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Science and Technology Parks and Regional Economic Development

An International Perspective

Edited by

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Dedicated to the memory of Mike Wright

Series Foreword

The Palgrave Advances in the Economics of Innovation and Technology is proud to include this edited volume in its scholarly series of monographs. Science and technology parks are critically important topics not only for the advancement of science and technology per se, but also for continued economic growth and development in related regions. Because of the public good nature of science and technology, the related regions affected through and by advancements in tacit and codified knowledge from the research of park tenants and the associated university faculty are global.

The chapters in this edited volume were developed from presentations at the 2018 European Commission sponsored international workshop on science and technology parks. This event was held at the European Commission's Joint Research Centre in Seville, Spain, on October 10 and 11, 2018.

The purpose of the workshop was to explore concrete ways to systematically collect information on public and private organizations related to their support of and activities in science and technology parks including incubation to start-ups and scale-ups and collaborations with centers of knowledge creation. Rather than perpetuating the qualitative assessment of successful practices, the focus of this workshop was to present quantitative and qualitative evidence of the impact of science and technology parks on regional development and to raise awareness on the importance of systematic data collection and analysis.

Only through a systematic collection of data on fiscal identification numbers of companies, universities, and university spin-offs, would it be possible to conduct current and especially future analyses on the impact of science and technology parks on entrepreneurship, effectiveness of technology transfer, and regional economic development. The chapters in this edited volume are an important step forward in this direction.

Greensboro, NC, USA Albert N. Link

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CHAPTER 1

An International Perspective on Science and Technology Parks

Sara Amoroso and Fernando Hervás Soriano

1.1 Introduction

Science and Technology Parks (STPs) are organizations that accommodate and foster the growth of tenant firms, by managing the flow of knowledge and technology amongst universities, R&D institutions, companies and markets (IASP 2002). The concept of STPs derives from the evolution of industrial districts started in the UK at the beginning of the industrial revolution. The idea of concentrating companies in the same area quickly caught on in the US in the 1950s, during World War II, where the close cooperation between scientists and engineers played a major role in the allied victory (Vilà and Pagès 2008).

The success of early STPs such as the Stanford Research Park (affiliated with Stanford University) and the Research Triangle Park (Duke University, North Caroline State University and the University of North Carolina at Chapel Hill) has fuelled the growth in the formation of STPs around the world. Since then, many countries have taken a great interest in the shaping of STPs. The main factor driving the development of

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STPs has been technology change: new and established firms introducing new technology demand new environments and services. STP models are functionally diverse in order to meet the needs of new industrial activities, changing industries, changing technologies and specific policy demands from governments.

The spontaneous and endogenous formation of these peculiar sets of industrial-research clusters accompanied by the local concentration of skilled labour and flourishing entrepreneurial eco-systems quickly became the object of investigation for both academic research and policy making (Saublens et al., 2016).

From a policy perspective, clusters and STPs have become an important element in many regional economic development strategies. Indeed, STPs have been considered by many governments, as innovation and local development policy tools aimed at fostering the creation and growth of indigenous knowledge-based start-ups.

Mainstream theories in economics explain how knowledge spillovers are a key explanatory factor for the clustering of innovative firms (Breschi and Malerba 2001). Much of the industrial and innovation economics literatures stressed the importance of localized learning and the transfer of tacit knowledge between firms and research centres. Indeed, while codified knowledge is relatively easy to transfer even among individuals far apart, tacit knowledge can only be transferred through everyday practice, face-to-face interaction and interfirm mobility of workers, all of which depend on geographical and cultural proximity (Bryson 2015). In an effort to extract the essence of successful STPs and industrial innovation clusters, business scholars have long tried to identify organizational factors and models that characterize different types of STPs. However, there is a problem in trying to measure the success of STPs, as there is a lack of clear consensus of the definition of such success (Phan et al. 2005).

Given that STPs have been widely used as innovation policy instruments to strengthen the local innovation system, more effort should be directed in systematically evaluating the effectiveness of such policy measures. The evaluation of impact has always been a challenging task due to a host of reasons.

First, there is a notable lack of quantitative data, especially at firm level, and, for many countries, the scant evidence of positive contribution of STPs to regional development is based on few selected, mostly successful, qualitative case studies, whose lessons are hardly generalizable. Second, studies aimed at quantitatively evaluating the performance of STPs very often compare two groups of firms—on-park and off-park—to assess whether the on-park firms perform better than the off-park ones. However, there may be a selection bias at play, as on-park firms may a priori be different from off-park firms. Third, the functional diversity of STPs resulted in heterogeneous groups of parks (Westhead 1997; Phan et al. 2005) that inevitably have different focuses and aims. Finally, due to this functional diversity, it is not straightforward to define what "success" is for an STP and how to measure it. Most of the empirical studies have focused on three main dimensions of tenants' performance: economic performance, innovation performance and cooperation patterns of tenants.

Moreover, STPs may play a relevant role in the local economy and innovation eco-systems and as a tool of cluster policy. However, the non-spontaneous, top-down, "if you build it, they will come" approach to the formation of innovation clusters such as technopoles, STPs and firm incubators has not always proven to be effective (Cooke 2001; Taylor 2010), as it fails to take into consideration the complexity and diversity within local economies. Rather, government policies may play a crucial role in regional economic development by first identifying the critical conditions for sparking the growth of new STPs or innovative clusters, and then supporting the formation of such innovation catalyst, by recognizing local competencies in existing firms and embedded organizations.

With the intent of stimulating debate on the importance of collecting adequate quantitative data and developing appropriate methodologies for the impact evaluation of STPs, the Joint Research Centre (JRC) of the European Commission, in collaboration with the Cartuja Science and Technology Park, organized the "Workshop on Science and Technology Parks in Europe – Steps towards a systematic and harmonized data collection" (Seville, Spain, 10–11 October 2018). The workshop brought together academics and practitioners dealing with STPs, and policy experts interested in STPs (and innovation clusters in general) as instruments for local economic development and innovation policy.

The main findings, common challenges and recommendations deriving from the workshop can be grouped into three thematics: (1) the relevance of STPs and clusters for innovation eco-systems; (2) heterogeneity and evolution of STPs and (3) identification and measurement issues.

1.2 Relevance of STPs and Clusters for Innovation Eco-Systems

Among the participants to the workshop, Anna Sobczak (Policy Officer for clusters and emerging industries at the European Commission) and Alexander Lemcke (Economist at the Organization for Economic Cooperation and Development, OECD) stressed the relevant role of STPs as a policy tool for fostering local clusters of innovative firms, and for technology diffusion through entrepreneurship. As the overall knowledge intensity of STPs is usually very high, they are likely to include seeds for the domains of knowledge-intensive specialization, on which regions can rely to increase their competitiveness. STPs are thus well placed to play a key role in Research and Innovation Strategies for Smart Specialisation (RIS3). Rissola in Chap. 10 presents a conceptual framework to explore how place-based innovation eco-systems support innovation and stimulate collaborative innovation locally, and shows—with two cases in Sweden and Slovenia—the coordination or orchestration role played by the STPs in their local innovation eco-systems. In Chap. 6, Nauwelaers et al. further highlight the role of STPs as knowledge-intensive territorially based actors that can contribute to the design and implementation of Research and Innovation Strategies for Smart Specialisation. Three potential roles of STPs in RIS3 are discussed, together with limitations and success conditions for each of the three roles. This creates a new agenda for STPs as important actors and “boundary openers” in smart specialization strategies. Illustrative cases from Finland, England and the Netherlands show how STPs can actively and creatively contribute to the design and implementation of RIS3 and to the external connectivity of their home regions. Finally, Belitski and Audretsch in Chap. 7 report empirical evidence for 131 public universities in the UK during 2009–2016 on the positive effects of STPs and business incubators on entrepreneurship (start-ups and spinoffs), considering the moderating role of regional economic development.

1.3 Heterogeneity and Evolution of STPs

Another important message that emerged during the workshop is that there is no unique definition of what a STP is. On the one hand, park associations have their own definitions based on a description of activities related to the associations’ particular members. On the other hand, the existence of a great variety of shareholders and founders gives rise to heterogeneous groups of STPs. As Albert Link (Professor at the University of North Carolina at Greensboro) said during his keynote speech: "if you've seen one research park, you've seen one research park", stressing the underlying complexity of a generalized impact evaluation. In Chap. 9, Albahari draws on existing literature to propose that contrasting findings can in part be explained by most studies not considering the heterogeneous effect of the on-park location. He suggests that there is a need to understand what makes some parks more effective than others and detail several sources of park heterogeneity that may play a role when evaluating their contribution to tenants' value creation.

In Chap. 3, Link goes beyond the concept of heterogeneity and offers an insightful consideration for the future of US University STPs. Link's review of the evidence suggests that for STPs to remain viable, they must reidentify themselves especially in the eyes of their stakeholders. If they fail to do so, critical resources might not be forthcoming to deal with current infrastructure issues as well as their ability to attract new tenants in to the park.

Stoyan Kaymaktchiyski (Project Officer at the European Commission's Competence Centre of Technology Transfer at the JRC) provided an insight into the projects and services of the Competence Centre in the domain of innovation eco-system facilitating technology transfer (as one of its three core domains of operation). He contributed to the discussion on the future of STPs presenting ideas on the next generation of STPs. Specifically, these will be characterized by strong internationalization and connectedness, with multidisciplinary interactions; quicker market entry for promising start-ups and on-site amenities for young people (restaurants, leisure and sport facilities). Laura Lecluyse (PhD candidate at Ghent University) confirmed—with a case study on four STPs in Belgium—the evolving nature of STPs and tenants who need to meet their expectations both in terms of networking opportunities and in terms of location. Further, in Chap. 11, Lecluyse and Spithoven discuss shortcomings in the science park literature and correspondingly propose pathways for future research to advance the current state of knowledge on science park contribution. They present an integrative framework of science park contribution allowing for deeper insights into its relevancy, and suggesting new approaches to assess science park contribution, while highlighting the need to study mechanisms and conditions by which science parks provide benefits for tenants. Additionally, they underscore the importance of considering conditions in science park studies. With a comparison of key characteristics (such as ownership structure, management and services offered) of 42 science parks in three European countries, they demonstrate that science parks largely vary in terms of characteristics and discuss why these heterogeneous characteristics may influence science park contribution.

1.4 Identification and Measurement Issues

In the second keynote presentation of the workshop, Mike Wright (Professor at Imperial College London) transitioned from the heterogeneity of STPs, incubators and accelerators into the heterogeneity of the level of analysis and how this affects the data needs and challenges. In Chap. 4, Wright and Westhead outline an organizing framework of analysis that highlights the need to consider three contextual levels of analysis (macro, meso and micro) and that reflects the heterogeneity of STPs and their close relations. They identify a range of impact variables and drivers needed to assess the impact of STPs and their close relations at different contextual levels. They then discuss the data sources to obtain these variables, drawing upon existing studies to illustrate the uses of different data sources to study the heterogeneity of STPs, incubators and accelerators.

On the practical side, José Guadix (Professor at University of Seville) and Luis Sanz (President of the International Association of Science Parks, IASP) presented two evaluation tools. Guadix showed how a fuzzy-set Qualitative Comparing Analysis (QCA) can be used to evaluating parks' operating characteristics and to identifying the strategies of successful parks. He reported the published work on the evaluation results of Andalusian (South Spain) STPs. Sanz introduced the IASP Strategigram©, a software-based tool that allows STP managers to analyse their strategic profile, track strategy evolution over time and compare park's strategic profile with those of other parks. In Chap. 2, Lund explores the strategic choices that science parks face worldwide, with reference to the Strategigram© tool developed by IASP. The tool establishes seven key strategic axes (Location and environment, Position in the knowledge/technology stream, Target firms, Degree of specialization, Target markets, Networking and the Governance/Management model), using a number of complex indicators and objective data to determine the position of an STP on each axis. Each axis is examined in turn and the implications for science park managers of the position their science and technology occupies considered.

Soledad Díaz (Managing Director at the Association of Science and Technology Parks of Spain, APTE) described the role of APTE and its effort in collecting data on companies' balance sheet information. She also laid out some of the practical obstacles to data collection, such as the low rate of response to surveys, law restrictions of data protection and unsynchronized data collection. In Chap. 5, Díaz explains in depth what data are collected, the limitations and results from studies based on these data, which illustrate the evolution of the activity of Spanish STPs. While there have been many efforts in collecting data and evaluate the performance of STPs in Spain, the US and UK, empirical evidence for other countries is lacking.

Chapter 8 presents an empirical analysis to understand contributors of STPs' growth in Turkey following the enactment of a Technology Development Zones Law in 2001 aimed at supporting the establishment of technoparks to increase R&D investment. Mikaela Hellberg (Senior Project Leader at the Swedish Incubators & Science Parks, SISP) presented the case for Swedish science parks and incubators. She talked about the dilemma when deciding what to measure. On the one hand, there is the influence of stakeholders who are mainly worried about the implications for funding of quantitative measurements. On the other hand, there is the concrete need to have realistic expectations regarding the value of STPs in terms of social capital, entrepreneurship/entrepreneurial culture and so on.

To reiterate, the relevance of STPs for place-based policy and for the development of innovation eco-systems, together with the practical and political challenges in gathering data and identifying measures of performance, is what motivated the present collection of analyses and experiences from a variety of countries.

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CHAPTER 2

The Strategic Choices That Science and Technology Parks Must Make

Ebba Lund

2.1 Introduction

Since they appeared back in the 1950s as a new and innovative concept of spaces for businesses to locate in, science parks[1] (from hereon referred to as STPs) have grown very significantly both geographically and in terms of models and strategies. The fact that, after being logically born in technologically developed regions and countries, STPs expanded into lower tech areas and environments necessarily implied profound changes in the models, missions, and overall strategies.

[1] There are a number of expressions used throughout the world to refer to these projects. Science parks and technology parks are the most common, but they are also referred to as research parks, technopoles, tech parks, and so on. In some cases, they are used interchangeably and in other cases they denote certain differences, which we may dispense of for the time being, and assume that, despite minor differences, they refer to the same type of project.

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The International Association of Science Parks and Areas of Innovation (IASP) definition is the following (IASP 2002):

> A science park is an organisation managed by specialised professionals, whose main aim is to increase the wealth of its community by promoting the culture of innovation and the competitiveness of its associated businesses and knowledge-based institutions.
>
> To enable these goals to be met, a science park stimulates and manages the flow of knowledge and technology amongst universities, R&D institutions, companies and markets; it facilitates the creation and growth of innovation-based companies through incubation and spin-off processes; and provides other value-added services together with high quality space and facilities.

Sticking to this definition, it is estimated that there are approximately 1200 STPs throughout the world. Of course, there are quite a few other projects that, while they do not fully fit the IASP definition, do have some of the more important building blocks of STPs, and that could arguably be considered such, at least to some extent.

Studying the evolution of the STP concept by comparing the older and newer models and their successive strategies, one conclusion comes immediately to mind: STP is a living concept in permanent evolution: as happens in biology, where evolution can sometimes be dramatically accelerated and produce mutations that result in new or modified species, even if it is always possible to trace back to their ancestors. Perhaps we are now in the midst of one such mutation, which could explain the emergence of concepts and projects that have been labelled “areas of innovation”, “innovation districts”, and so on. But let us stay with STPs for now.

2.2 Understanding STP Strategies

In 2010, IASP President Luis Sanz created a method to analyse and understand the different strategic models of STPs throughout the world. This tool, called the Strategigram, uses specific software and has been widely used by the IASP membership since then. A set of generic indicators, comprehensive yet flexible, and applicable to all STPs are needed (Dabrowska 2016). To devise his analytical model, Luis Sanz proposed seven “strategic axes” that must be taken into consideration. By “strategic axis”, Luis Sanz refers to an aspect (of the life and activity of STPs) about which a decision must be made, having to choose between two alternatives. They are strategic because there is a general consensus about their intrinsic importance and, more importantly, because they have long-term implications. Of course, the choices to be made are not often an "either/or" dilemma, since between the two opposing alternatives, there is a wide range of intermediary positions.

The seven strategic axes of the Strategigram are the following:

1. Location and environment
2. Position in the knowledge/technology stream
3. Target firms
4. Degree of specialisation
5. Target markets
6. Networking
7. Governance/Management model

Sanz's Strategigram uses a number of complex indicators and objective data to determine the position of an STP on each axis, which is represented graphically by a horizontal bar whose two ends are the two opposing alternatives and the middle point (point 0) would represent a balanced position, indicating that the STP pays equal attention to both alternatives (Fig. 2.1).

Let us take a look at each one of these strategic axes.

2.2.1 Location and Environment

One of the very first things that needs to be decided when an STP is going to be created is, of course, its location. A dichotomy has always been offered to anyone having to select a location: in the city or outside the city?

The implications of choosing one or the other are major and have a knock-on effect that lasts throughout the entire life of the project. It affects the volume of investments required, the commercial offer that the STP can make to its future residents and tenants, the type of activities and companies that they can host, the type of companies that will be attracted to the park, its marketing, communication, and many other variables.

It must be emphasised that in this particular strategic axis talking about "choice" could be an optimistic euphemism: quite often the freedom of

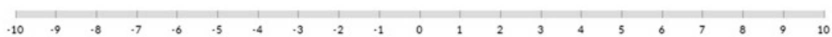

Fig. 2.1 Example of a Strategigram axis. (Source: Author's creations based on data from the International Association of Science Parks and Areas of Innovation)

choice is severely constrained by the money available for the creation of the project, the availability of land or space, land/space prices, and also, more often than not, legal and urban regulations that could make the project more or less feasible. Nevertheless, in recent years, an interesting trend can be observed by which STPs are being created in urban areas and cities much more than they were a couple of decades ago.

It is important to highlight that to determine the position on this axis, the Strategigram does not only take geographical indicators into consideration. In fact, more than the geography, the Strategigram looks at indicators and aspects that have to do with their "urban density", rather, it considers a series of elements that make a given space something more than just a workplace: cultural activities, places and facilities for social interaction, sports facilities, and, increasingly, housing, residential areas, or schools. In other words, a hybridisation of the space and its uses.

The two opposing alternatives on this axis are "urban" versus "non-urban". In the central segment of the axis, we mainly find those STPs that are not located in the centre of cities but instead in the outskirts, and who have added typical urban elements and activities to the purely work spaces (Fig. 2.2).

2.2.2 *Position in the Knowledge/Technology Stream*

The overall goal of science and technology parks is increasing the competitiveness of businesses, both mature and new, mainly by ensuring the right flow of knowledge and technology between the source of the knowledge and its destination. They manage the transfer of knowledge between universities and research institutions, and the companies that will acquire it, apply it, and bring it to the marketplace. STPs do this job in two main different ways.

