% of adults age 25–64 have completed upper secondary education, much lower than the OECD average (74%). In terms of employment, about 61% of people aged 15–64 in Mexico have a paid job, lower than OECD employment average (77%). Regarding health, life expectancy at birth in Mexico is 75 years, 5 years lower than the OECD average (80 years). In general, Mexicans are satisfied with their lives. In a scale from 0 to 10, Mexicans gave it a 6.6 on average, quite similar to the OECD average (6.5).

Conclusions

In recent years, Mexican science and technology policies induced sustained yet not spectacular growth. This is reflected in the increase of highly qualified personnel dedicated to science and the increase of Mexican scientific production. Despite these undeniable accomplishments, it is necessary to urgently address the factors that hinder scientific development to give greater dynamism and strengthen the role of science in the economic and social development of the country.

Former President Enrique Peña Nieto's administration promised to strengthen national science and technology development. In fact, there was a commitment for 1% of the GDP expenditure in science and technology at the end of the administration. Nevertheless, multiple factors like the fall of oil prices, the limited investment in science by the private sector, and the contraction of economic growth complicated the accomplishment of that goal. This condition might have hindered the advancements of the fragile Mexican science and technology system.

Nowadays, Mexico faces several dilemmas, none of them new, of course. The biggest one is to update a system that has historically regulated, financed, and assessed the science and technology activities to align it to "the emerging tendencies toward collaboration, internationalization, bonding, and the opening of new fields" (Kent, 2014, p. 347). Although current policies are no longer favorable for the expected results regarding quality, change would mean to increase current tensions in higher education, given the competitive allocation of resources. A change of policy aligned to the support of STEM would signify more and major resources to federal institutions. This condition would increase annoyance among the remaining institutions for the gaps in funding and governmental support. In this regard, De Vries and Alvarez (2014) explained that "at the beginning of the nineteen-nineties, the question was whether governmental policies could change the workings of the system in Mexico. Nowadays, the key question is whether policies can be changed, as policies themselves have turned resilient to change" (p. 33). Another dilemma is to both explain and justify why currently implemented national policies are decreasing their impact on the improvement of higher education in Mexico (Galaz et al., 2012). Therefore, in the future, policymakers, scholars, and administrators are required to look at different options to face the weaknesses of public policies in terms of higher education, science, and technology.

Mexican scholars generate knowledge and innovation in alignment with the role assigned to their universities, which is not necessarily aligned with scientific and technological development. Within each institution, it is possible to distinguish disciplines growing in both size and diversity, which generates new research directions. There is a tendency for science growth to occur in aggregate and diversified forms, from which new scientific areas emerge, assuming the legitimate coexistence of diverse theories about the same phenomenon (Bonaccorsi & Vargas, 2010). This triggers the development of new disciplines and emergent fields of study (e.g., environmental sustainability, renewable energies, aerospace, biodiversity, cold technology, energetic sustainability, sustainable agricultural innovation, food innovation) that can offer a view toward more dynamic environments in relation to the intensive use and innovative application of knowledge. From the HEIs, these new disciplines and sciences aim to respond to priority areas of attention reported by the CONACYT (such as information and communication technologies, biotechnology, advanced materials, manufacture design and processes, infrastructure, and urban and rural development) regarding strategic knowledge for the solving of problems.

Mexican academics have a distinctive feature as they have increased their productivity in recent decades despite receiving very few resources in a country that has been allocating an expenditure on research and development. If this stagnation continues, scientific competitiveness and productivity in the country would hardly approach the pace of developed countries or even emerging ones. There are pending inquiries on the details of this distinctive feature and a pending analysis of the limit to which academics will maintain these tendencies in their scientific production rates before they are replaced by a new generation.

It is clear that the new circumstances in the national and international contexts require deep changes in higher education for further STI development. In the face of paradoxes deriving from knowledge-based social dynamics and innovation, it is for HEIs and academics to further progress through the complex path of developing and perfecting their scientific and technological processes.

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Etty Haydee Estévez-Nenninger is a senior research professor at the University of Sonora, Mexico. Her research interests focus on higher education, academics, teaching, and innovation in education. She holds a PhD degree from the Center for Research and Advanced Studies (CINVESTAV) of the National Polytechnic Institute of México. She is the coordinator of the Academic Profession in Knowledge-based Society project in Mexico, in which most of the co-authors participate. She is a member of the Council of Educational Research and of the National System of Researchers.

Angel Alberto Valdés-Cuervo is professor of higher education at the Technological Institute of Sonora, Mexico. His research interests focused on school violence, family-school, higher education, and academics. He earned his PhD from the Center of Research in Feeding and Development of National Council for Science and Technology (CONACyT). He is a member of the Mexican Council of Educational Research and of the National System of Researchers.

Edgar Oswaldo González-Bello is professor at the University of Sonora, Mexico. His research interest focused on higher education, teaching, digital technology, and innovation in education. He holds a B.A. in computer science, a master's degree in educative innovation, and a PhD degree in social sciences from the University of Sonora. He is a member of the Mexican Council of Educational Research and of the National System of Researchers.

Juan Pablo Durand-Villalobos is professor of higher education at the University of Sonora, Mexico. His research interests are focused on the internationalization of higher education and educational inclusion. He holds a PhD degree at the CINVESTAV of National Polytechnic Institute. He is a member of the Mexican Council of Educational Research and the National System of Researchers.

Marion Lloyd is a research professor at the National Autonomous University of Mexico (UNAM). Her research interests focus on access and equity, comparative higher education policy, international university rankings, science and technology policies, and internationalization. She earned her PhD at the UNAM during 2014–2017 and is a member of the National System of Researchers.

Jorge Gregorio Martínez-Stack is Academic Director of the Mexican Institute of Orientation and Educational Evaluation and is consultant at the General Directorate for Institutional Evaluation of the National Autonomous University of Mexico (UNAM). His research interests are higher education, teaching, academics, and evaluation. He is a member and organizer of UNAM's Seminar of Higher Education (SES).

Lizeth Guadalupe Parra-Pérez is professor of higher education at the Technological Institute of Sonora, Mexico. Her research interests focused on educational policy. She is a member of the National System of Researchers. She holds a PhD from the School of Education of the Colorado State University, USA.

Chapter 21
Canada: The Role of the University Sector in National Research and Development

Olivier Bégin-Caouette, Glen A. Jones, Grace Karram Stephenson, and Amy Scott Metcalfe

Abstract This chapter presents the structure of the Canadian higher education system and the relationship between Canadian universities and research and development (R&D) at the national level. In Canada, the constitutional jurisdiction for higher education resides at the provincial level. Research and development constitute a large portion of the federal government's investment in postsecondary education. Using OECD and national data, we describe R&D in Canada from 1997 to 2017, with an emphasis on the university sector. We compare these trends over time with policy changes that have separated or integrated a national approach to skills training (workforce development) and innovation (science and technology). An overview of Canadian research activity is provided, including publication rates, citation rates, international collaborations, doctoral degree conferral rates, and the percentage of the population with advanced degrees.

Keywords Higher education · Research and development · R&D expenditures · Faculty · Innovation

O. Bégin-Caouette
University of Montreal, Montreal, Canada
e-mail: olivier.begin-caouette@umontreal.ca

G. A. Jones (✉) · G. K. Stephenson
University of Toronto, Toronto, ON, Canada
e-mail: glen.jones@utoronto.ca; grace.karram@utoronto.ca

A. S. Metcalfe
Department of Educational Studies, University of British Columbia, Vancouver, Canada
e-mail: amy.metcalfe@ubc.ca

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Introduction

Canada is a large, sparsely populated nation located on the northern end of the North American continent. The Canadian constitution establishes a federation (currently ten provinces and three territories) and divides authority over policy issues between federal (national) and provincial levels of government. While institutions of higher education are created and regulated by the provinces, the federal government plays a major role in a variety of policy sectors that directly intersect with institutions of higher education, especially research and innovation, student financial assistance, culture, and the education of Canada's Indigenous peoples (Jones & Noumi, 2018).

Given this arrangement, higher education in Canada is best understood as the sum of ten, quite distinct, provincial and three territorial "systems" of higher education (Jones, 2018). There are significant differences in the structure of and regulatory arrangements for higher education between provinces although there are also key common elements. The vast majority of Canadian universities are relatively autonomous, private, not-for-profit corporations established by provincial legislation.[1] While most Canadian universities are considered "public" in the sense that they receive provincial operating grants, there is a modest private university sector, largely composed of faith-based institutions, though private secular and private for-profit universities can also be found in some provinces (Li &Jones, 2015). There is only one university, Yukon University, among the three northern territories.

Public universities vary enormously in size and program offerings, but most institutions offer some combination of undergraduate, professional, and graduate programs. They have both a teaching and research function although several newer universities in British Columbia and Alberta are regarded as teaching-focused institutions. As we note in more detail below, the level of research activity varies dramatically by university.

The structure and role of nonuniversity institutions, commonly referred to as colleges, varies by province. Colleges generally offer a wide range of applied, vocational diploma programs though several provinces have assigned certain colleges the authority to grant degrees. A larger share of Canadian postsecondary students enroll in colleges than is seen in other OECD nations, and this sector is considered a key element within provincial systems. Some colleges also play a role in applied research, and several federal government grant mechanisms focusing on this functional role have emerged. While the colleges play an important role in human resource development, their direct role in research and development continues to be quite modest. This chapter focuses only on the academic profession within the

[1] Most universities operate under unique provincial acts though universities in British Columbia operate under the omnibus Universities Act, and the entire higher education system in Alberta operates under that province's Postsecondary Learning Act. The university sector in Québec includes institutions that operate under unique charters, but it also includes the University of Québec, a multicampus provincial university system.

public university sector and the role of universities within Canada's research and development (R&D) system.

Canada has a high participation system of higher education with the vast majority of students in the relevant age cohort pursuing some form of postsecondary education. At the same time, access to higher education continues to be a major policy issue given differences in participation rates by socioeconomic status. There is also a growing recognition that certain populations have been left behind in terms of access to and participation in higher education, especially Canada's Indigenous populations (Jones, 2018).

This chapter details the role of Canada's higher education sector (HES) in the nation's research and development. The second section provides an international comparison by using OECD data to determine the main sources of R&D funding in Canada. Canada's position is ranked against other OECD countries with a particular focus on the United States. The third section examines the position of higher education R&D across Canada, comparing provincial expenditures and production capacity. The fourth section considers the nature of academic work in Canada, relating the employment and working conditions of professors to their role in R&D.

Canada's National Research and Innovation Policy

Canada does not invest as heavily in R&D as other OECD countries, as indicated by the OECD (2018) data shown in Table 21.1. In 2017, Canada's gross domestic expenditure for R&D (GERD) represented 1.53 percent of the GDP, while the OECD average in 2016 was 2.00 percent. The United States, Canada's southern neighbor, invested the equivalent of 2.47 percent of its GDP in 2016. Canada's GERD as a share of GDP has declined steadily since 2001 while other OECD countries have seen an increase in spending. This situation is attributed to a historically smaller contribution from the government and business enterprise sectors, which finance 33 percent and 40.56 percent of the GERD, respectively. Correspondingly, these two sectors contribute a smaller proportion of the GERD than the OECD average, particularly compared with the United States. Following this trend, the Canadian business sector contributed 51.03 percent of the GERD in 2017 compared to 71.17 percent in 2016 in the United States. Interestingly, the proportion contributed by the government sector decreased from 19.06 percent in 1997 to 7.17 percent in 2017. In most OECD countries, government contributions also decreased between 1997 and 2016, yet Canada remains below the OECD average of 10.92 percent.

In a national research and innovation system (NRIS) that is smaller than other OECD countries, the contribution of the higher education sector is worth exploring. In Canada, the proportion of researchers per thousand employees has increased by 45 percent over 20 years, placing Canada above the OECD average. Notably, 37.14 percent of all researchers work in the higher education sector. In terms of expenditures, the higher education contribution to GERD increased almost 30 percent over 20 years, reaching 41.25 percent in 2017, while the OECD average and the

Table 21.1 Selected OECD indicators related to research and development in Canada (1997–2017)

Indicators	1990	1997	2007	2017[a]	% of change
GERD (constant PPP) [b]	12,665.65	15,961.98	25,709.92	24,305.50	47.89
GERD as % of GDP	1.48	1.62	1.91	1.53	3.27
% of GERD financed by…					
• Government	45.90	31.97	31.97	33.00	−28.00
• Business sector	38.60	48.05	49.19	40.56	4.83
% of GERD performed by the…					
• Business sector	50.37	59.71	55.80	51.03	1.29
• Government sector	19.06	13.21	9.74	7.17	−48.89
• HE sector	29.56	26.50	33.92	41.25	28.34
Total researchers per thousand total employment	4.93	6.65	8.89	8.96[c]	44.98
HE researchers as a % of national total	41.53	35.88	31.26	37.14[c]	−10.57
HERD as % of GDP	0.44	0.43	0.65	0.63	30.16
% of HERD financed by the business sector	4.98	9.82	8.54	7.85	36.56
General university funds as % of civil GBARD	30.18	29.05	29.98	31.71[c]	4.82

Source: OECD (2018) [a]Projected; [b]US dollar, millions, 2010; [c]last year available: 2014

proportion in the United States is 13.31 percent. Correspondingly, higher education expenditures in research and development (HERD) increased by 30.16 percent over 20 years and represented, in 2017, 0.63 percent of the GDP. In comparison, in 2016, HERD represented 0.36 percent of the GDP in the United States, and the OECD average was 0.41 percent. Thus, the Canadian business sector contributes comparatively less to the GERD, but it finances a greater proportion of the HERD (7.85% in 2017) than the OECD average (6.16% in 2015) or the United States (5.31% in 2016).

Few international indicators have been developed to characterize funding streams in the higher education sector. The OECD does measure the proportion of the civil (nonmilitary) government budget appropriations or outlays for R&D invested (GBARD) in general university funding (GUF), which are usually considered as non-oriented block grants given to higher education institutions for research purposes (OECD, 2013). The GUF-GBARD represented 31.71 percent in Canada in 2014, while the OECD average was 24.87 percent in 2016 (the United States reporting no GUF at the federal level). In 2010, the OECD (2010) tried a new indicator to compare research funding instruments. In 2008, in Canada, over half (55.5%) of government-funded R&D in higher education was institution based, and 44.5 percent was project based. Only 14 countries participated in this project; by comparison, in Germany, 93.3 percent was institution based and 6.7 percent project based. In Norway, 63.4 percent was institution based, and 36.6 percent was project based.

The relative weakness of the business sector is seen in Canada's share of patent applications, which represents around 1 percent of the world's total, placing Canada only 18th in the world. Canada also represents 0.9 percent of trademark applications (34th rank) and 0.5 percent of industrial design applications, placing the country at the 34th rank (CCA, 2018). In contrast, the Council of Canadian Academies (CCA, 2018) calculated that the country's scientific publications increased by 26 percent between 2003 and 2014. Canadian researchers averaged 52 publications between 2009 and 2013 compared to 41 per researcher in the United States. However, Canada's relative share of the worlds' research publication fell from 4.2 to 3.8 percent and from 7th to 9th rank. This comparative decline was partly explained by the growth in the number of publications in India and Italy. Canada's science production can also be estimated through citations and reputation. Between 2009 and 2014, Canada's average relative citation rank (ARC) was 1.43 (the US at 1.40), ranking 6th in the world. Moreover, 36 percent of the top-cited international researchers ranked Canada in the top five countries in their scientific discipline (CCA, 2018).

Comparing academic fields, Statistics Canada reported that in 2017, Natural Sciences and Engineering accounted for 76 percent of Canada's HERD, and Social Sciences, Humanities, and Arts accounted for 24 percent, which still represents a large proportion of the total funding compared to other countries. Correspondingly, the CCA (2018) calculated that Canada produced more than 5 percent of the world's research in Psychology and Cognitive Sciences, Public Health and Health Services, Philosophy and Theology, Earth and Environmental Sciences, and Visual and Performing Arts.

Academic R&D Capacity

Although the National Research Council of Canada (NRC) has existed since 1916, academic research has a considerable role in the country's linkages between science and technology (S&T) and R&D. The potential for academic research to contribute to Canada's economic development has been an explicit policy focus for several decades (Doern et al., 2016). While provincial governments create and administer their own research policies, the national authority for S&T is the federal government, with the Prime Minister, the Cabinet, and Parliament. Discursively, federal S&T policy has moved toward an emphasis on R&D over the years as the names of the ministries changed from Ministry of Science (1960s) into the present Ministry of Innovation, Science, and Economic Development. Furthermore, the guiding policies and strategies for S&T were influenced by the ruling political party agenda, with responses by the opposition party and special reports commissioned by various stakeholders. The government of Prime Minister Stephen Harper issued two policy documents that outlined the administration's S&T focus: *Mobilizing Science and Technology to Canada's Advantage* (Government of Canada, 2007) and *Seizing Canada's Moment: Moving Forward in Science, Technology, and Innovation* (Government of Canada, 2014). With regard to the academic profession, a key "pillar" of the Harper S&T framework was an emphasis on "highly-qualified personnel" (HQP). In contrast, Canada's current science strategy under Prime Minister

Justin Trudeau focuses on investment in key programs and developing a more diverse scientific community (Government of Canada, 2018).

Canada's academic R&D was slow to develop (Kavanagh, 1993); however, a number of systemic factors have increased production significantly. First, the establishment of a Cabinet Committee on Science and Technology in 1968 and the release of the Lamontagne Report in 1974 led to the successive increases in Canada's tri-council grants and other funding instruments which have contributed significantly to university research capacity. For Doern, Castle, and Phillips (2016), the granting space is the most important pillar of Canada's NRIS. Various funding instruments support networks (critical in a sparsely populated country) and research infrastructure which alleviates the burden on researchers who obtain grants but do not necessarily have the financial capacity to develop or maintain the resource-intensive equipment needed for research.

The Government of Canada's funding instruments account directly for half of HERD and 11 percent of universities' total revenue. The three granting councils—Natural Sciences and Engineering Research Council of Canada (NSERC), the Canadian Institutes of Health Research (CIHR), and the Social Sciences and Humanities Research Council (SSHRC)—received CAD $3.5 billion in 2019 (Government of Canada, 2020). Each council runs a competition for student scholarships (e.g., doctoral fellowships), individual grants to support fundamental research (e.g., CIHR Foundation grants), and collaborative research with Canadian companies (e.g., NSERC Development Grants). Together, they run joint programs such as the Canada Research Chairs (CRC) and Canada Excellence Research Chairs (CERC) to help Canadian universities retain and attract top researchers, and the Canada First Research Excellence Funds, which supports institutions to become global leaders in their expert fields (Advisory Panel, 2017). Those multiple funding instruments distribute research capacity across the country and significantly increase the HERD and, correspondingly, strengthen the role of universities in the NRIS. However, while granting council dollars per researcher rose by 48 percent between 2000 and 2009, they fell by 30 percent between 2009 and 2016 (Advisory Panel, 2017). This coincides with the decline of Canada's share of the worlds' research publication. The effects of the new investments by the government since 2016 are not yet clear.

Other funding instruments include agreements with federal-level Canada Foundation for Innovation (CFI) (Advisory Panel, 2017). Created in 1997, the CFI funds 40 percent of a project's eligible infrastructure costs, with the remaining coming from provincial governments and other sources. The merit-based awards to institutions represent over CAD $1 billion annually. CFI profoundly transformed Canada's NRIS by enhancing research capacities, supporting universities' institutional strategies (over researchers' individual research programs), compelling provinces to follow federal priorities, and, like CRC and CERC, reinforcing hierarchies between and within universities (Doern et al., 2016). The largest universities, for instance, received 97 percent of the CFI funding in 2015 (CFI, 2015). Finally, there is also a funding role of not-for-profit organizations such as Genome Canada, Mitacs, and other smaller nonprofit research organizations (Advisory Panel, 2017).

Another important factor is Canada's extensive international research collaborations. Studies suggest the level of international collaborations in science have a positive, significant impact on the level of academic research production (Bégin-Caouette, 2019; Li et al., 2013; Puuska et al., 2014; The Royal Society, 2011; UNESCO, 2015). The relative prominence of academic research is likely connected to the extensive level of collaboration between Canadian researchers and international counterparts. In 1980, only 15 percent of Canadian NSE articles, and 11 percent in the Social Sciences, involved international partners; by 2002, these figures were 42 percent and 25 percent, respectively (Larivière et al., 2006). According to the CCA (2018), Canada's international collaboration score was 1.6 between 2009 and 2014. This means Canadian researchers have 60 percent greater international co-publications than would be expected based on the number of papers published. This metric places Canada in the 7th position globally, before the United States but after the UK, Germany, and the Netherlands. Canada offers a variety of scholarships and grants to international graduate students and scholars; 28.1 percent of the 1750 Canada Research Chairs and all of the Canada Excellence Research Chairs go to researchers from other countries (Government of Canada, 2014).

Considering the comparatively high HERD per GDP, GUF to GBARD, and international co-publications, one could characterize Canada's NRIS as "academically central." This expression, as interpreted by Bégin-Caouette, Askvik, and Bian (2016), suggests academia sits at the core and leads the research production process in a given system. Another important element of academic centrality is the proportion of doctoral graduates. While Canada has a well-educated population with half of those between 25 and 64 years having completed some form of postsecondary education (CCA, 2012), Canada only ranks 22nd among the 35 OECD countries for its doctoral-level graduation rates (Advisory Panel, 2017). In 2016, 7768 Canadians received doctoral degrees or equivalent (OECD, 2018). It has been suggested that lower doctoral graduation rates could limit the Canadian NRIS's capacity for renewal and affect the country's contribution to science long-term (Advisory Panel, 2017; Lacroix & Maheu, 2015).

A final factor is the increasing number of collaborations between academic and nonacademic actors. The federal government boasts one of the most comprehensive R&D investment tax incentives in the world (Sá & Litwin, 2011) and has initiated multiple instruments to foster university-industry collaborations. Between 2008 and 2016, the relative value of traditional grants declined, but the value of strategic initiatives targeting specific areas (such as partnerships between CIHR and NSERC) increased by 35 percent (Advisory Panel, 2017). Since its inception in 1989, the Networks of Centers of Excellence (NCE, 2020) invested CAD $2 billion in research commercialization and helped create 1332 start-up companies. In 2018, the federal government transferred NCE's funds to the New Frontiers in Research Fund (NFRF), which will focus on high-risk and high-reward interdisciplinary research. If there is a general consensus that the push for industry-university linkages has influenced universities' strategic behaviors (Polster, 2003–2004), the impacts of those measures on researchers' behaviors and the country's NRIS remain unclear. Findings from the previous Changing Academic Profession (CAP) study suggested that most Canadian professors were not engaged in activities with industry, and 61 percent agreed that the quality of academic research was threatened by the industry sector's high expectations of useful results and the push for applicable research (Gopaul et al., 2016). It should be noted that while the proportion of HERD financed by the business sector increased between 1990 and 1997, it then slightly decreased until 2017. Despite a shift in federal funding, CIPO (2018) reports that between 2008 and 2017, patent applications declined by 17 percent.

The multitude of funding instruments as well as international collaborations have positioned the HES at the core of Canada's NRIS. However, the HES contribution could be heightened if the innovation policy mix (Borrás & Edquist, 2019) had measures to increase the proportion of graduate students and foster federal-provincial coordination, monitored by systematic impact studies (Bégin-Caouette, Nakano Koga, and Karram Stephenson, forthcoming).

Internal Variation in R&D Capacity

To better understand Canada's NRIS, it is important to consider the cross-country distribution of R&D capacity. As previously mentioned, Canada is a federation. The ten provinces have exclusive jurisdiction over education, including higher education, but the federal government intervenes in the sector through various mechanisms including funding for R&D. In the past decade, the proportion of research funding allocated by the federal government (23% in 2016) has been much larger than that allocated by provincial governments (8%). If funding from businesses or foreign sources has been relatively stable (respectively 8% and 1%), there was a slight increase in the amount allocated by private, nonprofit sources (from 7% in 2000 to 11% in 2007). Higher education institutions, which are funded operationally through provincial and federal funding, tuition fees, and donations, remain the first source of funding for R&D, contributing half (50%) of the national total (Statistics Canada, 2017). Recent studies suggest that Canada's research ecosystem is weakly coordinated and that provincial and federal funding initiatives seldom align (Advisory Panel, 2017; Tamtik, 2017).

Although the federal government plays an important role in supporting research capacity, disaggregating R&D indicators per province (Table 21.2) reveals considerable variation by jurisdiction. The most populous provinces have the highest expenditures, with Ontario and Québec representing 39 and 23 percent of the Canadian population, respectively. Ontario and Québec also account for 41 and 25 percent of national expenditures although Québec's share has slightly decreased since 2000. In raw numbers, Ontario outpaces the other provinces in research production and has the highest percentage of graduates with master's or doctoral

Table 21.2 R&D indicators per province and territory in Canada

Provinces-territories/indicators	% of Canadian population [a]	% of national R&D funding[b]	Publications per 1000 inhabitants[c]	Average relative citation[c]	International collaboration rates[d]	% of 25–64 with master's or doctoral level[e]	PhD graduates per 100,000 inhabitants[f]
Provinces							
Alberta	11.68	11%	15.8	1.46	42.5	8	73.3
British Columbia	13.12	12%	16.0	1.69	48.2	10	78.1
Manitoba	3.65	3%	13.0	1.34	39.7	7	44.5
New Brunswick	2.07	1%	9.6	1.10	38.0	7	42.9
Newfoundland and Labrador	1.44	2%	12.9	1.26	38.7	6	74.3
Nova Scotia	2.60	3%	19.2	1.37	40.9	11	63.8
Ontario	38.67	41%	16.5	1.54	43.4	12	91.4
Prince Edward Island	0.41	0%	9.2	1.08	40.6	8	35.8
Québec	22.87	25%	13.4	1.51	43.8	9	102.0
Saskatchewan	3.17	2%	15.4	1.36	41.7	6	59.7
Territories							
Northwest Territories	0.12	3.5% [g]	6.2	1.25	32.5	11	n/a
Nunavut	0.10		4.3	1.32	34.5	6	n/a
Yukon	0.10		6.1	1.36	39.0	10	n/a
National total	100%	100%	14.0	1.43	43.7	10	87.7

[a]Source: Statistics Canada (2017b). [b]Based on 2016–2017 data. Source: Statistics Canada (2018). [c]Based on 2009–2014 data. Source: CCA (2016). [d]Based on 2003–2014 data. Source: CCA (2016). [e]Statistics Canada (2016). [f]Source: Statistics Canada (2011). [g]Aggregated estimates based on 2009–2013 data

degrees. Québec, the only province in which French is the official language,[2] has significantly more international research collaborations with France and Belgium than its counterparts (Larivière et al., 2006). Québec also had the highest doctoral graduation rates for the 25–29 age cohort in 2011.