Those who are close to the upstream side of this flow work closely with universities and research institutions to help them in the difficult job of transferring their knowledge and research results to the companies. Parks that operate closer to the downstream end of this flow work closely with

Fig. 2.2 Strategigram axis 1, location, and environment. (Source: Author's creations based on data from the International Association of Science Parks and Areas of Innovation)

companies, helping them to formulate their needs and to pass them on to the sources of knowledge trying to find the available solutions, or how new ones can be found. As you can see, it is the same job, approached from two different angles. STPs must know from day one what their position is in this strategic axis.[2]

In the Strategigram, "Technology stream" refers to the set of processes, mechanisms, and actions that enable the flow of knowledge and technology from its sources (upstream) to its recipients (downstream), and the pumping back of resources towards the sources to keep the flow running. This axis' extremes are "research/upstream" and "market/downstream".

It is safe to assume that upstream STPs work more intensely in conjunction with university departments and R&D institutions than with companies, and vice versa. However, it is important to underline that the Strategigram axes usually indicate a degree of emphasis, and not an "either/or" situation; it is obvious that STPs must work with both elements, research and markets, to be real STPs, and not just extensions of a university in one case or mere business parks in the other (Fig. 2.3).

2.2.3 *Target Firms*

STPs are not about science, nor about technology, despite their name. Science and technology parks (just like areas of innovation) are mainly concerned with companies, businesses, entrepreneurs, startups, jobs, and the like. They are concerned with the economic aspects of innovation, technology, and science; with applying knowledge and technology in order to enhance the competitiveness of its associated businesses; and with

Fig. 2.3 Strategigram axis 2, position in the knowledge/technology stream. (Source: Author's creations based on data from the International Association of Science Parks and Areas of Innovation)

[2] Up to a certain extent, we can presume that STPs clearly positioned in the upstream zone of the axis respond to the "Science Park" label, whereas those positioned at the other end, that is, in the downstream zone, respond to the "Technology Park" label, although this is not always the case, and STPs may choose to call themselves one or the other also for marketing or communication reasons.

raising the overall level of innovation in its city and region and creating wealth for the community by developing a prosperous business community.

In today's context, companies cannot compete and prosper without the necessary injections of knowledge and technology, all within a dynamic frame of constant innovation which is not just scientific or technological, but holistic. This means that it is the job of STPs to put in place the right environment and the right mechanisms and services through which companies can receive the knowledge they require from the knowledge producers, who in turn will receive money to be reinvested in generating more knowledge, thus keeping the wheel spinning for the benefit of all the parties involved.

What every park needs to do in relation to this strategic axis is decide on its main focus: will it concentrate mostly (or only) on nurturing startups from scratch via the usual mechanisms such as business incubation, business acceleration, or spin-off programmes? Or will it focus mainly (again, or only) on attracting more mature and already existing companies to the park, together with multinationals that may be persuaded to locate in the STP? These are two completely different approaches, and choosing one or the other also has important implications which have to do with the type of infrastructure needed in the park, the type of commercial offer that is proposed to the marketplace. In other words, will land be for sale or lease, or will there be workshop and office spaces for rent? Or both? And if so, in which proportions?

Of course, most parks deal with both options; most parks pay attention to nurturing startups as well as attracting existing companies, but very often they do so with different intensities or focus, and therefore where the project lies on this strategic axis needs to be decided on as well (Fig. 2.4).

2.2.4 *Specialisation*

Each science and technology park must have a clear idea about its objectives and mission, and this includes deciding as to whether a park should be generalist or specialised to one degree or another. Parks that are gener-

Fig. 2.4 Strategigram axis 3, target companies. (Source: Author's creations based on data from the International Association of Science Parks and Areas of Innovation)

alists will accept companies and activities from any technology or economic sector. The STP selects its companies not based on their technologies, but simply on whether they are innovative and technology based, regardless of the technology.

Parks that are specialised will focus on one or just a few technology sectors, and that is why we also have life sciences STPs, agricultural STPs, ICT (Information Communications Technology) STPs, and so on. The decision will depend on a number of factors and also on the particular needs of the region and city where the park is located. There is no one decision better than the other: it all depends on making the right decision based on the context, and indeed we can find successful examples of generalist, semi-specialised or highly specialised STPs (Fig. 2.5).

2.2.5 Target Markets

How international, as opposed to local or domestic, should a science park be? What is understood if it is an "international orientated science park"? Here again decisions must be made, because choosing to be mainly concentrated on a regional or national market or choosing to focus more on international activities and companies will require different types of services and certainly different profiles in the team that manages the park. Of course, as in most of the previously mentioned strategic axes, there is hardly ever a black or white decision. It is almost unheard of for there to be a park that is only "domestic" and pays no attention to the international dimension: most parks pay attention to both options.[3] As per most of the other strategic axes, it is a matter of degree to which side of the axis there is the greater emphasis, not meaning that the other aspect is completely forgotten.

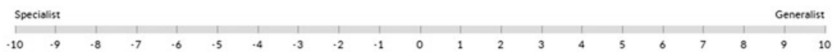

Fig. 2.5 Strategigram axis 4, degree of specialisation. (Source: Author's creations based on data from the International Association of Science Parks and Areas of Innovation)

[3] Interestingly, the traditional Research Parks in the USA show, in general, much less interest in being international than most of their peers elsewhere in the world. The US areas of innovation, on the contrary, are keen on internationalisation.

Looking at STP examples like the Singapore Science Park or the International Technopark of Panama immediately illustrates how important the international dimension is. These two parks, and others, have concentrated their strategy on attracting foreign companies and activities, and while not rejecting local companies, this is a less important aspect of their activity. When one looks at the contexts in Singapore and Panama, one can easily realise that it was practically the only reasonable strategy to adopt, in view of their small local markets. Many other parks go in the opposite direction. Whichever the decision, it has to be based on an accurate analysis of the needs and possibilities of every project.

It is also perhaps important to mention that, contrary to what some people tend to think, internationalisation is a two-fold activity. Internationalisation is not only about succeeding in attracting foreign companies to your park, it is also about succeeding in pushing a park's own resident companies into becoming global, accessing foreign markets, finding partners in other countries, or creating their own international network where they can acquire knowledge and technology and they can find new ventures and customers, and STPs have to work in both directions, pulling in and pushing out (Fig. 2.6).

2.2.6 Networking Strategy

As opposed to the axes mentioned until now, there is not really a choice to be made here. It is not that anyone can choose between being a science park that does not care about networking, or being one that does. The first is not an option, and those who inadvertently behave as if it were very soon go down the drain of sure failure. When the model and the strategy of a new STP are designed, the importance of understanding each STP as a network, made up of many nodes (companies, the research institutions, the related universities, professionals and individuals), is crucial. Moreover, on top of being networks themselves, STPs are also nodes of bigger networks, made up of the many STPs and areas of innovation worldwide. It is key to understand that just as important as the nodes are the links through which all these nodes communicate with each other: it is precisely such links and communication that constitute a network.

Fig. 2.6 Strategigram axis 5, target markets. (Source: Author's creations based on data from the International Association of Science Parks and Areas of Innovation)

Networks are not, and never will be, the paradigm of equality; their nature is more Darwinian than all that, because some nodes count more than others. When you analyse any network in detail, it is clear to see that some nodes attract more attention and interest than others. Their gravitational fields are stronger, they are the bigger planets, and large numbers of smaller planets and satellites are attracted to them, want to have access to them, be visible for them, and get in touch with them. Of course, this is a dynamic and mobile situation. Smaller planets may succeed in attracting interstellar matter and increase their mass so as to join the bigger league, while others may undergo the opposite process. It is of the utmost importance that everything is done to make sure that the managing team of the park becomes one of the main nodes, that is, one of the biggest nodes that attracts the most interest and attention. Every other node in the park must feel the need to be in contact with this node and to have privileged links with the management.

The question is, how can the managing team of a science park, which has to be the coordinator, if not the manager, of that network, succeed in organising a truly dynamic and efficient network? Classic thinking held that one needs to work on the nodes, as they were considered to be the main elements of a network, but more modern networking theories have realised that this may be a mistake. Are STP managers expected to modify the nature and behavioural patterns of companies, institutions, or adult and well-educated people? Quite unlikely. Wishful thinking. The way to improve a network and render it dynamic and efficient is not to work on the nodes, but rather on the links. Many of these links will appear spontaneously, but others must be created. For example, activities and spaces that will not only facilitate but encourage people in our parks to get together, to get to know each other, and to talk. Huge numbers of new ventures and business opportunities are born in a bar between beers (although of course, it is not only in leisure time or spaces that these things occur). Smartly organised business meetings, workshops, clubs of entrepreneurs, events for the wider community, and many other activities can be key to the success of a science park. It is crucial that the nodes talk to each other, and this is also how knowledge capture and spill-over occurs (Parry 2017) (Fig. 2.7).

Fig. 2.7 Strategigram axis 6: Networking (Source: Author's creations based on data from the International Association of Science Parks and Areas of Innovation)

2.2.7 Governance/Management Model

It goes without saying that having the right management and institutional architecture organised around a park is absolutely crucial for any STP. There are many elements to be considered and certainly not only who the owners are (owners of the land, of the buildings, of the shares, if there happen to be any, because all this depends on the chosen model). Ownership is important, but even more so is governance and management, and the complex relationship among the various stakeholders. In this regard, there are no right answers in an absolute way, as these answers will all be different, depending on the economic, social, and institutional context in which the park is created.

However, in order to assess what may be the best option in each case, especially when starting a new STP project, considering the following questions may be of help:

What is the legal form of the management team of the park? Is it a foundation? A private company? Public? Or maybe simply a management team that belongs to a governmental body or a university?

Who has a seat or a say at the highest governing body of the management structure (board of directors or equivalent)? Should this be reserved only for owners and shareholders, or could it be open to people and organisations that may not have invested capital in the park, but who have an interest in the project and from which the project itself could benefit in some way?

How about the manager, the CEO, or the Director General of the Park? What is the right profile? Is it better to have someone coming from public administration? Perhaps someone with an academic or research profile? Wouldn't it be wise to hire someone from the private sector? Moreover, what powers should this CEO have? What should their decision-making capacity be? On what things can they make quick decisions alone, and for which other things is the approval of the Board needed? How about the rest of the team? Which are the right profiles?

STPs face the same situation as many companies in their life cycle, in that there are certain profiles and skills that work perfectly well at the initial stages of an organisation, but that may not be adequate after a few years, when that organisation has grown to a much bigger size.

Whatever the formula, the governance should be agile, and not encumbered by bureaucratic procedures in the decision-making processes. Heavy administrative procedures might be understandable in the context of public administrations but certainly not in the context of business markets and international competition. Bureaucratic procedures and the desire of political representatives and authorities to intervene directly in the management of the park typically lead to excessive rigidity and collapse (Fig. 2.8).

Once all the different indicators used for each axis have been analysed, the Strategigram yields a graphic representation of the strategic model of the STP in question. Here is a real example (name anonymised for privacy reasons) (Fig. 2.9).

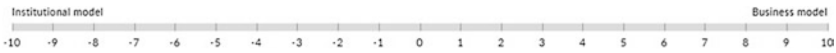

Fig. 2.8 Strategigram axis 7: Governance / management model. (Source: Author's creations based on data from the International Association of Science Parks and Areas of Innovation)

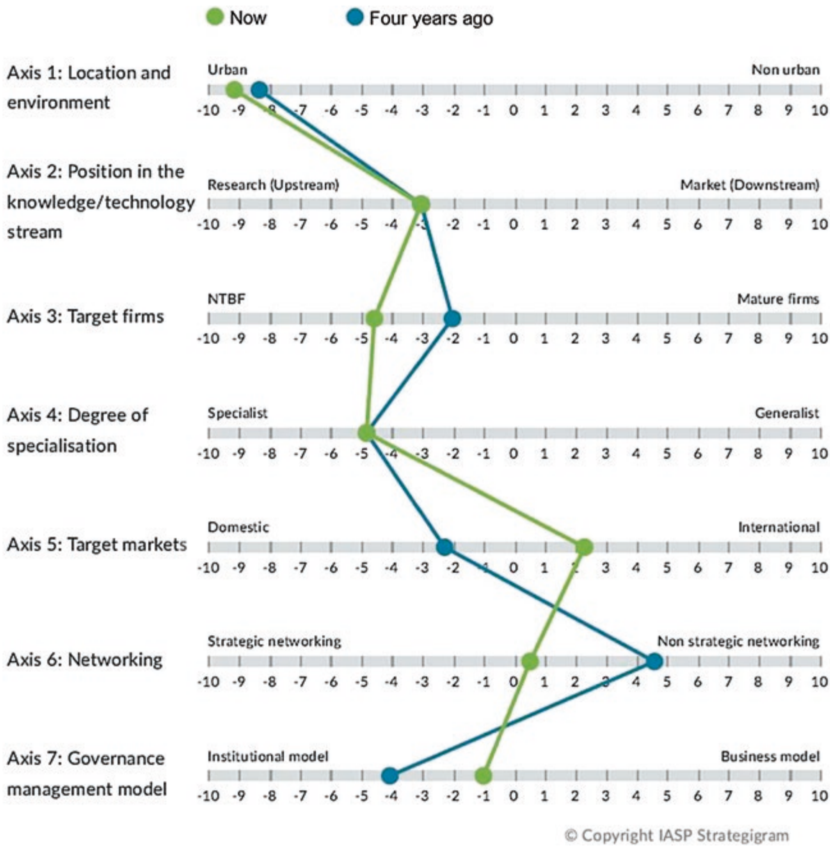

Fig. 2.9 Evolution of strategic profile in STPs using the Strategigram tool (Source: Author's creations based on data from the International Association of Science Parks and Areas of Innovation)

In this particular example, the STP that used the Strategigram methodology carried out two analyses with an interval of four years, so in addition to giving the strategic profile of the park at a given point in time, it also allows the user to see the evolution throughout the years. For example, we see that the position on axes 2 and 4 has remained the same, but that on the other axes, there have been changes.

In most cases, many of these changes follow premeditated decisions and changes that have been implemented in the STP, but, in other cases, they may follow external and even undesired reasons which sometimes are not clearly detectable by the management of the park. The use of the Strategigram at intervals of four to six years becomes an interesting gauge to detect such contingencies.

Additionally, the Strategigram can also be used to compare strategic profiles in the world, and this feature of the Strategigram becomes very important to choosing the best benchmarks, since it doesn't make much sense to compare one STP with STPs that have a completely different strategic model and mission.

2.3 Evolution and New Trends

Back in 2001, in a visionary article titled "From technology parks to learning villages: a technology park model for the global society" (Sanz 2001), Luis Sanz anticipated the main traits of what has become in recent years a clear trend in the STP industry: areas of innovation, innovation districts, and the like.

Indeed, Sanz foresaw that the future of STPs could not merely be as spaces where people went to work in the morning and left in the evening, leaving the area dark and empty. He anticipated the need for mixed-use spaces, with the capacity of being attractive not only for businesses but also for people.

> *A short list will, I believe, suffice to convey the idea of the great number of changes happening under our very eyes, and to give some clues as to which features many future STPs will have:*
>
> - *Companies are very flexible, open and internationally minded*
> - *Finding and retaining highly trained personnel is one of a company's top priorities*
> - *Telework (in its various forms) may grow in some ad-hoc spaces such as the new STPs*

- *In advanced economies, quality of life (and the 'place' where one lives plays a crucial role in this) is not only a wish but a requirement*
- *People want to become less car-dependent*
- *Education and training have become essential both for individuals and for organisations. Moreover, education needs to be a lifelong process. Globalisation not only alters space but also time, for there is no longer 'a time to learn' and 'a time to work' but a whole (adult) lifetime to study, enjoy, produce and learn on an enriching continuum.* (Sanz 2001)

Although the author himself warned of the dubious nature of some of these ideas, for example the issue of telework, the capacity of visualising the future in this article is indeed quite remarkable.

Whilst the majority of STPs are still located near cities but more in their outskirts than in the centre, via the Strategigram and evolution of STPs strategic profiles, we can detect the belief in the virtues of the city as a space to host and nurture companies. Of course, this was not possible in the classic industrial era, where the size of the factories, their massive logistic needs (transportation, traffic generated), and the inevitable pollution generated by many industrial processes made it impossible for such companies to be in the city.

However, the knowledge economy is changing everything, including the type of companies that top the ranking of added-value activities. When knowledge and skills replace the huge factories of the industrial era, many things that were impossible now become not only possible, but desirable. Besides, the regenerative virtues of the STP concept have been discovered and put to good use, and many of the most typical STP elements (incubators, accelerators, design centres, flexible office facilities, etc.) are being used to revive entire neighbourhoods or city areas that had been in decline.

This explains the emergence of the so-called areas of innovation and innovation districts. In some cases, it is quite clear that they are an evolution of the STP concept. In other cases, it may not be possible to establish a direct filiation, but even if there is not a father-son relationship, there is nonetheless a brotherhood or a family resemblance from partially shared DNA (Nikina and Piqué 2016).

The differences and similarities between STPs and areas of innovation (from hereon AOIs) can be seen by comparing their definitions. The IASP definition of STP was given previously: the association also drew up a definition of AOI which is the following (IASP 2016):

> Areas of innovation are places designed and curated to attract entrepreneurial-minded people, skilled talent, knowledge-intensive businesses and investments, by developing and combining a set of infrastructural, institutional, scientific, technological, educational and social assets, together with value added services, thus enhancing sustainable economic development and prosperity with and for the community.

If a similar tool to the Strategigram were used to analyse AOIs, it is clear that in most cases their position on axis 1 of the Strategigram would be very much on the side of urban projects. Some of the reasons for the emergence of these AOIs were mentioned above in reference to Sanz's paper "From technology parks to learning villages", and one reason in particular is of special importance:

In the classic industrial economy, companies decided where to locate based on factors like proximity to the materials, easy access to transportation nodes, and cheap available land. These preknowledge economy companies did not require a highly educated workforce; therefore, the workforce was not a particularly important part of their equation. Companies chose the location knowing that the workers seeking a job would simply have to follow the companies wherever they decided to locate.

But now, with the knowledge economy dominating the scene, the rules of the game have changed. Now, knowledge is the main asset that companies have and need, and knowledge lives mainly in the heads of qualified well-educated and skilled people, typically young graduates and PHDs. These individuals, who we may refer to as the knowledge workers, are the most coveted asset. And this has introduced a radical change in mobility patterns, because these knowledge workers know how much they are worth, speak languages, are connected to the world, have developed their own personal international networks, and have enough skills to be needed by many companies. They are increasingly in charge, they know it, and they are beginning to make their preferences and tastes be attended to. In other words, more and more workers no longer follow companies: quite the opposite, it is the new knowledge-based companies that follow their coveted workers wherever they like to live and work.