The three provinces of the prairie region (Alberta, Manitoba, and Saskatchewan) account for 19 percent of the Canadian population and 16 percent of R&D expenditures, while British Columbia accounts for 13 percent of the population and 12 percent of national expenditures. The only slight discrepancy between population and funding size is found in the four Atlantic provinces (New Brunswick, Newfoundland and Labrador, Nova Scotia, and Prince Edward Island), which constitute 7 percent of the Canadian population but account for only 4 percent of R&D expenditures. However, Nova Scotia, with its robust university sector, has less than 3 percent of Canada's population but 3 percent of national expenditures. It also has the highest publication rate in the country, with almost 13 publications per 1000 inhabitants (CCA, 2018).

National variation also partly reflects the distribution of the most populated cities. According to the CCA (2018), the five most populous cities in Canada (Toronto, Montreal, Vancouver, Ottawa, and Calgary) account for half of all clusters in the service sector, create nearly twice the share of patents and high-tech companies than other cities, and house the largest universities.

Finally, variations are largely explained by the concentration of academic research production into the fifteen most research-intensive universities, commonly referred to as the U15. The U15 obtains 80 percent of all research funding, conducts 83 percent of all research conducted in partnership with the private sector, trains 70 percent of doctoral students, and welcomes 23 percent of international students (U15, 2018). Moreover, eight universities in the U15 rank in the national top 10 for research productivity and impact (CFI, 2015; Jarvey & Usher, 2012; Lacroix & Maheu, 2015; U15, 2018).

Academic Work in Canada

With the academic centrality of research and development in Canada, university professors are essential contributors to the nation's research production. The nature of an academic career in Canada differs slightly between provinces and institutions. It is common, however, for most full-time professors to be hired in tenure-stream positions and retain a balance of teaching and research, with a peripheral expectation of service. The particular terms of their employment are frequently determined

[2] At the national level, Canada is officially bilingual (English and French), and this is also true at the provincial level in New Brunswick. English is the official language in the remaining eight provinces although some support French language or bilingual universities. Nunavut Territory recognizes the Inuit, English, and French languages, while 11 different languages are officially recognized in the Northwest Territory.

by negotiation between senior university administration and the strong institution-specific unions to which the majority of professors belong. Although the nature and prevalence of tenured positions have remained relatively stable in Canada, there is some evidence of a gradual fragmentation of academic work as institutions fill personnel gaps by hiring nonpermanent instructors and researchers on very different terms than their tenured counterparts (Jones, 2013; Rajagopal, 2002).

Academics who are hired into full-time, tenure-stream positions move through three academic ranks: assistant professor, associate professor, and full professor. A PhD is usually required for appointment to the initial rank of assistant professor. Tenure, often linked with promotion to the rank of associate professor, is normally gained between 3 and 7 years after the initial hire and is based on an extensive review by a committee of peers, during which the research, funding, teaching, and service achievements of the professor are examined. Tenure is a permanent appointment without term, and there is no mandatory retirement age. Although a professor may appeal a negative outcome, those who do not successfully attain tenure often leave the university the following year (Acker & Armenti, 2004). A committee review is also required in the promotion to full professor, which occurs later in a professor's career. However, not all professors choose to pursue promotion to full professor, nor is it mandatory. Across universities in Canada, around three quarters (76%) of professors hold the rank of associate or full professor due to promotion to associate professor occurring relatively early in an academic career.

While tenure has come under attack at different times, both for protecting unproductive professors and not truly guaranteeing academic freedom, it is still the main structure of employment at universities across Canada. Several relatively new universities that have made the shift from college to university in the province of British Columbia hire faculty at the open rank of *professor* or *instructor,* with considerable job security. There is a slowly growing trend toward creating teaching-stream, tenured positions in which professors are evaluated with more consideration of their pedagogy and teaching-related research accomplishments than research outputs (Sanders, 2011). At most universities, however, research production still tends to be the most important factor for a successful tenure review (Gravestock, 2011).

While women are only slightly underrepresented at the ranks of assistant (42.3%) and associate professor (46.6%), there are significantly fewer women at the rank of full professor (26.8%) (Statistics Canada, 2017a). In recent years, affirmative action policies and mentorship programs for new faculty have increased the number of women hired to academic positions (Acker and Armenti, 2004). Of both male and female professors, 74 percent are between the ages of 40 and 65, and 10.1 percent of all active faculty are over the age of 65.

As Table 21.3 indicates, the largest percentage (21.4%) of professors in Canada is found in disciplines within the Social and Behavioral Sciences, a sector that contributes around one-quarter (24%) of the country's HERD. Following this, the Business, Architecture/Engineering, and Physical/Life Sciences disciplines each host slightly more than 11 percent of faculty.

The position of women in Canadian departments differs dramatically among disciplines. In fields like Education and Health/Parks/Recreation, women represent

Table 21.3 2016–2017 full-time university teachers by gender and subject taught. Source: University and Colleges Academic Staff Survey (Statistics Canada, 2017a)

Academic discipline	Number of faculty	Percentage of women
Agriculture, Natural Resources, and Conservation	936	27.60%
Architecture, Engineering, and Related Technologies	4071	15.50%
Business, Management, and Public Administration	4278	39.40%
Education	2007	62.20%
Health, Parks, Recreation, and Fitness	3279	65.90%
Humanities	5037	46.30%
Mathematics, Computer, and Information Sciences	2625	20.60%
Personal, Protective, and Transportation Services	60	55.00%
Physical and Life Sciences and Technologies	4206	24.80%
Social and Behavioral Sciences and Laws	7905	44.60%
Visual and Performing Arts and Communications Tech	1905	45.50%
Other	474	42.40%
Not applicable, not reported	204	47.10%
Total	36,987	39.50%

more than 60 percent of the total faculty, whereas in Architecture/Engineering women represent only 15.5 percent and likewise 24.80 percent in Physical and Life Sciences. As noted above, Natural Sciences and Engineering account for 76 percent of Canada's HERD in 2017, and with the small number of women in these fields, women are likely underrepresented in the country's overall HERD. Past research confirms that women publish less, on average, than their male counterparts, possibly due to the "glass fences" that keep women from participating in highly productive international collaborations (Uhly et al., 2017; Zippel, 2018). However, marriage and childbearing are shown to have an opposite impact on productivity with women more likely to publish if married but less likely if they have children (Padilla-Gonzalez et al., 2011).

Canada's NRIS can be considered as a reflection of the academic staff who produce the research itself. From this viewpoint, Canada's approach to research labor is very successful as full-time, academic work in Canada is secure and well compensated. Since unions are responsible for negotiating salary and employment benefits for the members at their specific institution, salaries for full-time faculty differ between universities and between provinces. It is common, however, for full-time professors' salaries to be commensurate with other professional sectors (Statistics Canada, 2017). For example, Table 21.4 shows that associate professors in the province of Ontario received a median salary of $169,245 in 2017. This is almost double the median household income of $74,287 in the same province (Ministry of Finance, 2016). In comparison, associate professors in the small coastal province of Nova Scotia earned approximately $116,633 per year in 2017, which compares with the provincial median household income of $53,900 (Finance and Treasury Board, 2017). Accordingly, in both Ontario and Nova Scotia, an associate professor makes

Table 21.4 Median annual salaries for full-time teaching staff without senior administrative duties by rank and gender across Canadian provinces

Rank	Newfoundland	Prince Edward Island	Nova Scotia	New Brunswick	Québec
Full professor	$152,200	$152,550	$145,304	$147,875	$144,760
Associate professor	$121,325	$131,000	$116,633	$120,075	$116,113
Assistant professor	$95,625	$99,675	$94,113	$90,700	$94,424
Male	$129,900	$131,000	$123,975	$131,844	$129,274
Female	$117,050	$123,425	114,604	$118,613	$118,168
Rank	Ontario	Manitoba	Saskatchewan	Alberta	British Columbia
Full professor	$169,245	$152,938	$171,425	$163,339	$150,104
Associate professor	$141,095	$118,725	$139,692	$125,681	$117,721
Assistant professor	$108,185	$95,150	$111,833	$99,859	$98,325
Male	$149,245	$129,925	$94,400	$133,294	$114,428
Female	$136,328	$119,513	$148,383	$118,691	$106,445

Source: Statistics Canada 2017a: Average and median annual salaries for full-time teaching staff without administrative duties by rank and gender across Canadian Provinces (Part 2)

2.2 times the median household income. A slight difference is found in the province of Québec, where an associate professor receives a median salary of $117,321, only 1.96 times higher than the median household income of $59,822 (Statistics Canada, 2016).

While union-negotiated collective agreements frequently establish the baseline salaries and promotion scale of professors, individual salaries are also impacted by years of service, stipends for administrative work, and market supplements used to attract new faculty members or keep those being recruited by other institutions (Doucet et al., 2008). Likewise, in the larger cities such as Vancouver, Toronto, and Montreal, the high cost of housing affects academic labor (Stevens, 2018).

Table 21.4 shows that female professors earn, on average, between $10,000 and $12,000 less than their male counterparts. Although all of Canada's provinces and territories have pay equity legislation that requires employers to pay equal wages for equal work, studies suggest different reasons for the gender pay gap from unresolved biases in decades past to market supplements (Doucet et al., 2008).

Canada has not been immune to the global trend toward employing precarious labor (Finkelstein and Jones, 2019). While little national data exists, several provincial studies have highlighted the difficult working conditions of nonpermanent instructors, also identified in the literature as sessional instructors, contingent faculty, limited-term faculty, and non-full-time instructors (Field et al., 2014; Rajagopal, 2002; Webber, 2008). These instructors are hired on short-term contracts to teach courses, with little guarantee of job security (Field and Jones, 2016). Precarious instructors may have limited access to institutional resources such as office space, printing, or library services, and they are often unable to sit on committees or supervise graduate students. There has been increasing unionization of nonpermanent faculty categories, and there have been several recent strikes at Canadian universities focused on the working conditions of nonpermanent instructors and teaching assistants. In response to union activity, there has been a gradual increase in the employment benefits available to nonpermanent instructors such as health care, increased (though still limited) job security, and tuition benefits. However, these agreements are institution specific, and there is considerable variation in employment conditions by institution. This increase in precarious employment suggests a gap in Canada's NRIS as it relates to research personnel as these individuals often do not qualify to receive research funding and lack a permanent presence at a university to conduct ongoing studies.

Many of Canada's universities also hire researchers under term contracts. There is, again, little national data confirming how many contract research staff are employed or outlining their specific terms of employment. These positions are mainly dependent on project-based research funding, and individuals are hired in a variety of capacities, from lab technicians to project managers.

While there has been an increasing reliance on nonpermanent instructors and researchers, the growth of tenure-stream positions has remained relatively steady. The tenure-stream professoriate are central to university research, and recent data from the Council of Ontario Universities (COU, 2018) indicate that tenure-stream professors in that province make up 42.3 percent of all academic staff.

Conclusion

Canadian universities play a central role in R&D, especially given the relatively weak role of the private sector and government research compared with other OECD countries. Academic research, performed primarily by the tenure-stream professoriate, plays a central role in Canadian research and development. While the number of full-time, tenure-stream faculty has increased steadily, it has not grown as quickly as the overall increase in student enrolment, and Canadian universities have become increasingly reliant on precarious contract instructors. Questions remain about the role that full-time academic researchers will play within Canada's innovation system in the future due to the uneven linkages between applied research, basic research, and industrial partnerships throughout the various provincial higher education systems. The stability of the professoriate in Canada, strengthened by unionization, will continue to benefit the country's basic research capacities by permitting longer-term investments in research programs and careers. Yet the scope of those investments in terms of the social applications of R&D as well as economic returns will inevitably be determined by the diversity of the professoriate and the accessibility of career pathways available to newcomers into the profession.

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Olivier Bégin-Caouette is Assistant Professor in comparative higher education at Université de Montréal. Co-founder of the Laboratory for Interdisciplinary Research on Higher Education (LIRES), his research focuses on the interactions between political-economic contexts and the production of academic research.

Glen A. Jones is Professor of higher education and Dean of the Ontario Institute for Studies in Education, University of Toronto. His research focuses on higher education systems, governance, policy, and academic work. He is the author or editor of more than a dozen books and has published more than 100 papers. Recent books include *International Education as Public Policy in Canada* (with Merli Tamtik and Roopa Desai Trilokekar, McGill-Queen's University Press, 2020) and *Professional Pathways: Academic Careers in a Global Perspective* (with Martin Finkelstein, Johns Hopkins University Press, 2019).

Grace Karram Stephenson is a post-doctoral fellow at the Ontario Institute for Studies in Education (OISE), University of Toronto. Grace manages a team of researchers from across Canada and coordinates the various projects undertaken by the Canadian APIKS team. She also teaches graduate courses in higher education and comparative higher education.

Amy Scott Metcalfe is a professor in the Department of Educational Studies at the University of British Columbia. Her research focuses on higher education in Canada and the North American region, including (post)critical and visual approaches to internationalization, academic labour and mobility, and critical policy studies in education.

Chapter 22
The Emerging Role of American Universities in the Twenty-First-Century Knowledge Society

Martin Finkelstein, Olga Bain, Gustavo Gregorutti, William K. Cummings, W. James Jacob, and Eunyoung Kim

Abstract The American system of innovation and new knowledge production can best be described as highly decentralized and multipolar; that is, prominent roles are played by business/industry, government, and universities. Most of American university R&D involvement is concentrated in a group of perhaps 200 leading research universities that undertake contract research for the federal government and have close relationships with business and industry. At the same time, higher education contributes to the R&D enterprise through the training of an increasingly sophisticated cadre of knowledge workers. The past two decades have seen a vast expansion of graduate education as well as professional doctorates. The emergence of the knowledge society in the United States context has also included a redefinition of higher education's service function with "new" curricular components, e.g., service learning, and a reemphasis of the faculty role in public service projects above and

M. Finkelstein (✉)
Higher Education Department, Seton Hall University, South Orange, NJ, USA
e-mail: martin.finkelstein@shu.edu

O. Bain
Independent Scholar, Waxhaw, NC, USA

G. Gregorutti
Andrews University, Berrien Springs, MI, USA
e-mail: ggregoru@andrews.edu

W. K. Cummings
George Washington University, Washington, DC, USA

W. J. Jacob
Asia Pacific Multi-Country General Manager at FamilySearch International, Salt Lake City, UT, USA

E. Kim
Korea University, Seoul, South Korea

Hankuk University of Foreign Studies, Seoul, South Korea

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beyond their teaching and research. At the same time, increased performance pressures to do more with less, including the transition to part-time and short-term faculty appointments, has led both to diminished career prospects for many academic staff and lower morale in a prevailing managerial university. This chapter represents these core trends impacting US higher education.

Keywords Decentralization · Innovation system · Knowledge production · Research and development · USA

Introduction

The Academic Profession in the Knowledge Society (APIKS) project took its inspiration from the recognition of the emergence of "knowledge" as the key driver of economic development, including human capital formation, and the key driver of social betterment and the increasingly central role of universities as the center of the knowledge industry in promoting economic growth and social development.

While business and industry have a dominant role in Research and Development (R&D) and innovation in the United States (US) (e.g., Apple, Google, Facebook), universities play key roles in at least three respects. First, they serve as a major contractor for scientific and defense-related research funded by the federal government. Second, professors contribute to staffing government and private research institutes and laboratories. Particularly, universities have been taking a leading role in the technology transfer process, establishing on-campus patent and technology transfer offices that span boundaries between their science labs and the design and production capabilities of industry. Third, universities, especially through their professional and graduate programs, train the human capital to staff the engines of research, development, and innovation (Clotfelter, 2010).

These strengthening linkages between universities, government, and the private sector in promoting research and scientific/technological innovation have however engaged a fraction of the entire US higher education system: the research university sector. This group of perhaps as many as 200 leading universities, while representing barely 10 percent of the 4-year sector, embody a disproportionate number of faculty who conduct funded research and a disproportionate share of national research and development (R&D) expenditures.[1] A much broader array of institutions of higher education are intimately linked with training the human capital through graduate and professional education, and more recently through online education, providing the human infrastructure to support the existing research and innovation system. Similarly, responsibility for the development and transfer of knowledge for social improvement has been more widely diffused throughout the institutional structure of American universities.

[1] That said, pressures to conduct research and disseminate it in the form of peer-reviewed publications has spread widely through the four-year, institutional sector of U.S. higher education, adding research and publication to the work repertoire of the vast majority of four-year faculty members.

In the course of American higher education's expansion and adaption to the imperatives of a knowledge economy and society, the American academic profession has undergone significant structural changes. Higher education has come to mirror the larger society's emergent "gig economy," with a decline in permanent employment, the increasing specialization, and atomization of academic work and career becoming less predictable and less secure (Finkelstein et al., 2016; Kezar et al., 2019).

This chapter is divided into four main parts. In the first, we describe the national research and innovation system in the United States and the role of a circumscribed group of elite research universities and their academic staff in that system. Second, we describe the growth of graduate and professional education across an increasingly broad spectrum of universities in the United States and the growing role of the academic profession in graduate and professional education. In the third part, we provide an overview of the distinctive "social service" role of universities in the American context. Finally, we provide an overview of the structural changes in the faculty roles and academic careers over the past quarter century.

The National Research, Development, and Innovation System

How Is It Organized?

Unlike many other countries, the United States has a highly decentralized research and innovation system without an overarching science and innovation policy, or education and/or science ministry, at the federal level (Shapira & Youtie, 2010). Rather, the federal government supports research and innovation through various internal agencies, each with its own jurisdiction and agendas. The federal government provides direct funding for government research facilities and supports higher education institutions (HEIs) and the private sector through grants, contracts for projects, and tax incentives.[2]

With regard to the structure of the federal US national science and technology system, both the US House of Representatives and Senate as the federal legislative branches have committees and subcommittees, which deal with science, technology, and innovation issues overseeing scientific research and development programs such as Committee on Commerce, Science, and Transportation in the US Senate and the Committee on Science, Space, and Technology in the US House of

[2] Historically, the birth of U.S. National Science Policy. The report "Science: The Endless Frontier" (Bush, 1945) represents the seminal thinking with regard to the importance of science as the engine of economic growth; emphasis was placed on the role of the federal government in building scientific capacity and ensuring national security and the establishment of scientific agencies to coordinate government interests, such as the National Science Foundation (NSF), to provide funding for basic research and to coordinate research activities of interest to the national welfare (https://www.nsf.gov/about/).

Representatives.[3] In the executive branch of the US government, the Office of Science and Technology Policy (OSTP) provides the US President with advice on technology, science research priorities, and mathematics and science education. Alongside the OSTP, the President's Council of Advisors on Science and Technology (PCAST) and the National Science and Technology Council (NSTC) within the executive branch are responsible for setting national goals for federal science and technology investments and R&D policies and coordinating science and technology policy across the federal government (Sargent Jr. & Shea, 2017). The vast majority of the federal government's research budget is allocated through six federal agencies: the Department of Defense, the Department of Health and Human Services, the Department of Energy, the Department of Agriculture, the National Aeronautics and Space Administration, and the National Science Foundation. Most of the funds these agencies control are directed toward research universities (National Science Board, 2018). In terms of channeling support for R&D, the federal government funds large-scale research projects involving coordination of many researchers and subcontractors, such as the space program, as well as more decentralized initiatives that involve small groups of researchers and individual researchers.

Beyond these government entities, several scholarly, nongovernmental bodies bring together experts in the areas of science, technology, and medicine to address critical national issues and provide "expert" advice to the federal government. The National Academies of Sciences, Engineering, and Medicine serve as the collective expert scientific body along with the National Research Council as the operating arm of the academies.[4] The US National Academies are charged with addressing scientific and technological matters as a nonprofit, nonpartisan institution. While they do not receive direct appropriations from the federal government, they provide leadership and expertise for numerous projects funded by various government agencies.

How Does It Work?

In 2015, the United States led the world in R&D spending at $495.1 billion (current dollars), accounting for a 26 percent share of the global total (National Science Foundation, 2018).[5] The US gross expenditure on R&D as a percentage of GDP was ranked 11th in the same year. Between 1996 and 2016, US R&D spending has exhibited a slowly rising trend, growing from 2.44 percent to 2.74 percent (Fig. 22.1). But a closer look at the data reveals that the R&D to GDP ratio fell from 2.64 percent in 2001 to 2.48 percent in 2004, peaking at 2.8 percent in 2008–2009—the year

[3] For more information, visit: https://www.congress.gov/committees.

[4] For more information, visit: http://www.nationalacademies.org.

[5] However, in recent years, spending on R&D has increased markedly in some emerging markets, most notably in China with $409 billion (21% of the global R&D total) in 2015 (NSB, 2018).

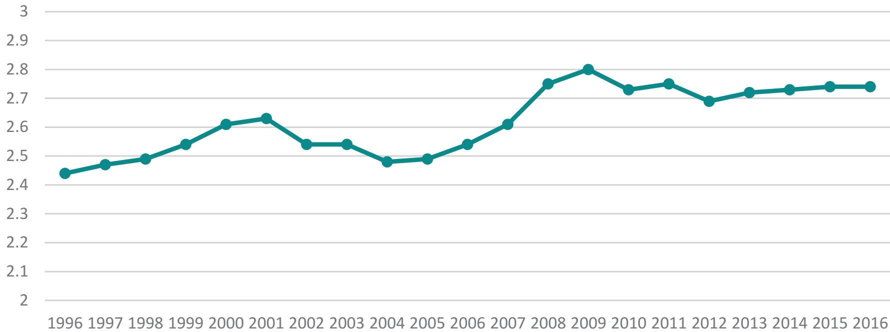

Fig. 22.1 US gross R&D expenditures as a percent of GDP, 1996–2016. (Source: National Science Board (2018) Science and Engineering Indicators 2018)

of the great global recession. Between 2013 and 2016, the R&D to GDP ratio remained stable at approximately 2.7 percent.

The business sector has driven R&D expenditure in the United States over the last two decades. More than 70 percent of total R&D ($326.5 billion) was attributable to the business sector in 2016, followed by the academic sector at $60.6 billion (National Science Board, 2018). The business sector and the federal government are the two primary sources of R&D funding; in 2016, the business sector contributed $308.1 billion (67% of total R&D), and the federal government provided $109.8 billion (24% of total R&D) (Fig. 22.2). However, the level of federal research funding has declined over the years, raising concerns about the sustainability of government support for basic R&D in a time of increasing globalization through a society driven by knowledge.[6] Indeed, the trend data in Fig. 22.2 show that while R&D expenditures by the business sector have accelerated after a brief dip in 2008–2009, those by the federal government and higher education have yet to recover from the 2008–2009 downturn.

The Nexus with Higher Education

Although total federal R&D spending for the academic sector grew from $18.4 billion in 1996 to $30.7 billion in 2016, the federal share of academic research has fallen over the past two decades; after a very slight rise initially, it later rose from 59.4 percent in 1996 to 59.7 percent in 2006 before dropping to 50.1 percent in 2016 (NSB, 2018). As the second-largest performing sector of US R&D, universities accounted for 13.2 percent of the national R&D expenditure ($60.6 billion). However, this funding is distributed unevenly in the extreme; more than 80 percent

[6] The federal government tends to support basic research, while business and industry tend to support more applied and commercially oriented research.

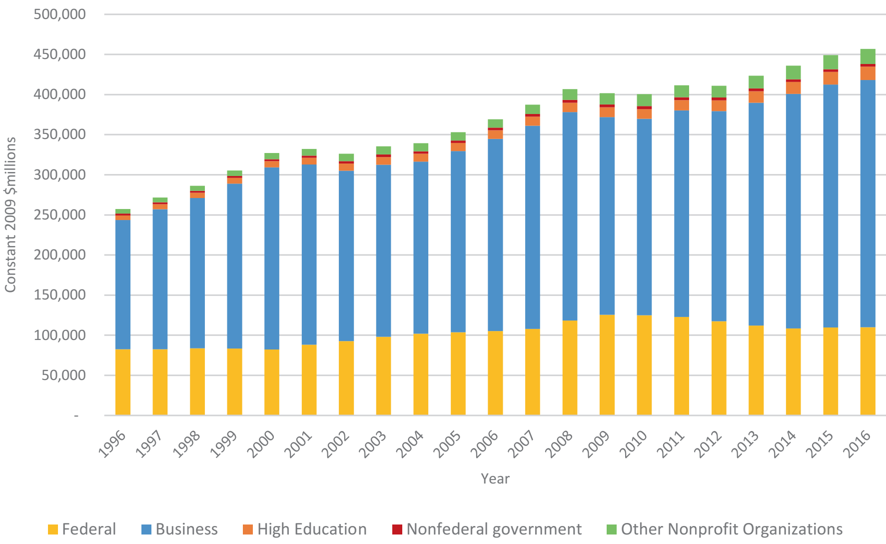

Fig. 22.2 US R&D expenditure by funding source, 1996–2016. (Sources: National Science Board (2018), Science and Engineering Indicators 2018)

of government funds are concentrated in only 100 research-intensive institutions, and these tend to be concentrated in around a dozen states (NSB, 2018).

HEIs have also become the sites of industrial and scientific "parks" aimed at serving as incubators for new product development and the launching of new industries, often with funding and collaboration of businesses that follow a triple helix model. Linking the local HEIs, government agencies, and industries, the triple helix model has enabled many institutions to expand their knowledge networks with their respective communities at several levels (Jacob et al., 2015; Etzkowitz & Leydesdorff, 2000), the permeability between the boundaries of academe, industry, and government being a key component of this model (Etzkowitz, 2012).

Douglass and King (2018) documented how knowledge-based economic areas (KBEAs) are central to economic hub regions within the United States, following this triple helix model. Perhaps chief among the KBEAs is in the greater San Francisco Bay area, and especially in Silicon Valley in California, "the linkages between industry and society—with universities at the center of these linkages—are well known, and governments from around the world have attempted to replicate the success model" (Jacob et al., 2015, p. 16). The unparalleled success of Silicon Valley is largely attributed to the triple helix model of academe and government partnerships that were forged in a series of growth spurts following World War II. Academic juggernauts, including the 10-campus University of California system and other renowned private research universities like Stanford University, have helped provide an unparalleled foundation for elite higher education graduates, industry internship opportunities, and R&D partnerships that have fueled innovation, industry, and the global economy. While some of the first successful business establishments in Silicon Valley date back to the early 1900s, it was also the geographic epicenter of the Internet industry in the 1990s and early 2000s, and many global STEM-oriented firms are headquartered or have branch offices there. Several notable success stories involved university student-led initiatives that have grown into household names worldwide, including Sun Microsystems, Yahoo!, and Google (Jacob et al., 2015).

Other triple helix metropolitan hubs in the United States include Boston, Los Angeles, New York City, Pittsburgh, Salt Lake City, the North Carolina Research Triangle, and Washington, DC. Many of the flagship universities in these KBEAs are Association of American Universities (AAU) and/or Association of Public and Land-grant Universities (APLU) member institutions, which are "…powerful drivers of the knowledge and innovation economy" (APLU and AAU, 2014, p. 37). Greater Boston heralds world-class universities such as Harvard and MIT, along with 47 other HEIs in the KBEA. Universities such as MIT have developed a variety of collaborative relationships with the United States and global corporations aimed at linking the research interests of their faculty and graduate students with the agendas of business corporations. In 2015, Rob Matheson estimated that MIT alumni had founded over 30,000 companies, which employed approximately 4.6 million people worldwide. He estimated that annual revenues from these companies amounted to approximately $1.9 trillion.