Thanks to a number of sociological studies and statistics, quite a lot is known about the preferences of the "new creative class", as knowledge workers are sometimes called:

- They love cities and urban density, because it is in cities that they find more job opportunities, as well as fulfilling cultural and social lives.
- They prefer cities with a distinct aura of personal freedom and flexibility, equipped with state-of-the-art ICT connectivity, and they expect wifi to be pervasive and available in all places at all times.[4]
- They like to feel that they have roots and links to a recognisable territory, such as a city, as long as they know and feel that they have no restraints whatsoever for their much-loved global connectivity, because again, their world is now the entire world. They are citizens of the world. They are true "globapolitans".

All this has straightforward implications, and the most important of these is that to be successful, modern STPs (or AOIs) can no longer be attractive only for companies or research institutions; quite on the contrary, it is imperative that they are also attractive to people, to the individuals that make up this new and empowered class, the knowledge workers. As well as sophisticated infrastructure and systems, an equally important driver of innovation is educated and skilled workers (Abdelaal 2016). Neglect their appetites and aspirations and you will inevitably fail. The global knowledge economy means new markets, customers, companies, and new workers.

As well as the changes on axis 1, changes on axis 7 (Governance/management model) can also be detected, and although a detailed account of these changes is out of the scope of this article, it is worth mentioning briefly.

Traditionally, STPs have been mainly public initiatives, launched with public money. They tend to be long-term projects and require significant initial investments, which explains why the private sector did not find investing in creating STPs attractive from a purely business perspective.

But things are also changing here, and there are now more and more cases of STPs being created by private companies, or of private companies investing in the further development of already existing STPs. As a result, more and more cases of private parks or PPP schemes are being created. When these projects move towards small downtown areas, the possibilities for the private sector to invest in them are multiplied exponentially, as new office or lab facilities are needed as well as new residential areas, commercial areas, and so on.

[4] Such conclusions must be approached with caution, as they can differ (and often do) depending on the cultural and historical roots of different regions and countries.

2.4 Conclusions

- The STP concept is alive and fully operational throughout the world, as demonstrated by the constant creation of new projects in all continents.
- New STPs tend to be created in urban areas or very close to them, while older STPs often incorporate urban elements in terms of facilities or services, so as to increase their urban density and become attractive for people as well as for companies.
- In a logical enrichment and evolution of the concept, many of the traditional STP tools are being applied innovatively within the cities, thus creating areas of innovation and sometimes innovation districts.
- Many STP concepts and elements are being successfully used to revive decaying areas and suburbs of cities.

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CHAPTER 3

University Science and Technology Parks: A U.S. Perspective

Albert N. Link

3.1 Introduction

One of the more prophetic statements by the Queen of Hearts in Lewis Carroll's *Alice's Adventures Under Ground*, the story on which *Alice's Adventures in Wonderland* is based, comes from the dialogue related to the stolen tarts made by the Queen of Hearts: "First the sentence, and then the evidence!"

In this chapter,[1] my view of the "sentence" or verdict for U.S. science and technology parks is not "off with their heads" but rather your fate might be uncomfortable. I suggest that U.S. university science and technology parks (hereafter, STPs) may be a remnant of the past. While the supply of U.S. STPs may remain the same in the near term, the demand for land or space in these parks by new tenants is waning nationwide.

[1] This chapter is based on my Distinguished Scholar Lecture at the European Commission's Workshop on Science and Technology Parks in October 2018.

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Before offering my evidence for this "sentence" or verdict, some preliminary definitions are needed to ensure that all who read this chapter are, so to speak, on the same page.

Perhaps the broadest definition of an STP is offered by the United Nations Educational, Scientific and Cultural Organization (UNESCO)[2]:

> The term "science and technology park" encompasses any kind of high-tech cluster such as: technopolis, science park, science city, cyber park, hi tech (industrial) park, innovation centre, R&D park, university research park, research and technology park, science and technology park, science city, science town, technology park, technology incubator, technology park, technopark, technopole and technology business incubator. However, it is worth noting that there are slight differences between some of these terms. For example, experience suggests that there is difference between a technology business incubator, science park or research park, science city, technopolis and regional innovation system.

There are other definitions of a park that are used by the various park associations. These definitions are generally based on a description of activities related to the association's particular members. For example, according to the International Association of Science Parks (IASP)[3]:

> A science park is an organisation managed by specialised professionals, whose main aim is to increase the wealth of its community by promoting the culture of innovation and the competitiveness of its associated businesses and knowledge-based institutions. To enable these goals to be met, a Science Park stimulates and manages the flow of knowledge and technology amongst universities, R&D institutions, companies and markets; it facilitates the creation and growth of innovation-based companies through incubation and spin-off processes; and provides other value-added services together with high quality space and facilities. [The expressions "technology park," "technopole," "research park," and "science park" encompass a broad concept and are interchangeable within this definition.]

[2] See, http://www.unesco.org/new/en/natural-sciences/science-technology/university-industry-partnerships/science-and-technology-park-governance/concept-and-definition/. Accessed November 9, 2018.

[3] See, https://www.iasp.ws/our-industry/definitions. Accessed November 9, 2018.

And, the United Kingdom Science Park Association (UKSPA) defines a science park as[4]:

> The term Science Park describes a business support environment that encourages and supports the start-up, incubation and development of innovation-led, high-growth, knowledge-based businesses; initiatives called by other names such as Research Park, Innovation Centre, Technology Park, Technopole or technology-based Incubator – where they aspire to meet the essential criteria set out above are also included within the definition.
>
> A Science Park is a business support and technology transfer initiative that:
>
> - encourages and supports the start-up and incubation of innovation-led, high-growth, knowledge-based businesses.
> - provides an environment where larger and international businesses can develop specific and close interactions with a particular centre of knowledge creation for their mutual benefit.
> - has formal and operational links with centres of knowledge creation such as universities, higher education institutes and research organisations.

Finally, the American Association of University Research Parks (AURP) defines a university research park as[5]:

> a property-based venture, which:
>
> – Master plans property designed for research and commercialization
> – Creates partnerships with universities and research institutions
> – Encourages the growth of new companies
> – Translates technology
> – Drives technology-led economic development

The common element among these definitions is that a park is an innovation-related infrastructure through which knowledge is exchanged, and a university is often a catalyst for that symbiosis. Accordingly, the definition of a U.S. university STP that I have used in previous research and that I use here to provide structure to this chapter comes from Link and Scott (2006, p. 44):

[4] See, http://www.ukspa.org.uk/members/how-join and http://www.ukspa.org.uk/our-association/about-us. Accessed November 9, 2018.

[5] See, https://www.aurp.net/what-is-a-research-park. Accessed November 9, 2018.

> A university research park is a cluster of technology- based organizations that locate on or near a university campus in order to benefit from the university's knowledge base and ongoing research. The university not only transfers knowledge but expects to develop knowledge more effectively given the association with the tenants in the research park.

The remainder of this chapter is outlined as follows. In Sect. 3.2, I describe the population of U.S. university STPs, In Sect. 3.3, I overview measures related to the success of university STPs. In Sect. 3.4, I summarize the more general academic literature related to university STPs. Sections 3.2, 3.3, and 3.4 thus provide context for my suggestion that the "sentence" or verdict for the future of university STPs might be an uncomfortable one. In Sect. 3.5, I provide evidence for suggesting this verdict. In Sect. 3.6, I reflect on the purpose of the European Commission's workshop vis-à-vis the theme of this chapter.

3.2 The Population of U.S. University STPs

Figure 3.1 shows the population of U.S. STPs by the year that they were founded.[6] The information used to construct this figure was assembled by Link and Scott through Internet searchers, AURP reports, academic literature, and personal contacts (Hobbs et al. 2017a, b). AURP makes available limited information about its members, but not all members of AURP are STPs and not all STPs are members of AURP. So, some might reasonably question or even disagree with the number parks we have identified through calendar year 2015 as being 146. Some might also question or even disagree with the year of the park's founding that is used in the figure as I mention below.

Several STPs might be recognized from Fig. 3.1 by their date of founding. For example, Stanford Research Park (California) was founded in 1951; Cornell Business and Technology Park (New York) was found in 1951, although some archival documents suggest that it was founded in 1952; and Research Triangle Park (North Carolina) was founded in 1959.

Figure 3.1 also shows a rapid growth in U.S. park founding from the late-1970s through the mid-1980s. This was a period of time that followed just after the productivity slowdown in many U.S. sectors (Leyden

[6] My various studies of university STPs, with my co-author John Scott, confirm over and over that many park directors and many park documents are not consistent about when the park was formally founded.

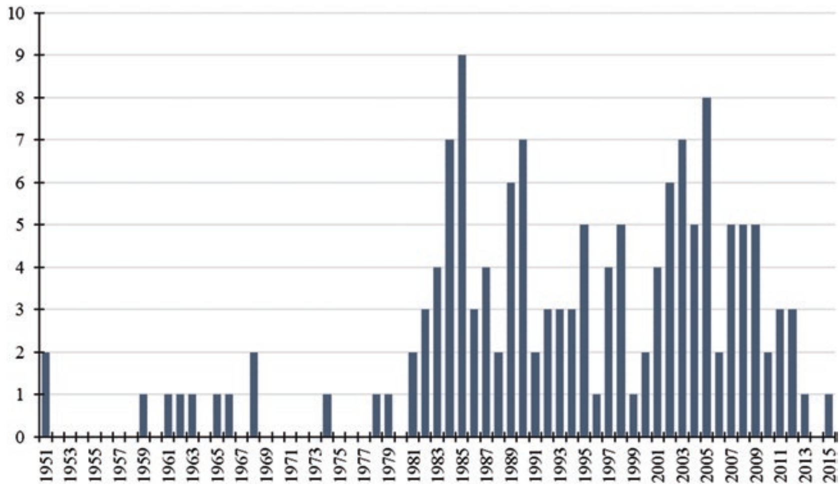

Fig. 3.1 Population of U.S. university science and technology parks by year founded (*n* = 146). (Source: Author's creation based on data in Hobbs et al. 2017b)

and Link 2015). Link and Scott (2006, pp. 45–46) relate this period of founding STPs to a corresponding period of technology policy initiates[7]:

> The period of the relatively rapid increase in park formation [in the late-1970s through the mid-1980s] corresponds to a period of significant public policy initiatives to encourage university-with-industry relationships, increases in industrial R&D spending, and the formation of cooperative research partnerships. The Bayh-Dole Act was passed in 1980, the R&E tax credit was enacted in 1981, and the National Cooperative Research Act was legislated in 1984. All of these public initiatives fostered additional private sector R&D activity, which could have stimulated states and universities to establish potentially beneficial locations for that R&D to take place.

[7] The University and Small Business Patent Procedure Act of 1980, known as the Bayh-Dole Act, reformed federal patent policy by providing increased incentives for the diffusion of federally funded innovation results. In particular, universities were permitted to obtain titles to innovations developed with government funds. The R&E tax credit of 1981 provided a tax incentive (originally 25% and today 20%) to firms that increased their R&D expenditures over those made in previous years. And, the National Cooperative Research Act of 1984 encouraged the formation of research joint ventures (RJVs) among U.S. firms—and universities were partners in many of those ventures. RJVs, if subjected to criminal or civil antitrust action, would be evaluated under a rule of reason, and if found to fail a rule of reason, they would be subjected to actual rather than treble damages.

Berman (2012) reflects on this period of growth in U.S. STPs, and she offers the argument that universities in the aggregate began to experiment with "market-logic" activities in the early as the late-1950s and 1960s, noting as examples the formation of university research parks. Berman (2012, p. 27) contents that:

> Universities were attracted to the research park idea for a number of reasons. They saw the parks as having the potential to provide financial support for research and academic programs, access to scientific equipment, and consulting opportunities for faculty, which remaining consistent with their educational mission. That is, they appear to have appealed primarily as a way to bring new resources to the universities.

And, in the late-1970s, university experiments with "market-logic" activities began to ramp up as a result of, among other things, faculty entrepreneurship in the biosciences and the establishment of university-industry research centres.

Finally, again based on Fig. 3.1, if one were to construct a companion figure showing the cumulative number for STPs by year, the curve would eventually begin to flatten out because there are simply a finite number of research universities in the United States for which an STP is a viable use of resources.

3.3 The Success of U.S. University STPs

An appropriate measure for park success may well be in the eyes of the beholder. Link and Link (2003) were among the first to explore characteristics of success of a university STP. Based on their field-based research and related interviews, these authors suggested that park directors and managers regularly consider at least three metrics for their park's success: the park's contribution to the regional economy, the number of *Fortune 500* companies located in the park, and the percentage of park land that had been sold or leased. Academics, in contrast, have generally focused on employment growth within in the park as a success metric (Hobbs et al. 2017a, b; Link and Scott 2006, 2007, 2012, 2013, 2018).

Link and Scott (2018) point out that there are other success measures that follow from economic theory. These measures relate to agglomeration benefits and the sharing of knowledge that results.

Marshall (1919) made the point, as interpreted by Link and Scott (2018), that there are competitive benefits of cooperation among industrial firms geographically close to each other. The park concept of sharing knowledge, often specialized knowledge among research-based firms and with universities, through proximity brings about the competitive benefits associated with ideas and even research directions. Specifically, Marshall (1919, p. 599) wrote:

> The broadest and in some respects most efficient forms of cooperation are seen in a great industrial district where numerous specialized branches of industry have been welded almost automatically into an organic whole.

Relatedly, cluster theory (Westhead and Batstone 1998) predicts that the process of creating innovations is more efficient because of knowledge spillovers, enhanced benefits, and lower costs that result from the clusters of research and technology-based firms near a university. Knowledge, tacit knowledge in particular, search costs, and acquisition costs are reduced through participation in clusters. Clustering engenders a two-way flow of scientific knowledge. As a result, it is perhaps not surprising that as Link and Scott (2003) found from their survey research, universities report more publications and patents, greater success getting extramural funding, improved placement of doctoral graduates, and enhanced ability to hire preeminent scholars.

In addition to the benefit of firms clustering together within a park, the issue of the proximity of a park to its university, that is the clustering of firm scientists with university scientists, might also influence the success of the park. The empirical research by Link and Scott (Link and Scott 2006; Hobbs et al. 2017a, b) is conclusive that the growth of employees over time in university STPs increases the geographically closer the park was to the university. This should perhaps not be an unexpected empirical finding. As Audretsch (1998, p. 21) noted, although not with respect to STPs in particular: "[Tacit] knowledge … is best transmitted via face-to-face interaction and through frequent and repeated contact." And Glaeser et al. (1992, p. 1126) noted, also not with respect to STPs, "Intellectual breakthroughs must cross hallways and streets more easily than oceans and continents." The Link and Scott relationship between employment growth and proximity of the park to its university ceases to be observed in the data beginning with the new millennium during which the information and communication technology revolution began and accelerated. Simply, "face-to-face interactions" could occur electronically and at a much lower cost than physical "face-to-face interactions."

Finally, path dependency theory (David 1985) predicts that for technologies spawned by ideas generated in a university, creating a park (from the university's perspective) and locating in the park (from the firm's perspective) give positive reinforcing feedback to both parties to continue their particular scientific development paths for a particular technology. The university STP reinforces path dependences that lock in the success for the technology developed in the park that relies on university ideas (Link and Scott 2018).

3.4 The Literature in Summary Form

3.4.1 Academic Studies

The final aspect of context that I believe is needed before I explain that the "sentence" or verdict for the future of university STPs might be an uncomfortable one deals with the limitations of STP topics that populate the extant academic literature. Very few journal publications address factors correlated with the success of STPs (the exceptions being the proximity studies by Link and Scott), thus there are very few guideposts to use to forecast the future success and growth of STPs. And, to anticipate a later discussion in this chapter, perhaps the available or systematic data will help to bring about such guideposts. Based on Hobbs et al. (2017b), the academic literature in academic journals resides to date in 87 scholarly publications. They fall within the following categories: 35 empirical studies, 34 case studies, 10 theoretical or conceptual papers, 5 literature reviews, and 3 publications related to park evaluation methods. Figure 3.2 shows this literature by year of publication. Overall, the trend in the number of publications, regardless of category, is upward.

Figure 3.3 shows the distribution of this body of literature by country of focus. That is, 16 of the 87 publications identified by Hobbs et al. (2017b) focused on China in one way or another, and 6 focused on the United States, in one way or another. The China-focused publications and the Spain-focused publications have been, for the most part, case studies of particular parks. The U.K. and the U.S. publications have been, for the most part, empirical analyses.

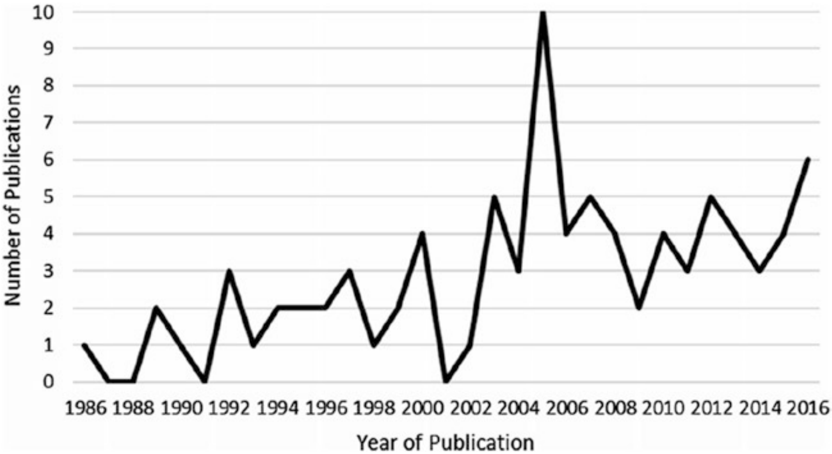

Fig. 3.2 Academic journal publications, 1986–2016 (*n* = 87). (Source: Author's creation based on data in Hobbs et al. 2017b)

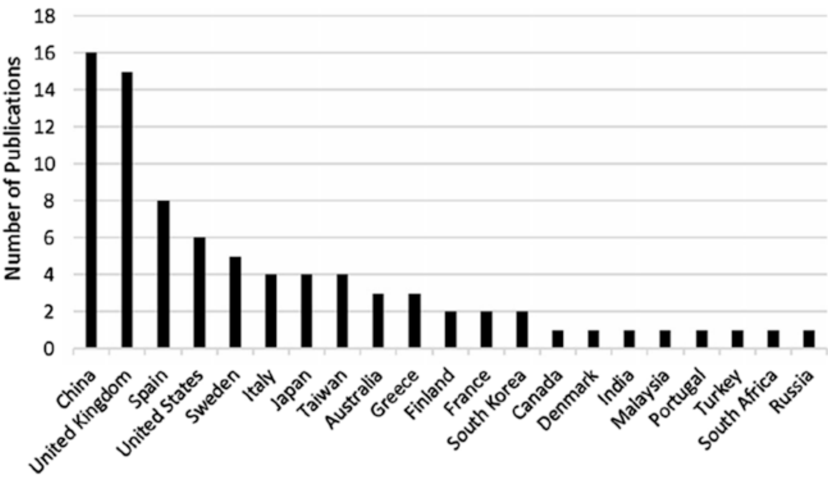

Fig. 3.3 Academic journal publications, 1986–2016, by country of focus (*n* = 87). (Source: Author's creation based on data in Hobbs et al. 2017b)

3.4.2 Evaluation Studies

Evaluation studies are one method to use to illustrate the success of STPs and possibly the future success of STPs. Nauwelaers et al. (2014, p. 7) offer a similar suggestion:

> Recent research [suggests that] a main overall success factor for STPs [is] to play an important additional role in regional development: their tight integration in the regional ecosystem and close interaction with, and complementarity to, regional innovation [should be supported by] policy. … STPs can play an effective role in regional development when they are part of a policy mix for regional innovation, including other elements necessary for innovation support such as: funding programmes for collaborative research (thematic or not); mobility schemes; various types of support for entrepreneurship and the creation of new technology-based firms; venture capital and other types of funding sources for knowledge-intensive business; etc.

Hobbs et al. (2018) report that of the 146 university STPs founded through 2015 (see Fig. 3.1), economics-based evaluation studies have been conducted by only 11 parks. These parks are described in Table 3.1.

Hobbs et al. (2018) are critical of these evaluations because of the evaluation method used. In every case in Table 3.1, the evaluation method was based on an input/output model to determine economic impacts. It is however surprising that from an exhaustive Internet search and from personal contacts with the Office of the Provost of each park represented in Fig. 3.1, only 11 evaluations out of a possible 146 have been conducted.

3.5 Waiting for Change or Inexplicable Behaviour[8]

In 2007, Battelle Memorial Institute (Battelle) conducted a membership park survey under the sponsorship of AURP. Several important issues were emphasized in their report, one of which was the financial challenges facing parks in the future. One such challenge that is wide spread and ongoing is the need to obtain resources for future park development and expansion. This documented fact is a reality, and one that suggests to me that the "sentence" or verdict for STP might be an uncomfortable one.

[8] This section draws directly from Link and Shelton (2018) and Hobbs et al. (2018).

Table 3.1 U.S. University STPs that conducted an economic evaluation (n = 11)

University name (alphabetical)	*Park name*	*Year of the evaluation*	*Year park was founded*	*State university*	*Internal/ external study*
Arizona State University	Arizona State University Research Park	2016	1983	Yes	Internal
North Dakota State University	North Dakota State University Research & Technology Park	2010	2003	Yes	External
Purdue University	Purdue Research Park	2011	1961	Yes	External
University of Arkansas	Arkansas Research and Technology Park	2016	2003	Yes	Internal
University of Arizona	University of Arizona Tech Park	2015	1994	Yes	External
University of Illinois at Urbana-Champaign	Research Park at the University of Illinois Urbana-Champaign	2015	1998	Yes	External
University of Missouri	University of Missouri Research Parks	2009	1985	Yes	External
University of Nebraska	University of Nebraska Technology Park	2011	2008	Yes	Internal
University of Pennsylvania Drexel University	University City Science Center	2016	1963	No	External
University of Wisconsin—Madison	University Research Park	2010	1984	Yes	External
Virginia Commonwealth University	Virginia BioTechnology Research Park	2010	1992	Yes	External

Source: Author's creation based on data from Hobbs, Link, and Shelton (2018)

At the time of the Battelle survey, Battelle reported that parks themselves reported that nearly 30% of funding sources for the park's operations came from three sources: the university, state and local governments, and the federal government. In addition to public support of park operations, park tenants themselves reported to Battelle that they face capital challenges (Battelle 2007, p. 10):

> Park directors responding to the survey indicated that helping tenants access capital will be a significant challenge during the next 5 to 10 years. As parks focus more on entrepreneurial start-up and emerging companies, the ability

> of these companies to access capital will greatly affect whether they are able to grow and expand in the park or in the community. Seventy-three percent of the respondents indicated that this was a significant or highly significant challenge facing their park in the future.

In 2012, Battelle conducted a follow-up survey of AURP member parks in an effort to update its 2007 survey and findings. Battelle reported that many parks are in the process of transforming their physical environment (2013, p. 25):

> University research park directors indicated through the survey that the greatest challenge facing them would be obtaining capital for park development and renovation.

One might infer from the above-quoted excerpts from the Battelle report that at least some parks are assuming that another major issue that they face now and in future decade(s) is the revival of their physical environment that is their space.[9] However, there is yet another issue that might be as pressing as or even more pressing than revival of the park's environment.

Katz and Wagner of the Brookings Institution (Katz and Wagner 2014, p. 1) note:

> Innovation districts are the manifestation of mega-trends altering the location preferences of people and firms and, in the process, re-conceiving the very link between economy shaping, place making and social networking. In recent years, a rising number of innovative firms and talented workers are choosing to congregate and co-locate in compact, amenity-rich enclaves in the cores of central cities.

One might ask, based on the Katz and Wagner (2014) report: Has the locational role of the university on park tenant research changed over time?

Discussed above with regard to employment growth in parks and their proximity to the park university, after about year 2000, proximity to the

[9] Referring to the Battelle observation about parks "obtaining capital for park development and renovation," which is within the scope of this study, it may be the case that efforts to transform the physical environment of parks would involve public moneys. And, when the use of public moneys is involved, the issue of accountability of how public moneys have been used is an important issue to state policy makers and to regional stakeholders in parks.

university became less important for the growth of the park and perhaps less important for the survival of the park.

Perhaps, in an effort to reverse this trend and thus to mitigate if not dismiss the reality that the future of STPs is in question, STPs should be increasingly involved in redefining their role and geographic benefits that they provide to existing and potential tenants, as well as to regional stakeholders. But, based on the Hobbs et al.'s (2018) finding of only 11 economic evaluation efforts, one might question if park directions are aware of external trend affecting the viability of their park.

3.6 Concluding Observations

I thus conclude that if STPs are to have an impact on entrepreneurship, on effective technology transfer, and on regional economic development in the future, they must first indemnify themselves from future decline or obsolescence. A first step in that direction is for park directors to not only understand existing trends but also understand the future role that park stakeholders will play.

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CHAPTER 4

Science Technology Parks and Close Relations: Heterogeneity, Context and Data

Mike Wright and Paul Westhead

4.1 Introduction

Science and Technology Parks (STPs) involve policy initiatives aimed at enabling new technology-based firms (NTBFs) to circumvent potential market failures in gaining access to resources (Chan and Lau 2005) required to address the potential liabilities of NTBF newness (Stinchcombe 1965; Sofouli and Vonortas 2007), smallness (Aldrich and Auster 1986) and/or location in less developed (Albahari et al. 2018) peripheral region (McAdam et al. 2004; Martin et al. 2005; Mueller et al. 2012).

There is a long-established debate surrounding the nature and impact of STPs on regional development and on the firms located on them (Link and Scott 2006; Phan et al. 2005). As illustrated in the previous chapter, there is growing recognition that STPs are quite varied, and at the same

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time agreeing a definition has been problematical. While the traditional focus has been on STPs, the innovation landscape is changing, not least as informal intellectual property (IP) grows alongside traditional formal ITP in patents (Autio et al. 2014, 2018). The emergence of digitalization and information and communications technology (ICT) has meant disruption to traditional property-based STPs, funding needs and innovation life-cycles (Nambisan et al. 2019). These developments have given rise to a variety of support structures with the same objective of assisting the development of firms close to a center of research excellence, whether that is a university or research lab. Accordingly, in this chapter, we explore the heterogeneity of STPs and their close relations. We adopt the broad definition of United Nations Educational, Scientific and Cultural Organization (UNESCO 2017) that includes:

> any kind of high-tech cluster such as: technopolis, science park, science city, cyber park, high-tech (industrial) park, innovation centre, R&D park, university research park, research and technology park, science and technology park, science city, science town, technology park, technology incubator, technology park, technopark, technopole and technology business incubator. (UNESCO 2017)

To this definition, we add the rapidly growing support phenomenon of business accelerators which are particularly important in providing support for early stage ventures in ICT, and are defined as:

> a fixed-term, cohort-based program, including mentorship and educational components, that culminates in a public pitch event or demo-day. (Wright and Drori 2018)

These accelerator programs are typically located within a physical space that affords interactions between the emerging entrepreneurial ventures.

Adopting this broad perspective of STPs and their close relations extends the already recognized challenges regarding the extent and nature of data required to assess their impact (Phan et al. 2005). We begin by outlining an organizing framework of analysis that reflects the heterogeneity of STPs and their close relations. We then draw on the existing literature to identify the range of outcome (i.e., dependent) and driver (i.e., independent) variables needed to assess the impact of STPs and their close relations at different contextual levels. We then discuss the data requirements implied by these variables. The subsequent section draws upon existing studies to illustrate the uses of different data sources to study the heterogeneity of STPs, incubators and accelerators. In the final section, we make some concluding remarks relating to data and assessment of the impact of science parks and close relations.

4.2 Levels of Analysis

Phan et al. (2005) note that analysis of STPs and their close relations (i.e., incubators and accelerators) is multi-level, but that we lack a framework to understand the connection between levels, and the variety of performance and impact measures that are implied. Many studies and conceptual approaches focus only on one contextual level. A focus only on the STPs' level (European Commission 2014; Guadix et al. 2016) ignores the impact on tenants or on the locality and region. Accordingly, in considering the evaluation of STPs, it is important to consider the following three contextual levels: macro (i.e., city, regional, country), meso (i.e., STP, incubator, accelerator) and micro (i.e., tenant firm, entrepreneurial team).

STPs and their close relations are heterogeneous, giving rise to different types relating to their ownership, goals and resources. These support mechanisms may be privately owned by firms such as property corporations, private equity institutions, manufacturing corporations or private universities. They may be publicly owned by organizations such as local authorities, regional development agencies, agencies of government ministries, charities or public universities. Such ownership differences matter because they impact upon goals, activities and resources at different contextual levels (Kotlar et al. 2018). While some STPs may have for-profit goals, others' goals may be not-for-profit.

Goals and activities may be dynamic since STPs and their close relations may experience changes in ownership which may impact on what they do and have. For example, changes in the ownership of STPs in the UK relate to acquisitions by private equity firms, divestments by property companies of STPs' investments at universities, and local authorities and universities buying out private investors. As examples, Angelo Gordon recently linked with Trinity Investment Management, a private UK property company, to buy five sites that are part of the Best Network of parks owned by La Salle Investment Managers. M&G Investments, part of the Prudential, recently announced it was offloading its 50 per cent interest in Oxford Science Park to Magdalen College, which already owned the other 50 per cent. Birmingham's Innovation Campus was owned by Lloyds TSB, Birmingham

City Council and Aston University but is now wholly owned by the council. St. Modwen, a listed property company, sold its interest in Cranfield STP to an international property company. These changes may have implications that could involve less emphasis on innovation and more on property management. They may also impact the amount of data available.

Resources relate to physical accommodation, organizational support, finance, human capital and social networks (Wright 2014). Different ownership forms may imply different amounts of these resources, which may be differentially provided at the different contextual levels. With respect to impacts, the contrasting types of STPs and their close relations may place different emphases on economic, financial and social measures. The nature of these measures may vary across contextual levels. In what follows, we discuss the variables and data sources required to evaluate STPs at these three levels.

4.3 Data and Different Levels

A comprehensive review of the literature on STPs and their close relations is beyond the scope of this chapter. Recent reviews have been presented elsewhere. For reviews relating specifically to STPs, see Phan et al. (2005), Siegel et al. (2003a), Guadix et al. (2016), Lecluyse et al. (2019) and also Chap. 2 by Link in this volume. For reviews relating to incubators, see, for example, Grimaldi and Grandi (2005), and, in respect of accelerators, see Colombo et al. (2018).

Policy-makers require a rigorous evidence base to guide their resource allocation decisions with reference to STPs. Magro and Wilson (2018) suggested the following questions need to be considered in policy evaluations: Why evaluate (i.e., the purpose of the evaluation)?, What to evaluate?, How to evaluate? and Who should be responsible for evaluation? We also suggest that a policy evaluation should consider: What are the outcomes for actors at the macro, meso and macro levels? The quality of STPs' evaluation studies has been questioned (Lehmann and Menter 2018). Phan et al. (2005) warned that many studies have failed to explain in detail the level of analysis in relation to STP performance. Concern has been raised relating to evaluations that solely focus on STPs' tenant firm survival alone. For example, STPs may seek to secure rental income and to fill their premises (Westhead 1997; Squicciarini 2009), but this may encourage the survival of 'living dead' NTBFs lacking sustained competitive attributes and making modest performance outcomes. This is because this outcome (i.e., dependent) variable does not measure the efficiency of the STPs' support organization. Calls for studies to focus on a broad array of STPs' performance outcomes have been made (Westhead and Storey 1994; Westhead 1997).

Distilling the evidence from the studies in the above reviews indicates the extent and complexity of data required to measure the impact of outcome (i.e., dependent) variables at the three contextual levels. Similarly, this literature shows that the independent variables driving these impacts are wide ranging. The various dependent and independent variables are summarized in Tables 4.1 and 4.2, respectively. It is evident that some measures relate to archival financial measures while others are more qualitative in nature. Note also that some variables relate to more than one level of evaluation, suggesting a need for cross-level analyses.

To evaluate STP outcomes, there is need for rigorously conducted qualitative and quantitative studies. Several widely used methods to gather information relating to the STPs phenomenon are reported in Table 4.3. Some methods such as primary questionnaire surveys can yield only cross-sectional data, but they can also provide qualitative measures relating to independent and dependent variables. Other methods such as proprietary databases provide archival and longitudinal quantitative data, but they generally do not provide qualitative measures.

Several data sources may have to be used to identify the *population* of tenants on an STP (i.e., names and addresses of all STP tenants). STPs and related associations can provide the names and addresses of tenants. Detailed up-to-date lists of all tenants on STPs can be (but not always) listed on STPs association's websites. For example, see http://www.warwicksciencepark.co.uk/information/tenant-directory/university-of-warwick-science-park. To ensure the population of STP tenants is identified, proprietary and online databases can also be used to identify tenants that could have been omitted from the STP association database. For example, Spinouts UK (now part of Beauhurst) provides the names and addresses of university spin-out companies. Further, some online databases list the names of firms that are or have been on STPs. On the downside, some of the online databases omit STP tenants that have not obtained venture capital and/or business angel funding. The latter online databases may, therefore, identify a sub-group of the population of STP tenants.

Evidence provided by STP associations and proprietary and online databases is generally cross-sectional relating to a single point in time. In order to gather rich cross-sectional and longitudinal evidence from STP

Table 4.1 Science park outcomes (i.e., dependent variables) monitored at the macro, meso and micro levels

Macro (region/country)	*Meso (science park/incubator/accelerator)*	*Micro (tenant/entrepreneur)*
Number of firms established	Land area	Firm survival
Seedbeds for NTBFs	Total number of STPs managing institution	Employment size and growth
Job generation and growth	Years of operation	High-technology job generation and growth
High-technology job generation and growth	Number of firms on STP	Sales size and growth in wealth creation
Wealth creation/GDP growth	Number of incubated firms graduated	Wealth creation in high-technology firms
Wealth creation in high-technology firms	Type of services provided and used, number of firms established	Market share
Innovation productivity	Job generation and growth	Relative performance compared with competitors
Knowledge spillovers	High-technology job generation and growth	Financial performance, profits and return on assets
Equity and venture capital funding	Wealth creation	R&D inputs (i.e., expenditure on R&D)
Environmental benefits	Wealth creation in high-technology firms	R&D outputs (i.e., adoption of new technologies, engagement in radical or incremental innovation, patents, publications, licenses, speed of innovation)
Enhanced efficiency, development and diversification of regional economies	R&D inputs, outputs and productivity	Productivity
	Number of patents and licenses	Links with higher education institutes (HEIs) and/or other public sector organizations
	Links with HEIs and industry	Research productivity
	Equity and venture capital funding gained and amount raised	Funding received
	Number of HEI graduates employed	Equity and venture capital funding gained and amount raised
	Progress against goals	Development progress
		Exports

Sources: Authors' creation based on information from Monck et al. (1988), Westhead and Storey (1994), Lindelöf and Löfsten (2003), Squicciarini (2009), Vásquez-Urriago et al. (2014), Guadix et al. (2016), Liberati et al. (2016), Díez-Vial and Montoro-Sanchez (2017), Hobbs et al. (2017), Lecluyse et al. (2019), and Ubeda et al. (2019)

Table 4.2 Measures of drivers (i.e., independent variables) at different levels

Macro (region/country)	*Meso (STP/incubator/ accelerator)*	*Micro (firm/entrepreneur)*
Type STP/incubator/ accelerator	Type	R&D expenditure
University characteristics	Ownership	Strategy
Types of large (hi-tech) firms	Goals	Sector
Regional characteristics	Entrepreneurial expertise	Age
Other policy measures	Managed/not-managed	Human capital—entrepreneurs
Scope region/metropolitan area	Social capital	Human capital—directors
Proximity	Infrastructure	IP endowments and prototypes
	Selection criteria	Social capital
	University characteristics	Ownership [group structure]

Source: Authors' creation based on an analysis of the existing literature as per Table 3.1

Table 4.3 Comparative assessment of different data collection methods

Method	*Positive attributes*	*Downsides*
Mail surveys	Attitudinal data	Poor response rate Targeting respondent Cross-sectional
Online surveys	Attitudinal data	Limited response rate; limited scales Targeting respondent Cross-sectional
Face-to-face interviews	Rich data	Time intensive; smaller number of respondents Cross-sectional
Archival data—government required	Population data Comparator firm data Longitudinal	May omit key (qualitative) drivers Smaller, newer firm data restricted Availability depends on regime
Archival data—proprietary databases	Specialist populations	Limited longitudinal Lower size cut-offs Availability of comparator groups
STP/incubator/ accelerator 'population' or 'cohort' records	Population data; applicants and joiners; longitudinal	Accessibility

Source: Authors' creation based on an analysis of the existing literature as per Table 4.1

tenants, researchers can conduct primary survey interviews. Relating to the *population* of tenants, quantitative studies may gather primary information from all tenants at a single point in time, or they can gather primary information from a *sample* of STP tenants at a single point in time. Also, tenants can be monitored over one or more points in time. Longitudinal qualitative and quantitative studies can gather entrepreneur and firm profile (i.e., independent (and moderator) variables) and firm (and entrepreneur) performance (i.e., dependent variables) at two or more points in consistent time (i.e., firm survival, sales and employment growth, profitability, number of innovations and patents, etc.). The issue of causality (or association) between independent (i.e., time period t1) and dependent performance variables (i.e., time period t1 compared to time period t2) can, therefore, be explored in longitudinal studies.