The greater NYC area is home to Wall Street, the headquarters of the United Nations, and several world-class universities. Students attending those institutions have unique opportunities to gain practical training in many global industries and multilateral organizations. NYC has taken the lead nationwide in implementing a tuition-free policy for students attending 2- and 4-year public HEIs like City University of New York and State University of New York systems. The policy will be phased in over a 3-year period where in 2019, students from families earning less than $125,000 per year will be able to attend one of the CUNY or SUNY system institutions (Gewertz, 2017). While these favorable government policies have helped buoy higher education access, other government initiatives have in some ways limited economic investment from at least some global IT firms. The most notable case is when Amazon selected the NYC KBEA as its second headquarter location, only to decide against this strategic move based on increased dissent from select state government leaders in early 2019 (Soper, 2019).

Pittsburgh's transformation from the buckle of the rust belt to an IT hub emphasizes how instrumental HEIs can be in leading change in the twenty-first-century knowledge industry. Flagship institutions like Carnegie Mellon University and the University of Pittsburgh have led the way in this transformation in areas of IT (e.g., robotics, software development, engineering, and cybersecurity) as well as service areas in health care. What was once a bustling, smoggy city built on the steel industry, Pittsburgh is now evidence that metropolitan KBEAs can reinvent themselves, with HEIs playing a lead role in this process.

Located in the heart of the Mountain West along the Wasatch Front, Silicon Slopes includes a robust IT industry. Major academic institutions with a heavy STEM focus include Brigham Young University, University of Utah, Utah Valley

University, and Weber State University (Christensen, 2016). Several of the leading IT and STEM service firms with headquarters and regional offices in this KBEA include Qualtrics, IM Flash, Franklin Covey, PluralSight, Vivint, and Adobe.

North Carolina Research Triangle Park (RTP) is the largest and the most prominent high-tech R&D park in the country. It is anchored by three leading universities—Duke University, North Carolina State University, and University of North Carolina at Chapel Hill—with forefront high-tech companies (e.g., IBM, Cisco Systems, NetApp, Oracle, SAS Institute, and others) as well as key life science and biotechnology companies (e.g., GlaxoSmithKline, Merck, Novo Nordisk, Pfizer, Bayer, Biogen, among others). It was created in 1959 as the US second university research park after Stanford through the collaboration of the three universities and the state and local governments to retain highly trained graduates and attract business through world-class innovation. The area's economy performed remarkably well. Research Triangle has been a focal point for countless attempts for emulation. It currently has 265 companies that employ 50,000 talented workers, and it has been dubbed "the smartest place on earth." The contribution of the RTP to economic, social, and environmental well-being is immense (Williams, 2018). The greater Washington, DC, KBEA offers local HEIs the unique opportunity to partner with federal agencies as well as industry. Among the many flagship HEIs within the region, George Washington University, Georgetown University, and Howard University are perhaps foremost within DC proper. A handful of other prominent universities are within a short distance as well, including Johns Hopkins University in Baltimore, MD, and the University of Virginia in Charlottesville, VA. Headquarters of many nongovernmental organizations, nonprofit organizations, faith-based organizations, and international bi-/multilateral organizations are located here, including the World Bank and International Monetary Fund.

Developing the Human Capital Infrastructure: The Growth and Dispersion of Graduate and Professional Education

The most pervasive link of higher education to the knowledge economy and society lies in its expanded and ever more specialized human capital training function. In 1958, 175 universities awarded nearly 9000 PhDs in the United States (Berelson, 1960). By 2016, more than 350 universities were awarding some 180,000 doctoral degrees; the vast majority are not traditional research PhDs, but what have come to be known as "professional" doctorates. These include not only the usual MDs, JDs, and DDSs but a whole array of new professional practice doctorates in the health professions and business. In the United States, professional practice doctoral programs (PPDs) have mushroomed from near zero in 2000 to roughly 650 programs in 2015. The majority of these doctoral programs are in health-related fields, but they span many of the traditional disciplines in some form (Blessinger & Stockley, 2016). Most of these PPDs do not require original research but do include clinical components and are intended to create leadership pathways toward nonacademic

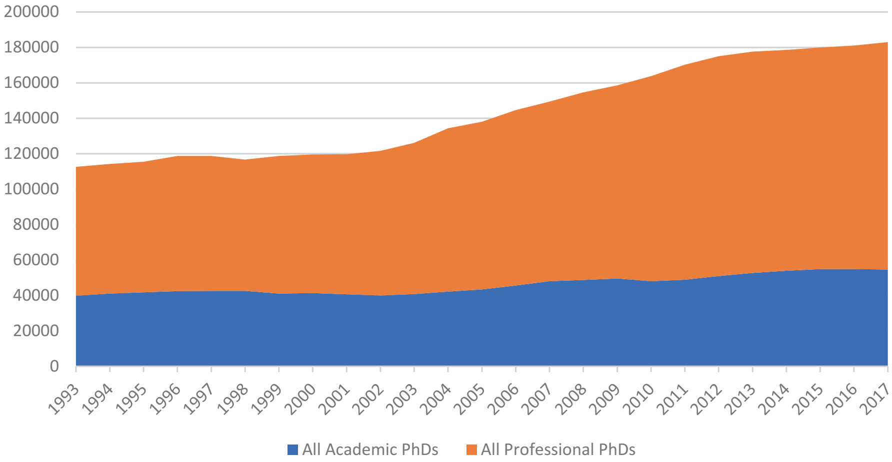

Fig. 22.3 Growth in US doctoral degrees awarded by degree type, 1993–2017. (Source: US Department for Education (2019))

careers in professional practice. While there is little agreement on what these doctoral degrees are, or what they should be, they now outnumber PhDs by a ratio of 3:1, as is shown in Fig. 22.3.

Beyond the ascent of the professional doctorate, the last quarter century has seen a doubling in the number of master's degrees awarded from just over 400,000 to nearly 800,000 (see Fig. 22.4). The vast majority of these master's degrees are in the professional fields, including business, public administration, nursing, and fine arts.

This vast expansion of graduate education has meant that unlike most other nations, the majority of academic staff in US colleges and universities are typically involved in graduate and professional education beyond the baccalaureate degree.

Service and Engagement with the Greater Society: A Unique American Tradition

Historical Origins of College Service and Engagement

From their origins during the eighteenth- and nineteenth-century colonial period, American colleges played a unique role in the life of their communities: Their chapels were often the center of community religious life, their boards of trustees often consisted of local clerics and government officials, their faculty served at the pulpit or on public commissions, and their presence became a public symbol that a community had achieved a certain "cultural" stature in the westward expansion (Thelin, 2004). It was however with the Land-Grant College Act of 1862, also known as the Morrill Act, that the federal government affirmed a role for a new species of

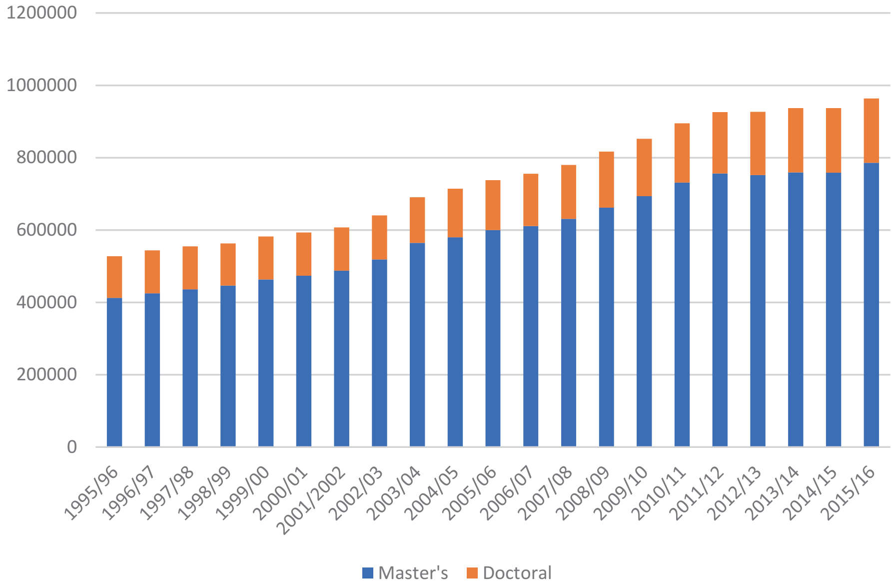

Fig. 22.4 Master's and doctoral degrees awarded, 1995–2015. (Source: US Department of Education (2019))

federally subsidized colleges and universities as centers of agricultural and industrial education. According to this act, federal lands were donated to states, and the funds from their sale were used to create schools of agriculture and mechanical arts, many of which became to be known as "A&M" colleges. These colleges developed agricultural, engineering, and business courses that served the needs of local development, workforce training, and technology transfer in the quintessential service extension programs. State agricultural experiment stations (SAES) and cooperative extension agents brought the fruits of teaching and research home to local farmers and consumers. Importantly, land-grant colleges and universities expanded access to higher education in every state and served as instruments of upward mobility for students from various socioeconomic backgrounds, effectively democratizing access to higher education in the United States (Lucas, 1996). Today, there are 106 land-grant institutions of higher education in the United States and its territories, most of which are members of the Association of Public and Land Grant Universities (APLU). Funded by state and national governments, many are now fully fledged universities and flagship public campuses, and yet they maintain their historical mandate of public engagement.

The philosophy of university outreach has been perhaps most fully embodied in *the Wisconsin idea* (McCarthy, 1912) that education should influence people's lives beyond the boundaries of the university campus. It is attributed to Charles Van Hise, the former president of the University of Wisconsin, a land-grant university, who stated in 1905 that he would "never be content until the beneficent influence of the University reaches every family of the state" (Van Hise, 1905). Under Van Hise's leadership, the University of Wisconsin became known nationally for supporting the policy design and development of state legislators, and American universities became linked to the reforms of the Progressive Era in the US government (the taming of the unfettered action of the captains of industry of the late nineteenth and early twentieth century, such as the Rockefellers, Vanderbilts, Carnegies, etc.). The university extension division pioneered summer courses, correspondence courses, and public lectures to bring adult education directly to state citizens.

The protests of the 1960s and early 1970s reignited the debate of the role of the American university, demanding that universities address social issues, in the context of political and cultural unrest (Baker, 2014). According to Ross (2002), student activism criticized the lack of involvement among professors and academia in general. This led to the creation of organizations such as ACTION in 1971, Peace Corps, Volunteers in Service to America, National Student Volunteer Program, and Campus Outreach Opportunity League, among others, that set the tone to reenvisioning higher education's missions (Ross, 2002, p. 6). During this time, the presidents of Brown, Stanford, and Georgetown Universities founded Campus Compact in 1985 and remains one of the most influential organizations to promote community engagement. This association of colleges and universities has an active and growing membership of affiliated institutions across the United States and Canada. Over the years, Campus Compact became one of the leading voices and hubs to facilitate community engagement providing a vast range of resources for institutions and faculty members. These initiatives were also coupled with supportive legislation and studies that provided the frame, along with funding, to explore and expand community engagement in its multiple dimensions. As Ross (2002) explained, "Just as the government helped craft the 'Cold War University' of decades past, it has also helped create the 'Engaged University'" (pp. 8–9). Setting up new federal and state sources of funding was one of the most effective ways to advance outreach projects and community research centers. Private support was soon added to contribute to the trend (Ross, 2002).

Lynton and Elman (1987) set the tone with their book *New Priorities for the University: Meeting the Society's Needs for Applied Knowledge and Competent Individuals*. As the title clearly expresses, they underscored that universities were the:

> prime source of intellectual development for society. But their task environment is changing drastically because more elements of society need to be able to use more forms of that knowledge on a continuous basis…universities need to change the ways in which they carry out their task. (Lynton & Elman, 1987, pp. 1–2)

They were voicing their disenchantment with the current higher education detachment saying that "universities, in their teaching as well as in their other professional activities, relate theory to practice, basic research to its applications, and the acquisition of knowledge to its use" (p. 3).

In his report "Scholarship Reconsidered," Ernest Boyer, a prominent educator and then president of the Carnegie Foundation for the Advancement of Teaching, called for a broadening of the definition of scholarship (1990) and, in effect, the role of the university and the academic profession in channeling scholarship to the larger social good. Boyer proposed to effectively flatten the hierarchy of faculty roles and broadened them into four domains: scholarship of *discovery* (traditional research), *integration* (scholarship of synthesis), *teaching and learning* (systematic study of teaching and learning processes), and *application*. The latter was later renamed into scholarship of *engagement* to capture the reciprocity of practical applications in the larger community (Boyer, 1990, 1996). Boyer's model of scholarship has been widely embraced throughout academia. Disciplinary and professional associations have developed guidelines for community engagement and service in their fields (O'Meara, 2010). Service learning as a progressive constructivist pedagogy has spread through college campuses, and the conceptualization of new knowledge production as public and collaborative has deepened the understanding of knowledge construction through community engagement. Improved teaching and learning, community-based research, connection to the community, fulfillment of campus civic mission, and the production of new knowledge are all cited as desirable outcomes in the model of service learning (Saltmarsh et al., 2009).

The Carnegie Foundation for the Advancement of Teaching launched a collection of best practices and cases in college community engagement through a self-application process. There are currently 361 institutions of higher education with elective Community Engagement Classification. The Carnegie Foundation defined community engagement very broadly, all-inclusively, and through multiple frames, including economic development, civic engagement, service learning, student engagement, and knowledge creation. According to the Carnegie Foundation, community engagement includes curricular engagement and outreach partnerships and is defined as "…the collaboration between the institutions of higher education and their larger communities (local, regional/state, national, global) for the mutually beneficial exchange of knowledge and resources in the context of partnership and reciprocity" (Campus Compact, 2019).