Primary survey respondents can mis-remember and/or exaggerate with regard to their responses. STPs' tenant respondent self-report bias needs to be considered. The information collected from primary survey interviews can be complemented by data relating to each tenant held on an online database. The trustworthiness of the self-report information provided during the primary survey interviews can be compared with the information provided on an online database (or audited archival sources). In some cases, it may be possible to cross-check self-report performance data in relation to at least a sub-set of firms with archival measures (Lockett et al. 2008).

Qualitative studies have the potential to gather a broader array of information relating to STP context, inputs, processes and outcomes. These studies do not seek to contact the population of STP tenants. In order to build theory, qualitative studies can gather information from a single tenant, or a limited number of tenants (i.e., conceptualized different types of STP tenants, extreme cases, etc.). The qualitative primary interviews relating to a *sample* of STP tenants can provide rich data over several points in time. Qualitative studies focusing upon process issues relating to Where? Why? How? So what? questions can provide insights that cannot be explored in quantitative cross-sectional studies. In line with quantitative studies, such qualitative information can be complemented by data relating to each tenant firm held on an online database.

Primary and secondary online data sources may not provide all the independent and outcome variables sought. To gather appropriate data, there may be the need for data matching across different datasets using company registration numbers (CRNs), or other identifiers. In some jurisdictions, such as the UK, private companies have to provide an annual return to Companies House. The information supplied to Companies House relates to balance sheet, profit and loss account and detailed data on directors' age, location and experience. Smaller firms have exemptions regarding the amount of data that they are required to provide. The latter method can fail to gather data from newer and smaller firms (which can be pre-revenue firms) incubated and fostered by STPs. Consequently, the performance of these latter firms can be omitted from STPs' tenant performance evaluations. This method also does not provide information relating to tenants that have not selected a company legal ownership form. However, this data source can be used to gather information relating to tenants and comparable firms not located on an STP.

A further data issue concerns differences between independent and subsidiary firms located on STPs. STPs may contain both types of firms, yet data availability from public sources for each type may differ. Further, the behavior and performance of each type of firm may not be shaped by the STP location alone as, for example, head offices may determine goals, resources and what their subsidiaries are permitted to do. There is, therefore, a need for data collection and analysis to make a distinction between independent firms and subsidiary firms belonging to holding group with several branches (Westhead and Storey 1994; Squicciarini 2008; Siegel et al. 2003a; Vásquez-Urriago et al. 2014).

To access some firm outcome metrics, it may be necessary to link with government survey data. Respondents to these surveys can be provided with anonymity and confidentiality assurances that prevent individual companies from being identified. However, government data labs may provide for data matching through confidentiality walls, governmental officers effecting the matching, and researchers undertaking the analysis in the data lab without downloading the confidential dataset (for an example of this process in a different context, see Bacon et al. 2018).

Findings from STP evaluations can be distorted by sample selection issues (i.e., weaker or stronger entrepreneurs (Flynn 1993)) can self-select (i.e., advantageous selection with NTBFs selecting STPs because they have better technological capabilities prior to entry versus adverse selection (Ramirez-Aleson and Fernandez-Olmos 2018)) to locate on STPs or not (Lukes et al. 2018). Qualitative and quantitative tenant evaluations, therefore, need to gather data from a control group of comparable off-park firms that are not located (or have never been located) on an STP (Westhead and Storey 1994). Statistical techniques can also help address potential selection bias and endogeneity bias issues (Siegel et al. 2003b; Vásquez-Urriago et al. 2014; Ubeda et al. 2019). Studies exploring the links between STPs firms and several outcomes can be distorted by the 'survivor bias' issue (Amezcua et al. 2013). The latter issue needs to be considered in data collection.

4.4 Evidence on Types of Support

In this section, we provide a review of illustrative articles that demonstrate the different data sources and measures that may be used to assess the performance and impact of STPs and their close relations.

4.4.1 Science Parks

Relating to an early evaluation of STPs, Westhead (1997) found that independent firms located on STPs did not directly invest more in R&D than off-park firms nor record significantly higher levels of technology diffusion. This study also found that there were no significant differences between on- and off-park firms in relation to a variety of innovativeness measures. Further, this study covered firms in the UK and involved a 'follow-on' sample of firms interviewed in 1992/3 that had originally been interviewed in 1986 by Monck et al. (1988), as well as a 'new sample' of independent firms located on a Science Park between 1986 and 1992 (Westhead and Storey 1994). Data collection by Monck et al. (1988) involved structured face-to-face interviews, with a representative random sample of owner-managers of firms located in a diverse range of STPs' contexts in Great Britain. Self-report outcome measures were collected. In addition, they gathered primary survey evidence from a matched control group of owners-managers whose firms had never been located on an STP. Trade directories and the Yellow Pages business directory were used to identify the off-park firms. Random samples of STPs and off-park firms were matched with regard to factors generally associated with business performance (i.e., business age, main industrial activity, ownership status and standard region location). Westhead and Storey (1994) followed up on the study conducted by Monck et al. (1988) using a longitudinal comparative static methodology to ascertain, inter alia, the survival or not of STPs firms. Westhead (1997) noted that 'Existing databases, whilst containing detailed information on mature businesses were found to be deficient with regard to the identification of young technology-based firms'.

As a result, the study established a link with accounting firm KPMG to identify off-park firms. On- and off-STP firms were matched by age of firm, industry, ownership status and region to give a sample of 177 firms comprising 89 STP firms and 88 non-STP firms.

A subsequent study by Siegel et al. (2003b) used the same dataset to explore research productivity. Outputs were measured in terms of new products, patents and copyrights with input measures, besides STP location, related to R&D expenditure and RDSCI. Data used was facilitated by access to the International Chamber of Commerce (ICC) / Forecasting Analysis and Modeling Environment (FAME) database. This study found that firms based on a university STPs show higher research productivity than equivalent firms not located on a university STP. However, these outcomes were less strong when they statistically controlled for endogeneity bias, or the possibility that the location on a science and the generation of research are jointly determined.

Relatively few studies encompass the heterogeneity of STPs' support structures. An exception is the study by Minguillo et al. (2015) that provided evidence indicating that output in terms of research publications relating to different support infrastructures varied regionally. Also, they found that Science Parks and Research Parks were the most successful infrastructures in fostering cooperation and research production in UK compared to Science and Innovation centers, Technology parks, Incubators and other parks. They found that parks had a positive impact on the overall level of collaboration and production of science and technology, which were highly concentrated in competitive regions. Further, on-park firms collaborated with partners beyond the local region rather than the local HEI. It was found that support infrastructures did not help to reduce the uneven development and geographic distribution of research-intensive industries in the UK. This study illustrated the use of a dataset from a novel source. Research publications associated with UK STPs were identified from Scopus for the period 1975 to 2010 and analyzed by region, infrastructure type and organization type.

Newer firms typically face severe resource constraints and need to search for resources from various avenues. Khavandkar et al. (2016) detected that STPs' resource search strategies were positively related to performance. To access data, this study used an online survey of 385 firms across 12 regions, located in 91 science and technology parks as well as innovation centers and accelerators in the UK (Khavandkar 2018). Search strategies were measured in terms of offsite market-driven search strategy, onsite market-driven search strategy, science-driven search strategy, institutional search strategy and technical and application-driven search strategy. Performance was measured using self-report measures relating to the degree of firms' development over the previous three years relative to main competitors in terms of: sales growth, turnover growth, profitability, market share and open system performance (i.e., adaptability to market changes, image of the firm and its products/services, and quality of products/services).

Firms located on STPs may create spillover benefits for firms not located on STPs. The study by Filatotchev et al. (2011) in China detected that returnee entrepreneurs, which is Chinese nationals who returned to China following education or work experience in a developed market economy, located on STPs created a significant spillover effect that promoted innovation in other local high-tech firms. The extent of spillover effect was positively moderated by the non-returnee firm's absorptive capacity approximated by the skill level of employees. This study benefited from a data collection approach in which all high-tech firms were compulsorily required to provide annual financial statements to the Management Committee of the ZSP science park in Beijing. The dataset included information on operations, performance, R&D Personnel, R&D activities and expenditure on importing foreign technology. The study involved high-tech SMEs with less than 300 employees and a total value of sales below Chinese RMB 5 million. The STP was very large, enabling the study to comprise 1318 firms, of which 222 were foreign-owned, 128 were founded by returnees and 968 non-returnee firms.

4.4.2 Incubators

Studies have recognized the different nature of incubators in terms of their organization, activities, services and objectives (Aernoudt 2004; Grimaldi and Grandi 2005), but they have generally focused on their impact in terms of an undifferentiated measure of the extent of innovation. Barbero et al. (2014) have asserted that the nature of innovation may vary across types of incubator. They found that within the Andalucia region in Spain the nature of innovation was influenced by incubator heterogeneity in terms of their ownership and objectives, sector focus and size in terms of start-ups supported, as well the technological, market and managerial support knowledge they provided (Table 4.4). Ownership and objectives categories were found to relate to basic research, private ownership, university ownership and economic development. As a result, each

Table 4.4 Incubator within-region heterogeneity: The case of Andalucia

Characteristic	*Basic research*	*Private*	*University*	*Economic development*
Sector focus	Focused	Focused	University-wide	Very broad; 10% technology
Number of start-ups hosted	Few	Few	Many	Many
Technology and market knowledge provided	Specialist events and close university ties to access new technological knowledge	Specialist, leading technical knowledge from parent's R&D department and outsourcing to universities	General training for ventures in doing business; access to university laboratories	General knowledge on doing business and secondary source information
Managerial knowledge provided	Deep technical sector knowledge of plastics sector; board comprises financial and sector expertise	Highly capable core company managers with sector experience; boards comprise deep sector experience	Little specialized knowledge on start-ups	Experience of limited relevance to start-ups
Nature of innovation (%)				
Product	46	22	14	8
Technological process	49	56	33	8
Organizational	38	56	29	31

Source: Authors' creation based information in Barbero et al. (2014)

incubator resulted in a range of innovation outputs concerning product, technological process and organizational innovation. However, there were significant differences in the relative importance of different types of innovation. This study was based on a questionnaire survey of key informants in 80 registered incubators in the Andalucia Innovation System in Spain, in relation to activity and impact self-report measures. Access to data benefited from the official registry of incubators created by the Innovation Ministry in Andalusia, which enabled the population to be identified.

4.4.3 Accelerators

Accelerator programs are a more recent new generational organizational support mechanism to support emerging high-tech ventures, especially in digital and ICT areas. The number of accelerator programs recorded rapid growth from around 2010. In Europe, they are concentrated in large cities such as London and Paris. Unlike traditional science parks and incubators, accelerators are not designed to provide physical resources or office support services over an indeterminate period. Rather they focused on a time-limited 3- to 6-month program of mentoring and coaching to get the start-ups to the point of being investment ready. As such, accelerators attempt to effectively compress the time taken to move through the early start-up stages (Qin et al. 2018). Accelerators typically provide pre-seed investment, frequently in exchange for equity, though this is less likely in public sector accelerators. With a focus on very early stage ventures, a principal aim of many accelerators is to be able to connect entrepreneurs with business angels to fund the next stage in their financing.

Although the basic program elements are quite common across accelerators, there is heterogeneity in terms of whether a particular accelerator is focused on one industry sector, or is generic covering various sectors. There are some differences between London and Paris in the relative importance of generic and specialist accelerators. Future growth in the number of accelerators is anticipated with specialist accelerators particularly focusing upon healthtech and fintech (Wright and Drori 2018).

Ownership of accelerators varies and includes financial firms, manufacturing and service corporations, universities, governmental and other public sector agencies, and charities. Table 4.5 shows that this ownership variety may differ across different locations and be associated with different accelerator goals and objectives.

Using detailed face-to-face fieldwork and data from accelerator websites in Berlin, London and Paris, Pauwels et al. (2016) identified three broad

Table 4.5 Accelerators: regions, types and ownership

	Berlin	*London*	*Paris*
Welfare stimulator [mainly generic]	**Corporates** Government Universities	**Leading universities** *Government* Charities	**Government** *Public sector corporates*
Deal-flow makers [mainly generic]	**Corporates**	**VCs, Angels**	**VCs, Angels**
Ecosystem builder [mainly specialized]	–	**Corporates** *Government*	**Corporates** *Government*

Source: Authors' creation based on information from Pauwels et al. (2016) and Wright and Drori (2018)

Note: Cell font size reflects relative importance of each type approaches adopted by accelerators. *Deal-flow maker accelerators* that receive funding from investors such as business angels, venture capital funds or corporate venture capital with the main aim being to identify promising investment opportunities so as to bridge the equity gap between early stage projects and investable businesses. *Ecosystem builders* are accelerators typically established by corporations that wish to develop an ecosystem of customers and stakeholders around their company. Large companies such as Microsoft and Accenture install or support an ecosystem builder accelerator in order to extend their network of stakeholders. The *welfare* stimulator accelerator type generally has government agencies as a main stakeholder. The primary objective of this type of accelerators is to stimulate start-up activity and foster economic growth, either within a particular region or specific technological sector.

Fehder and Hochberg (2018) explored panel data in the US relating to 59 accelerators in 38 regions, which were then matched to regions without accelerators. They detected that regions with accelerators reported more venture capital funding amounts and the number of funders for start-ups. Also, they found that there were spillover benefits to firms and entrepreneurs not attending an accelerator. Regions with accelerators tended to shift toward a higher share of early stage software and information technology-related venture capital deals. Interestingly, the funding increase experienced was less about the effect of accelerator programs on firms that attend them but more about the effect of such programs on stimulating entrepreneurship activity.

Accelerators can promote links with investors that enable firms to more quickly obtain external finance (Mejia and Gopal 2015). Studies have examined the outcomes from accelerator participation at the end of the program. Accelerator-backed start-ups have been found to exit faster than business angel-backed start-ups through acquisitions and quitting. Accelerator-backed start-ups have also been found to receive follow-on VC funding more quickly in the short-run (Hallen et al. 2015; Winston Smith and Hannigan 2014).

At the accelerator process level, Qin et al. (2018) obtained access to a leading accelerator in China, and they followed a cohort of ventures as they went through the program. Information gathered focused upon how the acceleration processes unfolded relating the development of each venture. Data collection involved interviews and questionnaire surveys with 25 participating ventures every two months over a one-year period (i.e., from selection into the program to graduation). Data was also gathered by shadowing accelerator activities relating to seminars, mentor meetings, social events involving the participants and the demo day. This information was triangulated with documents and reports gathered by the accelerator, and interviews with accelerator administrators.

In contrast to this study, Breznitz and Zhang (2019) compared different accelerators associated with a university in Canada. They found that accelerators with habitual entrepreneur (i.e., prior business ownership experience) directors and those with longer programs were associated with a higher number of products offered by cohort firms. However, they did not collect data relating to the elements within accelerator processes associated with outcomes. Notably, Qin et al. (2018) detected that even within a program of a particular length there are different outcomes. The insights from these two studies suggest a need for cross-level data collection and analyses that compare both between and within accelerator impacts.

4.5 Discussion and Conclusions

In this chapter, we have adopted a broad definition of support mechanisms for entrepreneurship that includes traditional STPs as well as their close relations. Besides looking in detail at data and impact issues relating to STPs, we have considered incubators and accelerators as two distinct but related types.

Collecting the data required to undertake assessments of the impact of STPs and their close relations is challenging. Given the paucity of data availability regarding some aspects of the measures needed to assess impact, especially for smaller and newer firms, there appears to be a need for at least some reliance on data provided by STPs and their close relations themselves. This of course begs the question of what is the incentive for them to provide this information. Provision of data may be useful to enable STPs and close relations to benchmark themselves, for example, through enabling access to anonymized online databases. Data provision would also enable governmental or other agencies to produce regular trends reports. As an example of a related area where data collection has enabled more transparency regarding activity in the UK is an annual survey of universities that collects data on their interaction with business including patents, licensing, spin-offs and so on (HESA 2017).

While we have highlighted the need to collect data that enables analysis of STPs diversity, studies should not solely focus upon comparing STPs and off-park firms. There is also a need to conceptualize different 'types' of STPs (Clarysse et al. 2005). Evaluations need to explore the beneficial outcomes associated with each 'type'. The goals (i.e., beneficial outcomes) sought by policy-makers and STPs owners and managers may not be the same as those sought by tenant firm owners. Further, some STPs are located in institutionally laggard environments relating to support for enterprise and NTBFs. The goals of STPs, the tenants selected and the services supplied in these potentially 'institutionally void environments' (Mrkajic 2017) may not be the same as those reported by STPs located in more 'institutionally supportive and resource munificent environments'. The beneficial outcomes that need to be monitored in one context may, therefore, not be exactly the same as those monitored in other contexts. Consequently, future studies need to monitor a diverse array of economic, social and environmental outcome measures.

Recognition of the heterogeneity within types of STPs and their close relations clearly shows that in analyzing outcomes and impact it is insufficient to compare firms participating in these support mechanisms with those that do not using a simple dummy variable. For example, with regard to a county-level panel dataset, Wallsten (2004) explored the provision or not of STPs at a county level in relation to job growth and the take-up of venture capital. This study found no positive effect of STPs on regional development. More fine-grained measures relating to type of STPs and their close relations with regard to their goals and the resources they provide are needed.

The scope of data to be collected also raises the issue of feasibility, especially if the intention is to compile panel datasets. Cost and time commitment issues are of particular importance because there is a need for flexibility to allow datasets to accommodate new developments and measures. One option to consider is to identify core measures that can be collected on a regular basis, and then to connect this data to other datasets as required for particular analyses.

Evaluations focusing upon regional impacts need to recognize that some demand and supply elements will be cross-regional. There is evidence that suggests a significant proportion of business angels invest outside their home regions (Wright et al. 2015). For example, experienced spin-off entrepreneurs outside the so-called South East Golden Triangle in England have been found to obtain venture capital from outside their home region (Mueller et al. 2012). Similarly, venture capital providers located in less developed regions may invest in more high-tech regions (Wilson et al. 2018a).

There is a need for additional research evidence relating to financing market failures that lead to the existence, nature and size of funding gaps. For example, Wilson et al. (2018a, b) combined data from proprietary venture capital and private equity databases, quantitative and qualitative data from UK Companies House, as well as a range of macro-variables to estimate the size of the equity gap for knowledge-intensive firms in the UK. However, there appears to be little analysis of parallel questions relating to a Science Park Gap. Concerns about the impact of STPs and their close relations, changes in ownership and the emergence of new organizational forms of support for entrepreneurial high-tech ventures raise questions about the existence of a Science Park Gap. While STPs and their close relations are established as solutions to address market failures faced by NTBFs and growing high-tech firms, the heterogeneity in STPs that we have highlighted suggests that there is a need for data that enables us to understand what specific role STPs have in addressing market failures, and how effective they are.

In conclusion, this chapter has highlighted the heterogeneity of STPs and their close relations, the different levels of context they relate to, and the types of qualitative and quantitative data required to rigorously monitor the assumed beneficial outcomes fostered by STPs. More longitudinal studies covering longer periods of analysis and using multiple sophisticated techniques in relation to a broad array of outcomes are required to generate a robust evidence base to guide the resource allocation decision of policy-makers and practitioners with regard to the STPs and close relations phenomenon. We hope that this chapter has provided insights into the kind of pathways to accessing and compiling the data that is needed.

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CHAPTER 5

The Experience of Spanish Science and Technology Parks: Gathering Data

Soledad Díaz Campos

5.1 Introduction

During this chapter, it will be described how over the last 20 years, the Association of Science and Technology Parks of Spain (APTE) has been developing a methodology in the systematic collection of activity data from its members. This is a difficult task that takes place at the beginning of the year and requires insistence, analysis and a good eye to homogenize the data that arrive in different ways from our members.

The objective was to obtain a series of data that could be compared year after year in order to be able to check the evolution of the activity of Spanish science and technology parks (STPs).

Furthermore, we will try to explain the importance of having a systematic methodology for the collection and analysis of activity indicators of science and technology parks (STPs) and their entities to demonstrate with data the important role of STPs in our country. In addition, I am going to give several examples of studies carried out demonstrating the

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impact that STPs have at a socio-economic level and how all of them together contribute to increasing the degree of innovation and competitiveness of our innovation system.

5.2 The Association of Science and Technology Parks of Spain (APTE)

APTE was created in 1989 by a group of professionals interested in the technological development of Spanish companies and promoters of the first six science and technology parks in the country.

This is how this Association was born, which to this day has been characterized by being a large family in which all its members participate and support the joint development of activities aimed at promoting scientific and technological development, technology transfer and cooperation of companies and entities located in science and technology parks throughout the country.

APTE is a non-profit association whose main objective is to collaborate, through empowerment and dissemination of science and technology parks, renewal and diversification of productive activity, technological progress and economic development.

It is located in the headquarters of the Technology Park of Andalucía (Málaga) and is an associate member of the International Association of Science Parks and Areas of Innovation (IASP). It currently has **64 members** scattered throughout the Spanish geography. Fifty-one of them are **Full members**, ten are Affiliates that are under development, two members are Collaborators and finally one Honorary member. Twenty-four of these parks are sponsored by universities, and **46 Spanish universities collaborate with them**. In 2018, these parks located **8.157 entities** that billed **28.984 million Euros**. These companies provide employment to over **175.763 people**, of which 34.291 are engaged in R&D.

For APTE, an STP is a project, generally associated with a physical space, with the following characteristics:

1. Formal and operational dealings with universities, research centers and higher educational institutions.
2. Designed to encourage the creation and growth of knowledge-based companies and other organizations belonging to the service sector, which are normally established in the park itself, with a high added value.

3. A stable managing body that promotes the transfer of technology and fosters innovation between the companies and organizations using the park.

However, we consider that the managing entity for STPs is the key element because it promotes and fosters collaborations and synergies between different stakeholders located inside of STPs. In this sense, we like to compare an STP to an airport because in both places people arrive and meet with others, these meetings produce new business and these businesses grow up and take off. In short, an STP provides a series of advantages for the companies and entities that are in them. Among the most important for them, we highlight the following:

- Excellent infrastructures and communications
- Nearness with the university and the possibility of having research services
- Wide range of common services: day-care centers, restaurants, financial institutions, vigilance, medical services, advice and so on
- Cooperation with tenants located in others STPs
- Access to international markets
- Prestige
- Business and innovative environment

Furthermore, it is important to review the STP's history and see how the emergence of STPs in Spain was a great boost to the development of innovative companies.

Spain has been one of the most active countries in Europe in the creation of science and technology parks. If we look back, approximately 30 years ago, new projects began to emerge in Spain, known as technology parks and later as science and technology parks, which were intended to improve the competitiveness of Spanish industry, which at that time was in a downward spiral. This improvement of the industry went through the approach to the new technologies of the moment, among them, an incipient internet and a shy contact with the scarce R&D. During those first years, many companies had contact for the first time with these new technologies when they were installed in an STP. Now, the parks have a similar challenge to that because their mission is to bring their companies and entities closer to disruptive technologies and to promote business digitalization.

Little by little STPs were appearing all over the country developed by regional governments because each time that an STP was created, it produced a strong impact on local industry. In addition, the university also begins to get involved in the development and promotion of STPs, so that progressively, these begin to develop a unique ecosystem until now, because in the same place coexisted companies, researchers, public administration, investors and entrepreneurs.

Currently, companies and entities that are in STPs tend to have higher indicators of innovation and competitiveness than those outside them. In addition, during the toughest years of the economic crisis, companies located in parks had lower mortality rates than those located elsewhere.

For all the above, APTE has ten reasons why science and technology parks should be considered as intermediate organisms of the Spanish innovation system:

1. STPs are spaces that promote the creation of innovative startups.
2. STPs are agents of proximity.
3. STPs generate employment.
4. STPs have softened the effect of recent financial crisis.
5. STPs contribute to local and regional socio-economic development.
6. STPs are physical environments of excellence.
7. STPs have created a big network (APTE).
8. STPs foster collaboration between academia and industry.
9. STPs are recognized worldwide as facilitators of innovation activity.
10. STPs disseminate innovations to society.

However, in order to demonstrate that these ten reasons are based on objective data, we must achieve them and, for this, it is vitally important to have a systematic methodology for compiling activity indicators of science and technology parks and their companies and entities.

5.3 The Importance of Measuring the Activity of Science and Technology Parks

APTE began collecting statistical data from its members in 1997. However, at that time, the Association had only 15 members in which 500 companies were located with 13,000 employees (4777 in R&D activities) and a turnover of 1064 million Euros. At that time, the only data requested were those relating to the number of companies, employment, employment in R&D and turnover.

In 2000, we started to ask our members information about the activity of their companies and institutions in order to know the sectors of their activity. However, we got a long list of different activities that was difficult to publish. For this reason, we grouped the activities of the companies in large sectorial blocks, so that it was easy to represent graphically. In this way, we created our own sector classification, which has been active for 20 years.

Over the last 20 years, the Association of Science and Technology Parks of Spain has developed the same methodology for collecting data from its members. During that time our tool for data collection has been an excel sheet where we ask our members the following 12 indicators:

1. Companies
2. Turnover
3. Employees
4. Employees in R&D
5. Employees per gender
6. Investment in R&D
7. Companies with foreign capital
8. Companies in incubation
9. Patents applied
10. Patents granted
11. Set-up companies
12. Settled companies

Thanks to the compilation of these statistics every year, we have been able to see the great impact and growth of the activity of Spanish science and technology parks over the last 20 years.

In this respect, STPs are places where economic and business activity has been increasing year after year. These spaces have multiplied by 16 the number of companies installed on them since 1997 to reach 8157 companies by the end of 2018. This growth in the number of entities is justified by the benefits for them of settling in an STP, where entrepreneurs have numerous state-of-the-art infrastructures, such as laboratories and research centers, as well as facilities to develop new business incubator projects or business incubators. It is precisely these startups that are currently generating employment in Spain.

We cannot say that STPs survive the crisis without any kind of problem, but we can say that the companies located in them have been able to survive to a greater extent than those located outside the STPs. Aspects such as high innovation and a clear international vocation have greatly helped these companies to move forward with their activity and mitigate the damage of the financial crisis in Spain.

We have compared the results of the statistics on R&D activities of the National Institute of Statistics with the statistics on the activity of Spanish STPs and we have found that if, at a general level, companies with between 10 and 49 employees who do R&D have decreased by 44.2% during the period 2008–2013, the companies located in the parks have not stopped growing during these years, even registering an increase of 27% with respect to 2008.

As with the creation of companies, **Spanish STPs are an important source of qualified job creation, and this has multiplied by 13 in the last 20 years**. Spanish science and technology parks are not only a place to "get a job", but they are places where people can advance and progress in their careers, even betting on entrepreneurship. For the development of these new professional challenges, they meet other people from the same environment as the STPs, whether they are other entrepreneurs or even teachers or researchers, with whom they can carry out collaborative activities that will help them to build solid and viable projects. In this way, parks are also an opportunity for many young people who finish their studies to develop their professional careers without having to change region or country. In relation to employment in STP, it is important to highlight the high number of professionals dedicated exclusively to R&D activities, specifically, almost 34,300 people at the end of 2018.

The ecosystem that makes up the Spanish STPs means that companies in these places have a higher turnover than those outside them. In fact, this has been the indicator of activity of companies in the parks that has grown the most in the last 20 years.

In summary, as shown in Fig. 5.1, thanks to the fact that we have measured the activity of the companies and entities of the parks with the same system over the last 20 years, we have been able to see how the number of companies has multiplied by 16, the number of workers in the entities and companies in the parks has multiplied by 13, turnover by 27 and R&D employment by 7.

However, we must say that most of STPs only send us the first six indicators and with a lot of difficulty. Every year an important number of companies and institutions refuse to provide their information. We consider this method we use to be the most efficient because it is the one we have been using for the last few years and it is the one our members are used to.

Fig. 5.1 Activities of the parks over the last 20 years. (Source: Author's creation based on data provided by the Spanish Association of Science and Technology Parks, https://www.apte.org/en/apte-reports. Accessed March 19, 2019)

During the data collection process we encounter different barriers, which increase year after year. For example, this year the data protection law is stricter and this makes it more difficult to obtain data. Also, companies receive a lot of surveys every day. Furthermore, sometimes, our members have different criteria to consider turnover and employment of multinationals with delegation in other places or countries. In addition, some STPs do not collect data at same time, and this can make the process of analysis of the information difficult.

That situation makes our data collection process difficult to develop; for that reason, it is very important to fix the same rules and criteria during the collection, analysis, understanding and classification of the data.

5.4 Some Studies Based on Spanish Science and Technology Parks Indicators

In this section, we are going to highlight three important studies that have measured the socio-economic impact of the activity of companies and activities of Spanish science and technology parks:

5.4.1 Study of the Social and Economic Impact of Spanish Science and Technology Parks

This was the first study on the socio-economic impact of the parks carried out by APTE in collaboration with the consultancy Información y Desarrollo S.L. (INFYDE) and with the support of de Ministry of Education and Science.

The study was carried out in 2007 about direct and induced economic impact of the activity of 11 STPs in 2005.

The tools used were input-output tables produced by the regional and national statistical institutes to obtain the impact multipliers that allowed them to measure the dragging effect on the rest of the economy. In this sense, three variables were considered: Gross Domestic Product (GDP), employment and taxation. Also, the study has three levels of analysis: national, regional-provincial and at the level of the 11 STPs that participated in the study.

The most important findings of this study are the followings ones:

- **The turnover of the companies in Spanish STPs was 0.44% of Spanish production that year.** This is something that is significant if we consider the relatively small surface area occupied by the parks included in the study in terms relative to the total of that existing in Spain.
- **The gross domestic product at market prices generated by the Spanish STPs accounted for 0.65% of the Spanish total.** The share of Spanish STPs in Spanish GDP was higher than the share in total production, from which it can be deduced that the production sectors that bring together the parks generated greater added value than the average Spanish production. However, at provincial level, in that province where there is an STP, the percentage is higher, reaching 1.05%.

- **The employment generated by the parks accounted for 0.60% of the Spanish total**. At provincial level, the percentage is higher, 1.12%.
- **The total revenue collected by public administrations thanks to the activity carried out by companies and entities of the parks can be estimated at 1695.61 million Euros**. This is one of the most significant results because it proves the public investment on Spanish STP produced an important return on investment for public administrations.
- **The R&D employment of the companies in the STPs accounts for 5.8% of the national aggregate**. Nevertheless, in those provinces where there is a park, the percentage of contribution is higher, reaching 8.5%.
- **The labor productivity of companies and entities of STPs is quite higher than the national average productivity, specifically 162% higher.**

The study demonstrates the great contribution of STPs at the provincial level, so it estimates what the contribution to the national total of parks would be if there were one park per province. In that case, the initial percentages of turnover and GDP at market prices will be duplicate. In addition, the contribution to the total national employment would be higher, reaching 0.93%. The total revenue would be registering a strong growth, increasing by 170%. Finally, the share of R&D employment of parks in the national total would increase from 5.8% to 11.28%. See Table 5.1.

Table 5.1 Summary of the main results

	Contribution of STPs at national level	*Contribution of STPs at provincial level where there is an STP*	*Contribution if there is an STP per province*
Turnover	0.44%		0.86%
GDP mp	0.65%	1.05%	1.27%
Employment	0.60%	1.12%	0.93%
Tax revenue	1695.61 million Euros		2920.92 million Euros
R&D employment	5.8%	8.5%	11.28%

Source: Author's creation based on information at https://studylib.net/doc/18690003/a-study-of-the-social-and-economic-impact-of-spanish-science. Accessed May 15, 2019

5.4.2 Estimation of the Impact of Spanish STPs on the Innovative Activity of Companies

This was the second study in which our association was involved and it **marked a before and after in demonstrating the positive impact of science and technology parks on the innovative activity of companies because it contrasts with some of the previous literature**, which has not found significant effects of STPs on the performance of companies.

It was carried out during 2011 by a research team led by Dra. Aurelia Modrego and which included the following persons: Dr. Andrés Barge-Gil, doctoral student Ángela Vásquez Urriago and Dra. Evita Paraskevopoulo. The team was advised by Jordi Molas and José Luís Virumbrales, and the study was financed by the Ministry of Science and Innovation with the collaboration of the National Statistics Institute and the Association of Science and Technology Parks of Spain.

The empirical analysis was carried out using the information corresponding to the year 2007 from the Survey on Technological Innovation of Spanish Companies, which is collected annually by the National Statistics Institute (INE) and with a sample of 39,722 companies, of which 653 were located in 22 STPs. This was the first time that a survey like a Community Innovation Survey (CIS) was used to evaluate the impact of science and technology parks.

Thanks to the agreement reached between the research team and the National Institute of Statistics, in 2007, the survey included for the first time a new question to provide information about if a company was or not located in an STP. This question opened a large window of possibilities when comparing the innovation indicators of the companies that were inside and outside the parks.

The results of the estimation of the innovation effect on companies of being located in a park (also known as STP's effect), assuming homogeneous effects, determine that **the location in an STP increases the probability that a company will introduce new products to the market between 10% and 18% and increases in a 32% the percentage of sales derived from these products,** when considering the subsample of these innovative companies.

5.4.3 Study of the Contribution of Science and Technology Parks and Technology Centers to the Goals of the Lisbon Strategy in Spain

The last study in which our association took part was the one carried out by the consultancy INFYDE between January and June 2011 at the request of the DG REGIO (European Commission).

The study had three goals:

1. Analyze and assess local, regional and national impacts of STPs and Technology Centers (TCs) in Spain in terms of economic growth, competitiveness, employment, and innovative and entrepreneurship capacities.
2. Identify best practices regarding the development and management of STPs and TCs in Spain and an in-depth analysis of success factors in their development.
3. Offer conclusions and strategic recommendations for the creation and management of STPs and TCs to optimize their territorial impact and improve competitiveness and innovative technology in their environments and sectors.

The methodology combines a quantitative approach and a qualitative one. The quantitative approach includes a micro and a macro analysis. In the macro dimension, the study is very similar to the first study and explained direct and induced regional GDP impact of STP with all tenants, direct and induced employment impact of STP with all tenants and direct impact on tax revenues of STP with all tenants.

The big difference on this occasion was the use of an important database called **PITEC** (the Technological Innovation Panel). This is a panel-type database that allows the monitoring of the technological innovation activities of Spanish companies, the result of the joint effort of the National Statistics Institute (INE) and the Spanish Foundation for Science and Technology together with the advice of a group of academic experts. With data from 2003, its final objective is to contribute to improving the statistical information available on the technological activities of companies and the conditions for carrying out scientific research on them. PITEC included information of 11,275 Spanish companies with 506 variables, including information about if these companies were location in an STP or not. Also, the micro analysis was a request for basic economic data sent to 21 STPs.

For the qualitative approach, the study included literature review on STPs and TCs' impact assessment and evaluation studies and methodologies. Also, 5 territorial Case Studies on STPs in Andalucía, Balearic Islands, Canary Islands, Basque Country and Castilla y Léon were included in the study. In addition, during the development of the study were elaborated 27 face-to-face interviews to national and regional policymakers and experts on Science Policy, SPTs and TCs promotion and development in Spain.

During the elaboration of the study, following methodology constraints were detected:

- Time and budget limit for such a huge field of analysis
- Limited return of answers to the survey and request for data
- Heterogeneity of STPs and centers, which makes it difficult to establish general conclusions and recommendations

The most important findings were the following ones:

- STPs represent 11.5% of all R&D jobs (full-time equivalent) in Spain in 2009.
- The total impact on the GDP reaches 2.2% at regional level and 2.74% at provincial level where there is an STP.
- The total impact on employment was 2.67% at regional level and 3.42% at provincial level where there is an STP.

The findings of this study were very important for our Association because they let us know the increase of some indicators analyzed in previous studies. For example, the indicator about R&D employment increased from 5.8% in 2005 to 11.5% in 2009. Also, we could check the impact of STPs at local level where they are located.

5.5 Conclusions

We consider that it has become clear throughout this chapter that STPs have an important positive effect on our innovation ecosystem.