The 1999 Kellogg Commission report was another key national report that reaffirmed the growing paradigm shift in American higher education. It was a call to get back the Land-Grant spirit among American universities but with the purpose of going beyond service and outreach, redefining the university's relationship with communities through the concept of engagement: "'Community engagement' describes collaboration between institutions of higher education and their larger communities (local, regional/state, national, global) for the mutually beneficial exchange of knowledge and resources in a context of partnership and reciprocity" (Brown University Swearer Center for Public Service, 2020). The report envisioned those partnerships as "two-way streets defined by mutual respect among the partners for what each brings to the table" (Kellogg Commission, 1999, p. 9). This is to say a university that produces impact in tandem with society.

In a 2016 survey of the 1000+ member institutions of the Campus Compact, nearly two-thirds had developed a clear definition of community service related to their institutional mission, kept track of courses and faculty engaged in these initiatives, and had linked these activities to student learning outcomes related to societal betterment.

Community service has developed today into a multifaceted phenomenon that numerous HEIs and their faculty members are actively involved in. Most American universities explicitly recognize contributions to social betterment—particularly concerning their local communities—and engage both substantial contingents of their students and faculty in these activities. They have become an essential and distinctive component of the US higher education landscape.

The Growth and Reconfiguration of the American Academic Profession

The Changing Institutional Landscape

The emergence of the knowledge economy and society has greatly expanded the demand for access to postsecondary training for both the traditional cohort of 18- to 24-year-olds as well as the nontraditional "adult" student. That has meant accelerated pressure on institutions to expand enrollment and on the academic staff to work harder: More students must be accommodated. Table 22.1 shows the institutional landscape for degree-granting institutions in the United States in 2018.

Perhaps most strikingly, the table shows the relatively small size of the university sector: only 319, or not quite one-sixth of the 4-year sector, and less than 10 percent of the entire degree-granting postsecondary enterprise. Beyond the 319 research and doctoral universities (two-thirds public; one-third private, not-for-profit), just under two-fifths (38.1%) of the remaining 3715 institutions are 2-year, associate degree-granting institutions, and the remainder are about evenly divided between masters and freestanding, baccalaureate-granting institutions, the latter of which are disproportionately (two-thirds) private, not-for-profit. While public institutions barely outnumber private institutions, enrollment in the public sector, primarily in research and doctoral universities, outpaces the private sector by 3:1.

While private nonprofits account numerically for a large segment of the institutional universe, they enroll a proportionately small percentage of students (they include among the academically strongest and weakest of academic institutions). While public research universities constitute only a small proportion of the institutional universe, they account for 40–45 percent of all academic staff and especially full-time academic staff.

A Changing Workforce Profile

Two major demographic shifts in the composition or profile of academic staff are discernable over the past two to three decades. First has been the infusion of women and foreign-born faculty. In 1980, women accounted for 26.3 percent of academic

Table 22.1 Number of degree-granting institutions,[a] enrollment by institutional type and control, fall 2018 (US Department of Education, 2019)

Type of institution	Number of institutions	Enrollment
Overall total	**4034**	**19,645,918**
Public	**1634**	**14,529,264**
Private	**2400**	**5,116,654**
Research and doctoral		
Public	193	4,870,524
Private	126	1,427,060
Total	319	6,297,584
Master's		
Public	271	2,505,556
Private	456	1,880,118
Total	727	4,385,674
Baccalaureate		
Public	249	1,512,103
Private	561	750,755
Total	810	2,262,858
Special focus		
Public	54	94,377
Private	788	560,056
Total	842	654,433
2-year		
Public	867	5,546,704
Private	469	198,504
Total	1336	5,745,208

[a]Degree-granting institutions grant associate's or higher degrees and participate in Title IV federal financial aid programs by field. Further information on the research index ranking may be obtained from http://carnegieclassifications.iu.edu/

staff; by 2017, that had increased to nearly 40 percent. In some fields in the humanities and social sciences, women are now the majority of academic staff. Over that same period, the number of foreign-born faculty has nearly doubled to about one-fifth of academic staff. In the natural sciences and engineering, those numbers double. Current data on PhD production suggests that these trends will likely continue, provided there are no drastic changes in immigration or social/parental work policies.

The single biggest shift in academic staffing has however been in the rise of contingent and short-term appointments—a veritable revolution in academic appointments. Historically, academic staff in the United States have been responsible for integrating the teaching, research, and service functions into a single "unified" role based on the Von Humboldt model, leavened by a dose of American "utility" (service). They entered an academic career in a probationary status and, after a designated period, usually about 6 years, were subject to a single high-stakes evaluation.

Those that survive that evaluation—actually, the vast majority, some 70 percent[7] at all but the most elite institutions—are granted "tenure," a continuous appointment subject to dismissal for cause, with dismissal wrapped in an onerous procedure requiring due process and peer review. Over the past two decades, there has been a substantial reduction in the percentage of such traditional or career ladder appointments and an explosion in the appointment of part-time academic staff (who may teach only one to two courses) and full-time academic staff on term contracts who can be more easily non-renewed. Such reductions have coincided with the end of mandatory retirement for academic staff in the United States, making retirement no longer an institutional decision but an entirely individual one.

Figure 22.5 shows the growth of part-time appointments from just over one-third of the total head count academic staff in 1993 to nearly half of all head count academic staff in 2017, as well as the concomitant decline of full-time appointments from nearly two-thirds of head count faculty in 1993 to just over half in 2017. Not only has the proportion of full-time faculty shrunk, but among full-time faculty, the proportion who are eligible for tenure has contracted from nearly 90 percent to just over 60 percent, with the remainder now on fixed-term contracts. Moreover, that trend has accelerated among most recent entrants to academe; more than half of all new, full-time hires for the past two decades have been in nontenure, eligible, fixed-term positions.

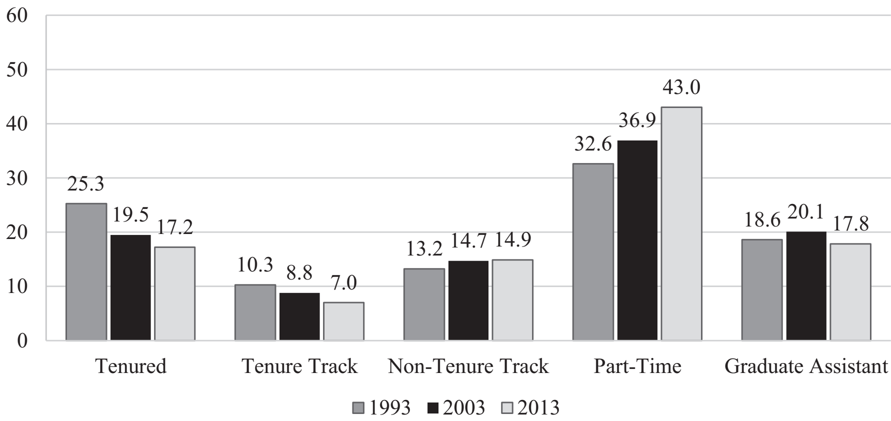

Fig. 22.5 Percent distribution of faculty by appointment type, 1993–2013. (Source: Derived from tabulation by AAUP Research Office, based on data from IPEDS. Released April 2013. Finkelstein, Conley, and Schuster (2016, p. 59). Note: Figures are for degree-granting institutions only, but the precise category of institutions included has changed over time. Graduate assistants include teaching and research assistants

[7] Overall, the limited available data suggests that about three quarters of the academic staff that apply for tenure are successful in attaining it—perhaps only one half, at the 200 or so research-intensive universities (and 1/10 at the handful of most elite institutions). This excludes, of course, those who leave their jobs or academe before the year of their tenure eligibility.

The proportionate increase of both part-timers and fixed-contract full-timers is visible across the institutional landscape—although slightly more prevalent in the private than the public sector—but manifests itself unevenly across academic fields, with the highest proportion of contingents among the humanities and social sciences and some of the professions (business, health sciences). What is most significant about this development is that part-time and fixed-term full-timers tend to play much more specialized academic roles: teaching only, research only, or program administration only. In effect, they have become a "secondary" labor market in American higher education (Finkelstein et al., 2016).

While increasingly stratified by appointment status, American academic staff continue a trend begun post World War II of increasing stratification by academic field. In those fields in which universities compete with business and industry for scientific talent, compensation is highly competitive and market driven; however, in the fields in which universities are the sole or primary employer of doctoral recipients, salaries are much lower (Finkelstein et al., 2016). The fact that American colleges and universities compete with business, industry, and government for the services of the ablest doctoral recipients in those fields with the greatest economic value outside the academy means that the "market value" of one's discipline or subdisciplinary specialization has an important shaping effect on the number of job opportunities available, their compensation, and the likelihood of landing a tenure-track position and achieving promotion through the faculty ranks. Medicine, business, law, engineering, the physical and biological sciences, and economics boast the highest market values, while the humanities and fine arts have the lowest (Bichsel, 2016).

Discussion and Conclusions/Implications

What then can we say about the role that American higher education plays in the knowledge economy and the broader knowledge society? The above analysis suggests first that with respect to the national R&D effort as it supports economic growth, American higher education plays a secondary role to American business, at least in dollars expended if not in intellectual leadership. Indeed, it is a relatively narrow group of perhaps 200 leading research institutions organized in a system of geographic hubs that undertake much of the contract research for the US federal government and much of the collaborative research with the business sector. For most of the rest of American higher education, the primary contribution to the knowledge economy and broader knowledge society comes from the human capital training function. That is reflected in the tremendous growth in the volume of graduate and professional education and the increasingly wide swath of institutions that are contributing to that arena. Perhaps what is most distinctive about the contribution of a broad array of HEIs to the knowledge society is in the area of community service. Dating from the Morrill Land-Grant Act of 1862, American universities have been asked to play a central role in the economic and social development (and overall well-being) of their surrounding geographic communities. Most recently, this has been reflected in the founding of the Campus Compact and the service-learning movement.

What has this emergent role in the knowledge economy and the knowledge society meant for the academic staff of universities? Indeed, in light of the fiscal constraints associated with the great recession of 2008 and its aftermath, that has meant increased pressure on the traditional model of academic staff appointments in the United States—findings ways to do more with the same number or fewer of higher educations' production workers. Over the past two decades years, there has been a substantial reduction in the percentage of such traditional or career ladder appointments and an explosion in the appointment of part-time academic staff (who may teach only one to two courses) and full-time academic staff on term contracts who can be more easily non-renewed.

In many ways, the boundaries between higher education, government, and industry are becoming increasingly blurred. A subset of the university sector is increasingly interacting with government agencies and industry on a project basis with various models of university-industry partnerships illustrated by leading institutions such as MIT, Caltech, and Carnegie Mellon universities, and faculty at these institutions are increasingly moving across these boundaries while maintaining a principal employer. Most of the higher education enterprise, however, is focusing on human capital formation with the tremendous growth of graduate and professional education—an increasingly online enterprise in this age of COVID. The institutional stratification within the higher education system is mirrored by increasing internal stratification within the higher education institutions along disciplinary lines: the value-added vs. non-value-added fields. So the portrait emerging is one of increasing differentiation and stratification amid an increasingly frayed career fabric.

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Martin Finkelstein is Professor of higher education at Seton Hall University, South Orange, New Jersey, USA. He is the author of *The American Academic Profession* (Ohio State, 1988) and co-author of The *New Academic Generation*, *The American Faculty*, Scholars in the Changing American Academy (Springer, 2011) and *The Faculty Factor*. He is co-editor of *The Internationalization of the Academic Profession* (Springer, 2013), and *Professorial Pathways: Academic Careers in a Global Perspective*.

Olga Bain, Ph.D. is an independent consultant and scholar, formerly at the Graduate School of Education and Human Development at the George Washington University, Washington, DC. Her research focuses on change in higher education as influenced by global, institutional, faculty, and student agencies. She has published on internationalization and globalization of higher education, faculty productivity, and women's advancement in academia, higher education financing, and institutional strategies of change. Olga has authored the book titled *University Autonomy in the Russian Federation Since Perestroika* (2003, Routledge Falmer).

Gustavo Gregorutti is a professor in the School of Education at Andrews University in Michigan. Prior to this appointment, he has been a visiting professor in several Latin American universities teaching and carrying out various research projects. Dr. Gregorutti also conducted research at the Humboldt University Center for Higher Education in Berlin, Germany. He has published on faculty research productivity and organizational commitment to create knowledge, mainly among private universities, at national and international levels. He is presently involved with several international teams to advance comparative research and emerging trends that promote a well-rounded person in universities.

William K. Cummings is Professor Emeritus of international education at the George Washington University, Washington, DC. He received his Ph.D. in sociology from Harvard University in 1972. Since then, he has taught at the University of Chicago, the National University of Singapore, Harvard University, and the State University of New York at Buffalo. He is the author of *Education and Equality in Japan* (Princeton University Press, 1980), *Profiting from Education* (Institute of International Education, 1990) (with Gail Chambers), *The Japanese Academic Marketplace and University Reform* (Garland Publishing, Inc., 1990), and *The Institutions of Education* (Symposium Books, 2003). He coedited *Scholars in the Changing American Academy* (with M. Finklestein, Springer) and *Crossing Borders in East Asian Higher Education* (with G. Postiglione and D. Chapman).

W. James Jacob is currently Asia Pacific Multi-Country General Manager at FamilySearch International. Prior to this, he held several senior higher education leadership positions, including as Vice President of Innovation and International at Collaborative Brain Trust and as a leadership faculty member and Director of the Institute for International Studies in Education at the University of Pittsburgh. He is a results-oriented senior manager and researcher specializing in strategic planning, quality assurance, professional development, community engagement, and change

management. He is the co-editor of the *International and Development Education* book series with Palgrave Macmillan and has written extensively on comparative, international, and development education topics with an emphasis on higher education leadership.

Eunyoung Kim is a former associate professor in the Department of Education Leadership, Management and Policy at Seton Hall University. She is currently working as a lecturer at Korea University and Hankuk University of Foreign Studies, in Seoul, Korea. Her scholarship focuses on the transition experiences of students within organizational and institutional environments and socio-cultural contexts. This focus is applied to three interrelated topics of research work: (a) college access and success for underserved student populations, (b) equity issues within the US and global context, and (c) international education and development. She holds an MA and a PhD from the University of Illinois at Urbana-Champaign.

Part III
Conclusion

Chapter 23
Comparing Systems of Research and Innovation: Shifting Contexts for Higher Education and the Academic Profession

Jisun Jung, Glen A. Jones, Martin Finkelstein, and Timo Aarrevaara

Abstract This chapter begins by revisiting the knowledge society and knowledge economy concepts introduced in the first section of this volume and outlines the key findings of case studies from a comparative perspective. The findings are presented in terms of the scale of research and innovation systems and coordination between stakeholders, including government and the business sector. We emphasize the role of higher education in a changing social and economic context and its implications for the academic profession and doctoral education. By identifying a list of similarities and differences across systems, we highlight that the academic profession should be understood in the context of shifting research and development policies from a long-term perspective. We also raise the questions of how nations can create a sustainable system of research innovation and foster collaboration between sectors and how the academic profession should respond and contribute to sustainable research and innovation systems.

Keywords Knowledge society · Knowledge economy · Research and innovation · Academic profession · Doctoral education

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J. Jung (✉)
Faculty of Education, The University of Hong Kong, Hong Kong SAR, China
e-mail: jisun@hku.hk

G. A. Jones
OISE, University of Toronto, Toronto, ON, Canada
e-mail: glen.jones@utoronto.ca

M. Finkelstein
Seton Hall University, South Orange, NJ, USA
e-mail: Martin.Finkelstein@shu.edu

T. Aarrevaara
Faculty of Social Sciences, University of Lapland, Rovaniemi, Finland
e-mail: Timo.Aarrevaara@ulapland.fi

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Introduction

Knowledge has become a crucial driver of economic and social development since the industrial revolution. The accumulation and application of knowledge are now major factors in economic development and at the core of national competitive advantages (World Bank, 2002). Over the long term, research and technological development provide social gains by helping create societies that are more cohesive and engaged (Välimaa & Hoffman, 2008).

Research and innovation involve increasingly complex collaboration between and among universities, governments, and business organizations (Carayannis et al., 2016). Universities play a crucial role in research, development, and innovation (RDI) systems for creating, disseminating, and applying knowledge and building professional capacity for the workforce. They produce basic and applied research and contribute to mobilizing scientific ideas globally (Horta & Mok, 2020). Governments have a responsibility to encourage industry and higher education and to be more innovative and responsive to the needs of a globally competitive knowledge economy and changing labor market requirements (World Bank, 2002). The business sector is involved in producing new knowledge and creating value-added industries. University-industry collaboration has been increasingly promoted in recent years (Farinha et al., 2015). These roles are commonly emphasized globally today, although concrete policy strategies vary according to the social and economic conditions of different countries. Analyzing the relationship between knowledge and innovation systems and higher education is particularly important as we enter what has been called the knowledge society and a knowledge economy (Burke, 2012).

This volume was divided into three parts: a conceptual overview, case studies of systems of RDI, and this concluding chapter. The conceptual overview illuminated key concepts of and existing research on both the knowledge society and the knowledge economy. Contributors to the comparative case studies section analyzed 18 higher education systems focusing on 3 main questions: How do different systems interpret and apply the knowledge society and knowledge economy concepts in their higher education systems and the academic profession? What are the major differences between RDI systems, and what creates such differences? What are the changing contexts of the academic profession and doctoral education?

The authors applied historical, empirical, and comparative perspectives. Each case study adopted a historical approach to describe the relationship of higher education and the academic profession to the research and innovation system. These studies made ample use of empirical data to describe the enhanced role of knowledge in contemporary societies and how RDI systems and higher education have evolved. As more and more case studies were collected, the authors were able to make a series of useful comparisons—geographical, sociological, and historical. This comparative perspective provided a useful framework for observing similarities and differences to compare systems in terms of governmental coordination, business sector engagement, and the changing role of the university. The findings also revealed the implications of how global and national challenges are reflected in the academic profession and doctoral education in each system.

This conclusion begins by revisiting the knowledge society and knowledge economy concepts before outlining the key findings of case studies from a comparative perspective. The findings are presented in terms of the scale of research and innovation systems and coordination between stakeholders, including government and the business sector, emphasizing the role of higher education in a changing context and its implications for the academic profession and doctoral education.

(Re-)visiting Concepts: The Knowledge Society, Knowledge Economy, and Higher Education

The knowledge society and knowledge economy concepts were highlighted in this volume as an analytical framework. Two conceptual overview chapters described how these concepts have been philosophically constructed, historically evolved, and globally implemented in policy.

As Teresa Carvalho (Chap. 2) and Olga Bain and William Cummings (Chap. 3) described, the knowledge society and knowledge economy concepts can be traced back to the definition of knowledge as a *social fact* (Durkheim, 1982) or a *normative structure of science* (i.e., universalism, communism, disinterestedness, and organized skepticism) (Merton, 1942). In more recent years, new paradigms for the knowledge discourse, such as interdisciplinary and applied knowledge (i.e., *Mode 2*, Gibbons et al., 1994) or as *relevance of economic rationality* (Ziman, 1994), were introduced. When considering technological advancements and economic growth, it is not surprising that the main discourse of knowledge emphasizes resources in the production of social and economic transformation (Drucker, 1986). As the case studies in this volume demonstrated, developing a knowledge society was a common objective, from the global level to each jurisdiction. The term "knowledge society" was widely used in policy rhetoric in many international organizations and government policy documents. Accordingly, tools for the measurement of the knowledge economy and research production have been widely developed and adopted in society and higher education. These changes were accelerated by shifts in the economic environment, such as the implementation of neoliberal policies across sectors.

The economic perspective of knowledge creation and its dissemination was particularly emphasized. The structure of research and development (R&D) was measured largely by input-output indicators in economic terms, though this may also be a reflection of the influence of international agencies, such as the OECD, on the standardization of national reporting and data collection systems. Most of the systems in this volume highlighted the correlation between economic scale and investment in R&D, between R&D investment and research outputs, and R&D scale compared to higher education enrolment. The meaning of socially useful knowledge was often equated with applied knowledge for new products and services, industrial collaboration, entrepreneurship, and commercialized knowledge, such as patents or technology transfer.

In higher education, more tangible inputs and outputs were emphasized. Output measures such as the number of higher education degree holders became important for comparing national competitiveness. In academia, it was interesting to observe the success of the booming bibliometrics industry seen on sites like Clarivate Analytics and Scopus. In the knowledge economy, the scholarly profession was often described as a *knowledge workforce* or a *qualified human resource*. The per capita number of doctoral degree holders was a typical factor for assessing the maturity of a given knowledge economy.

Despite this common emphasis on the knowledge economy, each system had a unique response when crafting and implementing public policies. This volume emphasized that consideration of social context is essential to understand the way in which knowledge is produced, disseminated, and advanced. For example, how each government established public polices for research and innovation, how these policies interacted with the country's economic and industrial structure, and how the system defined the role of the higher education sector and the academic profession were based entirely on the country's social and economic conditions. Public policies in certain countries have prioritized particular areas of knowledge for economic growth, while others have heavily focused on society's well-being as a whole. These differences explain the varied operation of RDI systems and the roles and different approaches to coordination among stakeholders.

By reviewing the shifted emphasis of the knowledge society and knowledge economy concepts and comparing national systems, this volume shared emerging issues for current input-output-oriented approaches in higher education and the academic profession. Beyond quantifying the input-output measures in the knowledge economy, what public engagement and service roles would it play in the higher education sector for society? How would we deconstruct the role of the academic profession in the new order?

Comparing Research, Development, and Innovation Systems

Many studies have examined knowledge production systems and their social and economic impacts in different contexts. For example, scholars have explored how R&D policies affected higher education institutions and what determinants are most important in increasing individual research productivity. This volume aimed to cover both macro- and micro-level issues of RDI policies and how they matter for the academic profession in terms of career prospects and scholarly activities.

Based on the 18 case studies, this volume reveals that most nations and regions today are confronting common global challenges. For example, the expansion of higher education, active engagement of the private sector, and diversification of institutions and programs were common experiences across systems. Although higher education in general has enjoyed remarkable growth on a global scale in recent decades, concerns over quality have become more prominent in the last few years, especially in developing countries. It was also common to find financial constraints in the higher education sector due to economic crises and cuts to public funding. Internationalization and global competition have become the norm in the higher education sector, and most systems have responded to these challenges by decentralizing the system and requiring more institutional accountability. Performance-oriented approaches and managerialism were common in assessing the scholarly profession at the individual level. Today, most systems seek to achieve goals like excellence in research, global competitiveness, and research collaboration.

Recognizing the common challenges noted above, we focus in this synthesis chapter on key differences between the RDI systems of 18 higher education systems on 5 continents and illuminate the contextual factors that are associated with systemic differences.

History: Path Independence Versus Path Dependence

Today, most jurisdictions emphasize the development of research and innovation systems to shape and serve the knowledge economy; however, the paths taken to reach this point reveal the systems' different histories and contemporary positions. Some jurisdictions launched national innovation systems and policy strategies beginning in the early twentieth century, while others only adopted a systematic approach in the late 1990s. Key historical incidents provided critical transition times for science policy in certain European countries. For example, during and after World War II, governments like Sweden and Portugal established national agencies to focus on science policy and R&D policies to prepare for global tensions that might arise. The fall of the Soviet Union led to dramatic higher education reforms in countries within Central and Eastern Europe and the gradual development of new national research and innovation strategies.

The pioneering systems were primarily located in North America (the USA and Canada) and Western Europe (Germany, the UK, France) and have shaped independent research and innovation systems since the early twentieth century; they became the reference group for many other countries. On the other hand, some countries lacked the resources and infrastructure to build a vigorous scientific system; some are still dependent on advanced systems. Particularly in countries with a colonial experience, the R&D and higher education systems tend to be a colonial legacy, follow the former colonizer's system, and downplay or even ignore any domestic postgraduate education system.

Notably, some systems focused on R&D to similar degrees historically, but a gap has opened in recent years in terms of research outputs and economic growth. This gap is largely attributable to political and economic conditions, as detailed in the following sections.

Government as a Coordinator: Centralized Versus Decentralized

Throughout the chapters in this book, the essential questions for RDI systems were how large the volume of research was, where the research volume was located in different societies, and who played the main role in funding and coordinating efforts. Obviously, the political environment is important in seeking to understand such differences. Supranational political structures have had a major impact for some countries; the European Union (EU) has significant influence on research and innovation policies on that continent. When the EU established the European Research Area (ERA) with the aim of accomplishing European integration in research areas, most European countries followed the EU's policy direction and launched national reforms to align with regional polices. For example, EU research funding support has played a key role in the development of initiatives in Lithuania and Estonia. On the other hand, in many other countries, the power of international organizations was symbolic rather than substantive. In Asia, regional bodies like the Association of Southeast Asian Nations (ASEAN) have almost no effect except in a few developing countries; instead, each national government plays the key role in most decision-making that concerns R&D policies. The Consortium for North American Higher Education Collaboration (CONAHEC) has had no direct influence on national research policies; instead, it functions as a supporting agency for the coordination of collaborative or exchange programs.

A shared role between national/federal, on the one hand, and provincial or state governments, on the other, was also found in countries like Canada, the USA, Germany, and even China; however, it was not common in the other cases studied. In most systems, the central government has the power to coordinate R&D policies, although there were clear differences in the breadth and strength of the various governments. In some systems, the government coordinated all research and innovation policies, but the government in other systems plays only a minimal role in providing a legal-regulatory framework, maintaining a highly decentralized structure, and relying on market principles.

The role and authority of government and its position in the market were fundamentally different across systems. The difference between an authoritarian regime and a liberal one is obvious. In countries that had experienced sudden regime shifts like a dictatorship in their political history (e.g., Argentina and Portugal), the main actor in research policy changed with political shifts. During periods of dictatorship, research was mostly carried out in government institutes and departments rather than in universities, a pattern that remains true to some extent. Countries with a transition from a planned to a market economy such as Russia and China also revealed a distinctive structure in financing their R&D policies and allocating resources. For example, the Russian government finances the largest proportion of research and development, with only one-third of funding coming from industry. Although the contributions from industry in funding research and development in China have been increasing in recent years, the central coordinating role of government continues to be strong in the resource allocation process.

It was common to find a central government agency (usually independent from the political side of government) that focused on R&D policies (i.e., National Science Foundation in the USA, National Research Council in Canada); most jurisdictions have experienced the expansion of these agencies. In many systems, the government merged research agencies for efficient and coherent policy implementation and encouraged collaboration with other government agencies. Many have been reinforcing and strengthening their roles and resources, which demonstrates the importance of coordination at the national level. These agencies play a primary role in setting up legal frameworks and regulations, undertaking strategic planning, allocating resources, evaluating institutional performance, and even determining national research agendas.