On July 2010, the European Economic and Social Committee (EECS) published an opinion document with several recommendations called "European Technology, Industrial and Science Parks in the crisis management, preparation of the after-crisis and post-Lisbon strategy period". Some of these recommendations were the following ones:

> *The EESC acknowledges the significance of the Technology, Industrial and Science Parks (TISPs) in the support of economic development and modernisation. The structures established support industrial change by the smart specialisation, concentration of resources and knowledge base.*
>
> *The EU needs a more focused and integrated approach geared towards sustaining and developing the TISPs of the 21st century. Particularly in the crisis and post crisis context, a more comprehensive strategy should be followed, to capture the potential benefits of parks for economic growth and competitiveness. These actions have to be implemented with leadership and ambition on behalf of the EU.*
>
> *The observatory–evaluation–accreditation activities in the field should be initiated and supported, together with the dissemination of good practices. Assessment and comparative empirical studies are required to frame concerted European and national policies and instruments related to park formation and growth. It is desirable to support the mapping of TISPs across Europe in the form of comprehensive database. This may facilitate collaborations among the parks by creating an interconnecting matrix that promotes connectivity to overcome regional barriers to growth.*

We think the time has come to listen again to these recommendations. This book may be a first step toward a systematic and harmonized data collection across all European STPs in order to get annual statistical reports measuring the growth of the economic indicators of European science and technology parks and their socio-economic impact.

CHAPTER 6

Science Parks and Place-based Innovation

Claire Nauwelaers, Alexander Kleibrink, and Katerina Ciampi Stancova

6.1 Introduction

Science and technology parks (STPs) are an instrument to boost the knowledge-intensive development of places. They have been established already in the 1950s in the United States, with the initial aim to foster the commercialisation of university research. Subsequently, regional planners have integrated STPs in many countries in the portfolio of regional development tools, keen to follow the models of Silicon Valley and the Stanford Industrial Park (Saxenian 1996). Their objective was to organise regional development around science-based growth poles by stimulating

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economic diversification away from declining industries. In response to these regional development goals, European Union Cohesion Funds have been called to support the establishment and the development of STPs. National initiatives have also supported STPs to attract inward investments and create development poles either in central urban areas or in the urban periphery connecting with the *hinterland*.

Today, STPs are present in many European regions: they concentrate a wide range of innovative companies and research organisations, and as a consequence the overall knowledge intensity of these places is very high. STPs are thus likely to include seeds for the domains of knowledge-intensive specialisation, on which regions can rely to increase their competitiveness. This is why STPs seem well placed to play a key role in place-based innovation policies. They are particularly relevant for Research and Innovation Strategies for Smart Specialisation (RIS3) in the European Union, where novel legal requirements introduced the need for regional and national authorities to strategically prioritise the most promising domains in 2013.[1]

But what could this role of STPs consist of? And what are the challenges faced by STPs willing to bring their contribution to—and benefit from—smart specialisation strategies? This chapter provides responses to these questions based on the exploitation of existing knowledge with respect to the role of STPs in regional development.

Section 6.2 highlights the diversity of STP models. It discusses the findings from empirical research about the success factors of STPs in influencing regional development paths, linking this to the various STP models. The existence of different STP models suggests that there might be different answers to the question of the role of STPs in smart specialisation, as some models might better fit smart specialisation objectives than others.

Section 6.3 discusses the specific challenges of smart specialisation and relates these to the understanding of STPs' role in knowledge-intensive regional development. Three key roles for Science Parks in the design and implementation of smart specialisation strategies are proposed:

[1] Foray and Van Ark (2007), in a Policy Brief of the KfG Expert Group, argue that "smart specialisation" in research, at the level of countries or regions, holds considerable opportunities for facilitating agglomeration and excellence which in themselves may make the EU a more attractive destination for R&D investment. What is implicitly proposed here is a shift from the traditional (almost) thematically/regionally neutral and "generic" orientation of R&D funding instruments to a thematically/regionally focused one. The rationale behind "smart specialisation" has to do with avoiding duplication in thematic orientations between geographic areas. To counter duplication, they argue, regions with similar thematic aspirations may engage in "smart specialisation". Source: http://publications.jrc.ec.europa.eu/repository/bitstream/JRC51665/jrc51665.pdf

1. STPs may provide an adequate innovation ecosystem for the development of pilot innovation initiatives, well in line with the entrepreneurial discovery process that should drive the regional economies towards new, distinctive and competitive domains of activities.
2. STPs can play an important role as one of the relevant stakeholders forming the quadruple helix of innovation actors shaping smart specialisation strategies.
3. STPs can add the needed external and outward-looking dimension to smart specialisation strategies, a dimension that is today still very much under-developed.

These contributions from STPs cannot be taken for granted though. We identify limitations and success conditions for each of the three roles.

Illustrative examples of STPs from Finland, England and the Netherlands are provided in Sect. 6.4.

The concluding section spells out a new agenda for STPs, in view of making the most of their potential contributions to smart specialisation strategies across European regions and states.

6.2 The Role of Science Parks in Regional Innovation Strategies

6.2.1 The STP Concept

Given the long history of STPs, it is not surprising that the concept has given birth to a diversity of different models in practice. Differences stem from their origins, driving forces and territorial contexts in which they have been established. The core elements of the concept are encapsulated in the definition adopted by the International Association of Science Parks and Areas of Innovation (IASP):

> *A Science Park is an organisation managed by specialised professionals, whose main aim is to increase the wealth of its community by promoting the culture of innovation and the competitiveness of its associated businesses and knowledge-based institutions. To enable these goals to be met, a Science Park: stimulates and manages the flow of knowledge and technology amongst universities, R&D institutions, companies and markets; facilitates the creation and growth of innovation-based companies through incubation and spin-off processes; and provides other value-added services together with high quality space and facilities.*

From this definition, we can infer five key elements that characterise STPs:

1. A localised economic development goal;
2. A focus on fostering science-industry relationships;
3. A priority placed on innovative and technology-based activities;
4. The provision of value-added services to companies;
5. A property-based initiative.

The difference in priority among these elements in design and operation generates a wide diversity in Science Park models:

- Some STPs concentrate on property management, while others have developed a wide range of professionalised "soft" business support services;
- Depending on their funding model, some STPs may prioritise the commercial viability of the property, possibly using less strict criteria for accepting firms, while others put a higher premium on high technology and potential for knowledge exchange between tenants;
- Partly due to their history but also in line with the environment in which they are located, a number of STPs connect mostly to global actors with few relationships with their regional environment, while others are key regional players with their tenants being deeply embedded in the regional innovation ecosystem;
- The presence or absence of a top level research institution or university at the core of an STP and the strategies pursued by these institutions in terms of their third mission (service to society) influence the nature and depth of science- and research-driven relationships within STPs;
- Finally and most importantly, depending on the thickness of the regional innovation support environment, some STPs serve as central innovation agencies in their regions, while others are just one instrument amongst many others that are available in a territory for the support of knowledge-intensive development.

This diversity of models generated by these differences in STP strategies, combined with differences in size, nature of tenants and funding models, has to be taken into account when discussing the role of STPs in regional development as a whole and in smart specialisation in particular.

6.2.2 Science Parks' Role in Knowledge-Intensive Regional Development

The role of STPs in regional development can be discussed according to two different approaches, a linear or an interactive one (Table 6.1). While such a dichotomy is helpful from a conceptual perspective, in practice, STPs hold features that belong to the two stylised models. Recent developments show that an evolutionary process is at play, in which STPs evolve from being "bridges" towards becoming "clusters of competences" at the heart of regional innovation ecosystems.

The linear view sees STPs mainly as instruments of technology transfer, emphasising their role in supporting research-based commercialisation. In this understanding, the role of STPs is mainly to act as facilitators in these exchanges, as a bridge from knowledge sources to recipients. To this aim, STPs offer place-based transfer services addressing the gap between the business and scientific communities.

In contrast, in an interactive approach to STPs, the overall innovation environment plays a key role in the operation of STPs. Here, STPs are seen as nodes in wider networks of actors supporting innovative business development. Technology transfer is only one of the ingredients of successful innovation, and the knowledge exchanges take a multi-dimensional character rather than a science-to-business direction. The aim of STPs broadens to a mission of supporting innovation cocreation. An interactive vision of STPs, thus, reflects a much broader role for this instrument in regional development.

Any assessment of the actual success of STPs on the development of their environment is obscured by the lack of consensus on their expected benefits. Typically, universities would expect an impact in research

Table 6.1 A stylised view on STPs: Linear versus interactive model

Linear model: STPs as bridges	*Interactive model: STPs as clusters of competences*
Technology transfer	Dialogue creation
From source to recipient	Multilateral exchanges
A specific place	A node in a system
Focused support	Multiple support
Material support	Learning support
In-house support	Clearing house
Technology gap	…and managerial gap

Source: Own compilation based on Nauwelaers (2009) commercialisation. Private investors seek return on investments in commercial premises, while regional authorities will look for wider regional development effects such as new companies and new jobs created as well as various other spill-over effects on their economic activities.

It is generally acknowledged that the main benefits of STPs are found in the following areas (European Commission 2008):

- Increased place visibility and attractiveness, conferring a high-tech image to the region where STPs are located. This improved image can play an important role for attracting talent and investors, and for creating good conditions for accessing a pool of high-skilled talents;
- Increased competitiveness of businesses through:
  - Provision of adequate infrastructure (including Information and Communication Technologies) for research- and technology-intensive businesses, which can be shared with public research organisations and universities located in the STP;
  - Provision of a range of tailored business support services targeting specific categories of firms and high-tech businesses. Theme-oriented STPs (on ICT, life science, etc.) may have more opportunities for developing specialised services (intellectual property rights, management support, technology brokering, etc.) and for attracting a critical mass of professionals specialised in these areas.

The creation of a stimulating milieu for the informal exchange of tacit knowledge amongst firms, and between firms and research organisations, which contributes to high levels of social capital, is another alleged benefit from STPs. In theory, being located in an STP populated with knowledge-intensive actors from different sectors and technology fields provides great opportunities for innovative combinations and cross-innovation. This type of qualitative effect is, however, much less straightforward to demonstrate than those previously stated. Several studies generated disappointing conclusions on the intensity of the internal networking effects of milieus in STPs. A review of the vast literature dealing with impacts of STPs on their environment is largely inconclusive (OECD 2011):

- Some studies find that the correlation between STP presence and intensity of high-tech development is due to third factors, such as urban density;

- The additionality of STPs is also questioned, since they may gather high-tech businesses that are present in a region anyhow rather than provide new conditions for their development. STPs may be a reflection of the quality of the innovation environment rather than a factor driving innovation. Tautological results are also frequently found in studies that underline the fact that STPs are more successful in more advanced regional environments;
- Studies that have found a correlation between the high performance of firms and their location in STPs have often restrained from claiming that STPs increase innovation performance. A selection bias is likely to explain the difference of performance between on- and off-park companies. Some studies have also found little difference in firm performance and survival rates between matched pairs of firms on- and off-parks.

We can conclude that STPs, while providing a favourable and potentially fertile environment for innovative firms, are not automatically generating such positive impacts for regional development.

Recent research has gathered evidence that STPs play an important *additional* role in regional development: their tight integration in the regional ecosystem and close interaction with, and complementarity to, regional innovation support instruments. This is well in line with the interactive model depicted before, in contrast with the narrower linear model of STPs. As expressed by Rowe (2013), a new model for STPs seeking to foster an innovation agenda benefitting their regional environment is visible when they:

- *Are seen as an integral part of the local innovation ecosystem that understand and work with it and also design and deliver programmes that reduce weaknesses in the innovation ecosystem. STPs may also create collaboration spaces to bring innovation actors together and act as host to the programmes of other actors as a means for increasing the visibility of the entire innovation ecosystem.*
- *Balance the need for short-term financial returns to secure sustainability against the opportunity to accelerate innovation-led business and economic growth. Where the public sector is involved in an STP, the subsidies and grants they provide serve as 'patient money' allowing the STP time to secure its economic development objectives as well as financial sustainability.*

– *Engage with the private sector to secure capital for development as the park proves they can attract inward investment (both national and international) and / or the park stimulates new innovation-led business activity in other ways, often involving partners in the process. Where the demand from new technology businesses in a locality is already strong the private sector may well take the initiative alone in creating an STP.* (Rowe 2013)

It follows from this view that STPs can play an effective role in regional development when they are part of a policy mix for regional innovation, including other elements necessary for innovation support such as: funding programmes for collaborative research (thematic or not); mobility schemes; various types of support for entrepreneurship and the creation of new technology-based firms; venture capital and other types of funding sources for knowledge-intensive business and so on.

Other important success conditions are rather internal to STPs and concern the strategy of the STP management and their main tenants:

1. The provision of "integrated policy mixes", offering more effective support for innovation; coupling real estate services with innovation support in broader sense is a strategy that is more effective than the provision of fragmented support (Nauwelaers et al. 2009).
2. The role of a professional management team cannot be overemphasised as a success condition for the contribution of STPs to knowledge-intensive growth. The development of a strategic vision is central to this role, since it solves tensions between conflicting objectives and helps to adapt all services to one shared vision.
3. The connection to other off-site actors and the presence of an internationalisation strategy is more and more recognised as a key element for STPs and their role in innovation support, while in the past most attention was traditionally paid to internal on-park interactions.
4. Since higher education institutions and public research organisations are frequently present in STPs, the contribution of these actors needs also to be maximised: the role they want to play and their strategies in terms of their "third mission" is a key factor in leveraging the potential of public research assets (people, infrastructures, networks) for the wider benefit of STP tenants and the surrounding environment.

5. Similarly, large firms located in STPs might pursue open innovation strategies which are conducive to the development of fruitful in- and off-park interactions. Multinational companies which are footloose provide a much weaker asset for turning an STP into an effective regional development tool.

6.3 STPs' Role in Smart Specialisation

In the previous section, we argued that STPs can play a positive role in fostering localised knowledge-intensive growth, when they are embedded in their regional (policy) environment and develop their strategies with this goal in mind. In the current period (2013–2020) of EU funding for regional development and innovation, new regional development policies have evolved following the smart specialisation concept.

Since 2013, EU member states and regions have developed and implemented RIS3 to ensure an effective use of European Regional Development Funds (ERDF). These national or regional RIS3 set a limited number of priorities and build competitive advantages by developing and matching assets in research and innovation with business needs to address market opportunities, whilst avoiding duplication and fragmentation of efforts. In other words, RIS3 are integrated, place-based economic agendas that build on national and regional assets, strengths and potentials, and focus on a limited number of priorities to stimulate growth.

Smart specialisation is not limited to research-based innovation: it also aims at innovation not embedded in science, such as social innovation, innovation in the public sector, innovation in creative industries and service innovation. The very aim of smart specialisation is to create jobs in growth sectors, for example by stimulating entrepreneurship and collaboration between education and research institutions and the private sector. It is meant to promote partnerships within quadruple helix arrangements (public entities—knowledge institutions—businesses—civil society), as well as to address grand societal challenges such as ageing society, social inclusion, environment and climate change. The RIS3 are currently being implemented and monitored with the involvement of national or regional Managing Authorities as well as local stakeholders including universities, industry and social partners. Smart specialisation thus offers a great opportunity and responsibility for STPs to shape the future of their home region or country.

According to the proposal from the European Commission, the next EU budget starting in 2021 will expand the idea of smart specialisation as "enabling conditions" for an effective investment of ERDF.[2] Under this proposal, every region and member state will have to fulfil the following seven enabling conditions:

1. Up-to-date analysis of bottlenecks for innovation diffusion, including digitalisation;
2. Existence of competent regional/national institution or body, responsible for the management of the smart specialisation strategy;
3. Monitoring and evaluation tools to measure performance towards the objectives of the strategy;
4. Effective functioning of entrepreneurial discovery process;
5. Actions necessary to improve national or regional research and innovation systems;
6. Actions to manage industrial transition;
7. Measures for international collaboration.

Thus, smart specialisation enshrines strategic innovation as a core element of regional development policy. It was a novel ex-ante conditionality that required policy-makers to design evidence-based innovation strategies focusing on a limited number of innovation priorities and informed by a broad and continuous involvement of stakeholders. Continuous policy learning and an "entrepreneurial discovery process" with all relevant stakeholders are important elements of this legal requirement for the use of ERDF.

How can STPs address the specific challenges linked to smart specialisation design, implementation and monitoring? Three proposals for the role of STPs in smart specialisation are developed below and discussed in the following subsections.

The first and most obvious bottleneck in smart specialisation relates to the prioritisation of those domains of activity that are likely to create the

[2] Proposal from the European Commission COM (2018) 375. Article 11 of the proposed Structural Funds Regulation details the characteristics of the enabling conditions and refers to Annex IV of the Proposal for further information on the thematic fulfilment criteria. Current Thematic Objective 1: Research, Technological Development and Innovation will be turned into Policy Objective 1: A smarter Europe by promoting innovative and smart economic transformation and will focus on: Good governance of national or regional smart specialisation strategy.

basis for future regional development. How to detect those fields in a bottom-up fashion, relying on an entrepreneurial discovery process that is mostly driven by companies but also nurtured by the contributions of knowledge institutions and other regional actors? Our argument here is that STPs of a "new generation" could serve as ecosystems for experimentation and demonstration of innovation pilots, thus contributing to the smart specialisation entrepreneurial discovery process (see Sect. 6.3.1).

The second challenge for smart specialisation is the engagement of a wide range of stakeholders, both at the design and implementation stages of the strategy. This is needed to secure the endorsement of the priorities by the main innovation actors and an adequate delivery of policies in line with the specialisation priorities. This is why we argue that STPs have the potential to be key actors in the regional quadruple helix for smart specialisation (see Sect. 6.3.2).

The third, and less widely acknowledged challenge for smart specialisation, is to develop the external dimension of the strategy. When priority domains are defined for place-based innovation, regional actors need to assess their position in European and international value chains and to identify complementarities with external actors outside their region and country. This requires taking strategic lines of actions to connect to these international actors and networks, as well as to support the building of regional actors' absorptive capacity. Today, regional development strategies are too much inward-looking. Our final argument is thus that STPs can help opening up smart specialisation thanks to their own external networks. We discuss this aspect in greater depth in Sect. 6.3.3.

6.3.1 STPs as Ecosystems for Experimentation and Demonstration of Innovation Pilots

Smart specialisation in a region is not about picking "winning sectors". It is rather about fostering the identification of new, original and distinctive areas of activities, which have the potential to transform the economy of a region. What becomes important here is the capacity of innovation actors to identify new business opportunities, tapping on their core competences and combining them with other skills and knowledge inputs, to create such new combinations. In this process, proximity can play an important role in facilitating exchange of tacit knowledge through face-to-face interactions.