The government entities in this volume commonly have strategic plans for R&D and ensuring its competitive position in the knowledge economy. However, they take different approaches to defining their roles by either making direct investments or inclining a laissez-faire approach. This sometimes leads to variations in funding allocations, such as providing block grants to institutions or requiring them to compete with one another for resources.

In some countries, the government plays a much more active role in determining the nation's research agenda and directing resources to support it. Prominent examples include Estonia's efforts at building a digital government, Japan's focus on robot studies, South Korea's emphasis on energy and artificial intelligence, and Turkey's Technology Development Zones.

The Business Sector as a "Driver" or Collaborator: Highly Engaged, Partly Engaged, or Scarcely Engaged

The comparative analysis showed that the economic structure of each system makes a significant difference in the scale of R&D investment. The basic comparison was conducted on the financial investment in research and innovation. As Table 23.1 clearly shows, this scale differed dramatically across systems, with large-scale investments in countries like China, Russia, and the USA and very small levels of investment in, for example, post-Soviet republics. They were mostly measured by national investment in R&D and R&D expenditures as a percentage of gross domestic product (GDP). In some cases, R&D investment was close to 3 percent of GDP and either steady or rising, but in several others, R&D investment has remained below 1%. Naturally, the global hierarchical structure has been influenced by the scale of investment in economically advanced and leading systems versus emerging systems that are still catching up, versus under-invested and less developed systems.

The major funding source for RDI was also different. While government is the major funding source in most systems (see the US and Taiwan examples), its proportional influence varied. In countries like Lithuania and Estonia, funding sources were balanced across sectors. In some other systems, such as Finland and Germany,

Table 23.1 Gross domestic expenditure on research and development (GERD) by jurisdiction in 2018

Jurisdiction	GERD as a % of GDP	Source of funds	
		% of GERD from government sources	% of GERD from business sources
Argentina	0.54	72.6	16.5
Canada	1.57	32.9	41.1
Chile	0.36	47.0	31.4
China	2.19	20.2	76.6
Estonia	1.43	40.2	43.6
Finland	2.77	29.0	58.0
Germany	3.02	27.7	66.2
Japan	3.26	14.6	79.0
Lithuania	0.94	36.4	35.4
Mexico	0.31	76.8	18.6
Portugal	1.37	41.0	46.5
South Korea	4.81	20.5	76.6
Russia	0.99	67.0	29.5
Sweden	3.34	25.0	60.8
Taiwan	3.30	20.0	79.0
Turkey	0.96	33.6	49.4
Uganda	0.17	37.9	3.40
United States	2.84	23.0	62.4

Source: Taiwan data from Taiwan (2020). Data for all other jurisdictions from UNESCO Institute for Statistics (2020). Data are for 2018 or last available year

the business sector accounts for more than 50% of the total investment; in Russia, meanwhile, the government finances most R&D spending, with only one-third of funding coming from the business sector.

The role of the business sector in the research and innovation process varies with local economic conditions. As Table 23.2 illustrates, in East Asian jurisdictions, the USA, and some European countries, business and industry are more prominent, whereas the former Soviet republics and Latin America are heavily state dominated. National differences in the nature of the business sector in terms of the roles played by large multinationals, large national firms, and small- and medium-sized enterprises (SMEs) were also revealed. In some countries, such as South Korea, the largest firms lead innovation; in others like Estonia, it is micro-enterprises and SMEs who are driving innovation. Portugal is among the countries in which the government offers tax incentives for the private sector to participate in R&D.

Table 23.2 Percentage of gross domestic expenditure on research and development (GERD) performed by sector in 2018

	Sector of performance		
Jurisdiction	Business	Higher education	Government
Argentina	24.97	25.95	48.16
Canada	51.36	41.73	7.03
Chile	34.24	45.83	13.11
China	77.42	7.41	15.18
Estonia	42.35	44.54	11.43
Finland	65.66	25.22	8.31
Germany	68.82	17.72	13.46
Japan	79.42	11.56	7.75
Lithuania	36.81	35.93	22.24
Mexico	22.11	50.56	26.19
Portugal	50.76	41.95	5.67
Rep of Korea	80.29	8.22	10.09
Russia	55.59	9.68	34.43
Sweden	70.88	25.38	3.63
Taiwan	79.00	9.00	12.00
Turkey	56.88	33.55	9.57
Uganda	4.34	45.99	47.09
United States	72.58	12.85	10.36

Source: Taiwan data from Taiwan (2020). Data for all other jurisdictions from UNESCO Institute for Statistics (2020). Data are for 2018 or last available year

Higher Education Institutions: Leading Versus Secondary Role (Central Versus Peripheral Role)

The role of higher education in national research and innovation systems was a particular focus in this volume. An expansion in enrollment was a common experience across higher education systems in the last couple of decades, although differences in system size and participation rates were identified between jurisdictions. The essential question in this volume was to identify the new structures and organizational forms established in higher education to promote a competitive position in the knowledge economy. Each chapter answered this question differently based on the distinctive higher education context under examination. In particular, the centrality of higher education institutions as drivers of R&D and innovation systems are different; in some, the higher education sectors took leading roles as central actors, while in others these sectors were far more peripheral. For example, especially in Latin America, Russia, and the former Soviet republics, higher education institutions are largely peripheral to R&D efforts; in other places such as Canada, higher education institutions are central, although the degree to which they share the spotlight with the business sector differed from country to country. Indeed, the reason why higher education plays such an important role in RDI in some countries is the more limited role of the business sector.

This phenomenon is partly related to the traditional mission of higher education institutions and their structural divisions. For example, in many European models, the missions of public research institutes (state laboratories) and universities were historically separate. In those systems, including France, the former Soviet Union, and most Latin American systems, universities have generally focused on teaching and preparing qualified personnel rather than on knowledge creation. Since the 1990s, most governments have launched policy reforms with an emphasis on the knowledge economy, so research has become a core mission for many institutions. Most higher education systems have implemented strategies to emphasize the research function and improve the scale and global position of their institutions by combining faculties, merging with universities with medical schools, and integrating colleges of applied studies into the mainstream of higher education. In addition, the higher education structure differed historically between unitary and binary systems. In binary systems, the university sector focused considerable attention on pure research, while non-university institutions—mostly applied sciences schools and polytechnics—focused more on applied research.

In some cases, the research mission focuses primarily on elite universities by strengthening vertical stratification in the higher education sector (i.e., China, Russia, the USA), while other systems have emphasized institutional and horizontal variety by diversifying institutional types (i.e., Germany, Canada). Despite these different approaches, the university sector is most deeply involved in research output, and most universities globally have started closely following research output based on Scimago rankings, indexed journal rankings, and patents.

The Academic Profession and Doctoral Education

The Academic Profession in the Knowledge-Based Society (APIKS) project that plays a central role in this book series was established to examine the scholarly profession and career prospects in the knowledge society across higher education systems; this volume aimed to provide the background necessary for examining the structure of the knowledge economy across systems. Globally, the role of the academic profession has taken a similar direction; roles are shifting in response to an increasing emphasis on research and the knowledge economy and knowledge society. Even the systems that had traditionally focused on teaching in academia have experienced similar changes. For example, in post-Soviet countries, the transition was associated with a movement away from research academies and toward a reaffirmation of the research role of faculty. In some systems, the academic profession was closely identified with higher education institutions, and doctoral graduates were seen as the next generation of academics, while in other systems, the locus of research and development was centered outside universities. The expansion of doctoral education was linked to the broader needs of the public research and innovation system, and the mobility of scholars between the business, government, and university sectors was more common and encouraged.

In addition, the nature of the challenge for the academic profession was different in many developing countries; the most urgent issue was brain drain, given the increasing importance of retaining highly qualified personnel to help shape and support a domestic knowledge economy. In these countries, the challenge was not only about how to design a training system for knowledge workers but also—and even more urgently—about how to keep those people at home. The case of China illuminated how the government took different actions in recruiting and retaining talented people based on government scholarship programs and supports for overseas returnees. Not every system has the conditions needed to retain talent; in fact, brain drain is an urgent matter in many places including Russia, Portugal, and Latin America countries.

Attracting and maintaining highly qualified personal at both the national and institutional levels was a frequent and important theme throughout the chapters, even though academic structures varied dramatically. This volume has demonstrated a wide range of career structures and working conditions for academics in terms of the tenure system, the career ladder, full- and part-time contracts, teaching track versus research track, expectation of service and knowledge engagement, and distribution by academic discipline. These results also confirm findings of recent comparative research about the academic profession (Finkelstein & Jones, 2019).

Despite differences caused by each system's unique context, the global academic profession has confronted similar challenges in recent years, including a growing pattern of precarious work. There are examples in several chapters of difficult working conditions for non-permanent instructors; of increasing numbers of contingent faculty, limited-term faculty, and non-full-time instructors; and of limited resources and access for these contract-based academics. These findings are aligned with recent studies about the global academic work environment (see Yudkevich et al., 2017).

These findings also raised the issue of doctoral education. In some cases, there are not enough doctoral degree holders in academia (i.e., Latin American countries and Uganda), while other systems have too many PhDs (i.e., Estonia and Taiwan). Several higher education systems have already experienced declining enrollments, including graduate education, and there appear to be limited opportunities for a traditional academic career in the higher education sector. How is the university-based research enterprise expected to grow while the higher education system as a whole is shrinking? In addition, given the weak investment in R&D by the private sector in many jurisdictions, the employment of researchers beyond academia can be equally challenging.

Concluding Observations

The case studies in this volume have revealed a common policy direction in knowledge and development, with focus on innovation in science and technology and skills training for highly talented people. Most systems emphasize the importance of R&D investment and have increased investment in both the public and private sectors. Output measurements like publication and citation rates, international collaboration, and number of doctoral degree holders are increasingly emphasized, and these indicators have been increased in many systems. However, most systems compare their investment and output with their reference groups and highlight the need for more resources and better outputs.

Given the contextual differences illuminated in this volume, we paid attention to the impact of the changing environment on the academic profession. In particular, as more information about the case systems was collected, we identified a list of questions that must be addressed on a globally comparative scale; for example, the boundary or scope of academics in terms of today's scholarly tasks, the location of R&D activities inside and outside the university campus, and the worlds that academics now inhabit in terms of career development and working conditions are all pressing concerns.

Some of these questions relate to important differences in the jurisdictional context related to research and development. Are there important differences in the research activities of faculty in different systems, in particular where there are significant investments in research and development compared to those where investments are more modest? Are there differences in the role research plays in faculty workload, in the relationship between the research and teaching activities of faculty, in the degree to which academics make independent decisions on the direction of their research activities, and in the relationships between academics and industry? Will there be differences between and within systems in terms of academics' research activities, engagement with industry, the teaching-research nexus, and the role of faculty in doctoral education and training?

The academic profession should be understood in the context of shifting R&D polices from a long-term perspective; for example, when the external environment of the innovation system is too dynamic and difficult to control, it is worth asking whether the centralized government coordination prevalent today is the most efficient way to enhance knowledge and innovation. We also raise the questions of how nations can create a sustainable system of research innovation and foster collaboration between sectors and how the academic profession should respond and contribute to sustainable research and innovation systems. These questions are even more important when we consider emerging social and economic challenges such as the short lifespan of technology and the need for more social engagement of scholars to prepare for global challenges like widening inequality, climate challenges, and public health issues.

Through a cross-case analysis in this volume, we have synthesized a list of similarities and differences across systems and conclude that, while many aspects of the academic profession may appear similar, they are often vastly different when examined in depth. Thus, methodologically, this volume also has implications for the comparative analysis of the academic profession, such as defining the unit of analysis and the ambiguity of certain terms that can have completely different meanings. For example, the apparently straightforward task of counting the number of researchers becomes much more complex when the term "researcher" can have widely different meanings in different contexts. Although the nature of international comparative projects often embed ambiguity, the clarification of several key terms and serious consideration of the political, economic, social, and cultural context are both sorely needed.

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Jisun Jung is Assistant Professor in the Faculty of Education at the University of Hong Kong. Her current research focuses on the academic profession, doctoral education, master's education and employment, and higher education research in Asia. Her recent co-edited books include: *The changing academic profession in Hong Kong* (with Gerard A. Postiglione, Springer, 2017), and

Researching Higher Education in Asia: History, Development, and Future (with Hugo Horta and Akiyoshi Yonezawa, Springer, 2017). She is a co-editor of *Higher Education Research & Development*.

Glen A. Jones is Professor of higher education and Dean of the Ontario Institute for Studies in Education, University of Toronto. His research focuses on higher education systems, governance, policy, and academic work. He is the author or editor of more than a dozen books and has published more than 100 papers. Recent books include *International Education as Public Policy in Canada* (with Merli Tamtik and Roopa Desai Trilokekar, McGill-Queen's University Press, 2020) and *Professional Pathways: Academic Careers in a Global Perspective* (with Martin Finkelstein, Johns Hopkins University Press, 2019).

Martin Finkelstein is Professor of higher education at Seton Hall University, South Orange, New Jersey, USA. He is the author of *The American Academic Profession* (Ohio State, 1988) and co-author of The *New Academic Generation* (Johns Hopkins, 1998), *The American Faculty* (Johns Hopkins, 2006), Scholars in the Changing American Academy (Springer, 2011) and *The Faculty Factor* (Johns Hopkins, 2016). He is co-editor of *The Internationalization of the Academic Profession* (Springer, 2013), and *Professorial Pathways: Academic Careers in a Global Perspective* (Johns Hopkins, 2019).

Timo Aarrevaara is a Professor of Public Management at the University of Lapland, and Principal Investigator of the research team of Professions in Arctic Societies. He has professional experience in public administration as well as in research and teaching. He is co-chair of the APIKS coordinators group.

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