STPs are characterised by an important concentration of knowledge-intensive activities and by the availability of a variety of high-level skills. This is a fertile ground for developing experimental innovation-oriented initiatives. However, this will only happen if (1) internal connectivity is high within a favourable ecosystem in the STP facilitating the creation of new, unexpected combinations leading to innovation, and (2) the STP ecosystem is well embedded in the wider regional ecosystem, where other skills and resources can be accessed. Globally speaking, almost 40% of STPs are generalists in terms of the economic and technology domains they cover (IASP 2018, 42). Only one quarter is highly specialised. Higher degrees of specialisation focus efforts and can thus facilitate linkages to the wider ecosystem.

This role of STPs is even more demanding in the context of smart specialisation: new and distinctive, regionally based competitive activities are likely to be found at the *intersection* of sectors and clusters, rather than within traditional sectors. In this understanding, STPs are promoters of "related diversification", an aspect that needs increased attention to:

- Services provided by STPs need to be well-tuned to the needs of existing clusters, but also to those of "informal clusters", that is, groupings of companies according to various types of interests, also outside of their traditional lines of activities.
- Traditional clusters might indeed not be the adequate target audience for STP services, if they do not promote cross-cluster innovation. Cross-cluster innovation and the creation of new activities across sectoral silos is a central element of smart specialisation.
- Practice-based innovation needs to receive new attention, in addition to the more traditional "technology push" types of service activities delivered by STPs.
- On-park innovation pilots, exploiting combinations of tenants' (and other actors') assets, are good testimonies of the success of a Park's strategy. But attention should be paid to the scalability of the pilots, in view of their contribution to regional growth.

STPs' challenges in becoming such fertile ecosystems are manifold, but two issues stand out:

- Funding: engineering a variety of EU, national and regional funding sources and from various policy domains (research, business development, environment, land planning, etc.) is needed to support innovation in an integrated way. Beyond the public funding question, a high share of private investment in services and operation of STPs is the best guarantee for success. And the new role of STPs places an increased focus on the need for "patient capital" to support new, risky endeavours.

- Talent: the main fuel for the knowledge ecosystem in and around an STP is human capital, in the form of a skilled, adaptable and mobile workforce. Talent attraction and retention may well be the most important new strategic direction for new STP models in line with a new generation of regional innovation policies.

6.3.2 STPs as Key Actors in the Regional Quadruple Helix for Smart Specialisation

As Foray (2016) put it, the entrepreneurial discovery process is essential for smart specialisation. It is a process in which a large number of local agents including firms, research centres, independent inventors and lead users are involved in making informed decisions on a limited number of smart specialisation domains. Embedding a wide range of regional stakeholders is a key success factor of smart specialisation strategies. Reaching companies is often the main hurdle in this endeavour, because they are not easily mobilised around policy-oriented exercises. Thanks to their close relationship with companies, STPs have the legitimacy to act as an interface in these partnerships, representing the voice of innovative companies. However, maintaining this type of interaction is not an easy job: it requires a high strategic profile, strong legitimacy and credibility from STP managers. And it is also not likely to occur automatically: managers must have a pro-active, constructive attitude in order to make their voice heard in policy-making circles.

Involving stakeholders in smart specialisation processes should, however, not turn into a competition between the "voices" of various regional actors, with those having the strongest voice becoming the winners. Instead, it is an orchestrated exchange of views, in which various regional stakeholders bring in their own contributions, but also undertake a search for new, emerging fields, where critical advantages can be built. STPs are well placed to contribute to these efforts, if they can demonstrate a genuine contribution to the smart specialisation process and content.

Stakeholder involvement in smart specialisation builds on the idea of quadruple helix, which refers to government institutions, universities and research organisations, industry and civil society as key actors in innovation ecosystems (Carayannis and Campbell 2009). The role of STPs in the regional quadruple helix is likely to differ according to three elements:

- Density of the regional innovation ecosystem: in denser ecosystems and/or more developed regions, STPs are more likely to be only one amongst many legitimate stakeholders participating to smart specialisation. At one extreme, STPs may deliver most innovation services themselves, acting like regional innovation agencies, or, at the other extreme, be a small operator within a range of powerful bodies and agencies with whom they need to coordinate. In between the two extremes, STPs can also sometimes take a role of orchestrators of a regional/national network of service providers.
- Scope and scale: smaller STPs may not get a sufficient level of visibility and legitimacy to play an important role in the quadruple helix. In regions where several STPs are present, complementarity and joint efforts are required to enhance their effectiveness.
- Institutional linkages with regional authorities: when STPs benefit from regional public funds, either structurally or on a project basis, they are likely to have more direct and more in-depth interactions with regional policy-makers and other constituencies in charge of smart specialisation.

6.3.3 External Connectivity of STPs: Outward-Looking Territories and Smart Specialisation

While countries and regions develop methodologies to explore and understand their own local assets, their strengths and opportunities, they often struggle to strategically identify opportunities for cross-border, transregional and transnational cooperation. One possible step is to analyse and map the situation of the identified national/regional priorities in wider value chains. Transnational and international STP activities should be exploited to link to global networks and connect to foreign partners active in related activities.

An outward-looking dimension and connectivity are essential features of designing and implementing innovation strategies for smart specialisation, at both design and implementation stages. During the RIS3 design stage, the external networks maintained by STP stakeholders can be activated to feed into smart specialisation strategies and help define those areas of specialisation to be targeted as regional priorities; an STP network can also provide access to experts in international innovation strategies and activities. During the RIS3 implementation stage, communities of actors in STPs can act as living labs for developing innovative products or services, and these need to be open and well connected to external sources of ideas and knowledge. Such open living labs can constitute a core element for the implementation of smart specialisation strategies and inform a continuous entrepreneurial discovery process.

At the same time, interconnectivity is essential for STPs for a number of reasons. (1) Networks provide an access to resources including financial resources, human capital and knowledge. Since STPs support their associated stakeholders by ensuring a highly innovative environment, business opportunities and favourable working conditions, access to these network resources can add substantial value. STPs also have to attract resources from the outside, and this is significantly facilitated by their networks and external partners. As STPs connect to other science parks and partners in EU countries and worldwide, they could be even more encouraged to explore their collaboration opportunities in other regions and (neighbouring) countries, for example, by connecting to existing clusters across borders, using international innovation vouchers or promoting joint participation in R&I programmes and schemes. (2) STPs seek to increase their firms' and stakeholders' access to markets. This, of course, requires solid knowledge of these markets and the opportunities elsewhere. (3) STPs advocate and lobby for their partner stakeholders. The impact of these activities is higher when they are made through international networks and in coalition with international partners.

To get an impression how regional and national innovation priorities in Europe compare with the thematic focus of STPs across the world, Tables 6.2 and 6.3 show the specialisation domains of digital transformation, key enabling technologies and health. In these domains, STPs are globally active, and European STPs and the regions in which they are embedded can use their joint networks for thematic collaboration.

In sum, STPs with a sound internationalisation strategy can act as bridging agents with targeted actors outside their host region, helping to embed regional actors in wider networks and value chains. Regional, national and international networks of STPs (including the International Association of Science Parks) have an important role to play in supporting the outward-looking dimension of smart specialisation.

Table 6.2 Top specialisations of STPs worldwide

STP specialisation	*Share of surveyed STPs*[a]
ICT & communications	64%
Biotechnology	35%
Computer science & hardware	32%
Electrics	29%
Software engineering	29%
Health & pharmaceuticals	27%

Source: Authors' creation based on proprietary data from the International Association of Science Parks and data from the European Commission's Eye@RIS3 database at http://s3platform.jrc.ec.europa.eu/eye-ris3. Accessed May 13, 2019

[a]The shares add up to more than 100% because many STPs have several specialisations

Table 6.3 Top smart specialisation priorities in European countries and regions

Innovation priorities in European regions and countries[a]	*Share of priorities*
Digital transformation	27%
KETs	18%
Sustainable innovation	17%
Public health & security	14%
Blue growth	7%
Cultural & creative industries	5%

Source: Authors' creation based on information and data from the European Commission's Eye@RIS3 database at http://s3platform.jrc.ec.europa.eu/eye-ris3. Accessed May 13, 2019

[a]The categories are based on EU-wide objectives approximated through the definition of priorities in national and regional strategy documents (n = 809 priorities) (European Commission 2008)

6.4 Examples of STPs from a Smart Specialisation Perspective

The three cases of STPs presented in this section illustrate different models and different types of potential STP contribution to smart specialisation in the predominant specialisation domains presented in the previous section.

6.4.1 The Finnish Joensuu Science Park: Taking on a Leadership Role in Smart Specialisation

Joensuu is the capital of Finland's easternmost province in North Karelia. It is located close to the Russian border, about 400 km from Finnish capital Helsinki. Joensuu is a centre for trade, culture, education and technology.

Three higher education institutions—the North Karelia University of Applied Sciences, the University of Eastern Finland and the HUMAK University of Applied Sciences—are based in Joensuu. The main industry sectors are metal, wood and forestry. Joensuu hosts strong research actors in forestry, including the European Forest Institute and Joensuu Science Park.

The Joensuu Science Park has been established in 1990 and is part of the Finnish Centre of Expertise programme. It has specialised expertise in nanotechnology, future forestry industry, building technology and energy technology. The main goal is to promote the commercialisation and use of research and new information in the business operations of companies. Joensuu Science Park Expert Services support companies in planning, developing, executing and monitoring strategy-based development programmes. To this end, it offers an integrated package of services covering all aspects of innovation.

Due to its central position in the knowledge-intensive economy of the region, the Science Park acts as an orchestrator of regional resources for the definition of a joint vision concerning growth choices and the principles behind them. A strong principle behind the strategy is the identification and stimulation of interfaces and intersections of the technologies and industries selected in the strategy. The Science Park is well placed to engineer such a vision. Thanks to their involvement in the definition of a joint vision and the elaboration of the regional smart specialisation strategy, the organisations involved in the platform created by the Science Park are committed to the choices made and the implementation of the measures. Three strategic domains of activities have been chosen: (1) Forest bio-economy; (2) Technology and materials; and (3) Creative industry and experiential content production. This priority setting was based on the following criteria: sufficient competence that meets high international standards; current significance to the regional economy; expectations concerning development and growth potential; special attention given to cooperation and interfaces between the focus areas.

The success of the regional smart specialisation strategy will be assessed according to the following indicators:

1. Development of revenue, export and jobs in the businesses operating in the focus areas;
2. Number of businesses founded in the focus areas/relocating into the region;

3. Amount of education organisations' internal and external funding for research and development in the focus areas and increase in the number of researchers and graduates;
4. Amount of public funding granted to the development of the focus areas by the North Carelia's Centre for Economic Development, Transport and the Environment, and Tekes, the Finnish funding agency for innovation;
5. Investments in the development of the focus areas, as calculated by the Joensuu Science Park Ltd. and Josek Ltd., a service provider to companies in the region.

6.4.2 *The UK North East Technology Park (NETPark): One Actor in the Wider Innovation Ecosystem*

NETPark is located in County Durham in the North East of England. This is a county which has diversified from the declining mining industry towards manufacturing and engineering, which accounts for about 20% of its economic base. The North East of England is home to four universities, including Durham University. Durham University's research covers fields such as nanotechnology, bio-science, electronics, chemistry, astronomy and engineering. Business Durham is the county's economic development company, delivering support for business and economic growth. NETPark is one of Business Durham's integrated portfolio of interventions, along with strategic account management, inward investment, enterprise and outreach. See Table 6.4.

The definition of the innovation priorities for NETPark builds on the strengths of Durham University and on the wider existing capabilities in North East England. NETPark focuses on supporting companies that are developing new technologies and products, particularly printable electronics, microelectronics, photonics and nanotechnology, and their application in the fields of energy, defence and medical-related technologies. One particularity of NETPark is that it brings its services also to companies and actors which are located outside the park. The set of indicators used to measure the park's success reflects the concern about the impact on the wider regional environment.

Table 6.4 Hierarchical indicators for assessing NetPark's success

Position in hierarchy	*Objective*
1	Increased GVA by occupants in NETPark
2	Increased employment
3	Increased GVA per head
4	Increased number of technology-based companies in county/region
5	Attraction of firms from other parts of the UK and abroad
6	Increased exports
7	Exploitation of technologies
8	Attraction of investment funds (including bank and venture funding)
9	Technology exchange work with universities in the north east and between companies
10	Retention of graduates from regional universities
11	Employment of local people
12	Raising employment aspirations amongst pupils studying STEM subjects in schools

Source: Authors' creation based on a presentation at the International Association of Science Parks – Joint Research Centre workshop, February 19, 2014

To underscore the uniqueness of some of the region's assets, NETPark has successfully argued for branding one of the smart specialisation innovation priorities as "surface science". This has the advantage that outside investors, researchers and interested parties can more easily recognise a particular niche that North East of England specialises in. The interaction of surfaces—air to air, air to liquid, air to solid, liquid to liquid, liquid to solid, solid to solid—encompasses some truly world-class university research, the two biggest corporate R&D hubs in North East England, existing innovation hubs and significant numbers of SMEs. It can be both broad and narrow. The broadness enables the North East to tie a number of seemingly disparate activities into a critical mass in order to be able to compete globally. It can be narrow in terms of enabling specific activities such as pharmaceutical, filtration, materials and electronics, among several others, to grow and thrive. Although not directly responsible for developing the regional RIS3, NETPark was able to use its networks and influence, working closely as a credible and respected partner with the North East Local Enterprise Partnership, to ensure that this vital area was included.

6.4.3 Brainport Foundation and High Tech Campus Eindhoven: Ensuring the Commitment of Businesses Towards a Cross-Border Top Technology Region

Brainport can be characterised as a "horizontal triple helix collaboration" partnership, since large companies and SMEs, knowledge institutes and governmental organisations collaborate at various levels in the Dutch region of Noord-Brabant (Wintjes 2011). Out of all triple helix parties, the provincial government is perhaps the least dominant and most limited actor in terms of resources. The project management approach builds on the model of the former EU-funded research project which consisted of a large number of bottom-up initiatives with external project owners. Brainport tries to persuade the involved firms or knowledge institutes to take ownership of individual initiatives or projects. For this innovative approach, Brainport Eindhoven has won the Eurocities Award 2010 in the "cooperation" category for their very promising cooperation amongst companies, knowledge institutions and government.

One of the key actors in the Brainport region is High Tech Campus Eindhoven. The establishment and continuous growth of the Campus is the result of efforts by several (collaborative) partners, with Philips as initial core partner, promoting open innovation practices in and around the campus. These parties' aim is to develop the Eindhoven region as an internationally recognised technology region with the Campus as central high-tech hub for the entire Dutch, German and Belgian cross-border region. The Campus is at the heart of one of Europe's leading R&D regions: the Eindhoven, Leuven, Aachen triangle (ELAt) is an area that has acquired a strong European position in microelectronics/nanoelectronics and life sciences. Campus companies are responsible for nearly 40% of all Dutch patent applications.

In line with the limited role of public government and public R&D investments, the innovation system of the region is privately driven, although public-private initiatives like Holst Centre and Solliance play an important role. The development of the innovation strategy was led by the former vice president of the multinational company DSM, and the steering group also included a former manager of Philips. In line with the approach of Brainport to appoint external people as "project owners", many initiatives and projects are led, or "driven", by businessmen. Private companies like Philips have become important actors in the governance of RTD policy in Noord-Brabant. Within ten years, High

Tech Campus Eindhoven has developed into a dynamic mix of more than 125 organisations from global brands, leading research institutes, fast growth enterprises, service companies and high-tech startups with a large impact on the innovation performance of the region. With accelerator programmes like Next OEM, Startupbootcamp HighTechXL and two European Knowledge Innovation Communities (EIT Digital and EIT InnoEnergy), companies, investors and innovation intermediaries became more involved in the further development of the Campus by providing incubation support. The Campus model of open, collaborative innovation has been adopted and implemented also elsewhere in the region.

The regional innovation strategy, "Brainport 2020: Top Economy and Smart Society", has been elaborated as a response to the request from the national government. It includes a vision, a strategy and a tangible implementation programme. The assignment was to "develop … a cohesive and comprehensive vision of Brainport, at the level of Southeast Netherlands with Brainport as pivot and with a focus on cross-border links to Flanders and Nordrhein-Westfalen". Brainport thus is a prime example of how a science and technology park can use its external connectivity as a strategic asset.

6.5 Conclusions: The Changing Role for STPs in the Smart Specialisation Era

Smart specialisation strategies constitute a turning point in the young history of regional and place-based innovation policies. They address the main development bottlenecks faced by European regions, namely (1) lock-in in outdated specialisations and in industrial structures which are not conducive to growth and employment, and (2) top-down approaches, which often overlooked place-based needs and capabilities. Smart specialisation adopts a place-based, bottom-up perspective pursuing regional economic transformation, as opposed to continental-scale planning from above.

The ambition of these strategies is high and an orchestrated contribution from all innovation actors in regions is needed to reach these goals. This cannot be achieved in a top-down manner. Science and technology parks are by definition place-based organisations that are active in many regions. Among the quadruple helix actors, these organisations stand out as suitable candidates to play a forward-looking role in the regional innovation partnerships, provided they support innovation experimentation. Yet, this does not give science and technology parks an automatic place in smart specialisation governance. This place has to be gained based on the credibility of these organisations and the quality of their contribution for developing specialisation domains. Misuse of strategic position by means of, for example, lobbying for scientific/technical areas of their interest with the objective to secure public funding can be harmful for the process and the needed regional economic transformation.

To support smart specialisation strategies, science and technology parks should act as *boundary openers* at several levels:

- Internal to STPs: they can foster unique and innovative combinations between the assets present in the park, but also in the regional environment;
- Interregional and international: STPs can activate their international networks to reinforce the external connectivity of smart specialisation;
- Intersectoral: STPs can foster linkages and related variety between sectors and clusters where a critical mass already exists.

This creates a new agenda for STPs, which will require the development of sound strategic skills for STP managers. In particular, this involves:

- A vision geared towards economic value creation and innovation ecosystem support, seeing STPs as "smart innovation intermediaries" rather than as real estate managers only;
- The adoption of a long-term perspective in the delivery of services and the definition of priorities in the STP strategy;
- Filling an important gap in terms of monitoring and evaluation of STP actions, seeking to achieve outcomes such as:
  - improvements in the ecosystem that are linked to the STP's activities;
  - *additional* value creation thanks to "STP effects" (thus taking into account any displacement effects);
  - long-term sustainability and the capacity of attracting private funding for the STP.

Ultimately, when all favourable conditions are met, STPs have the potential to play an important transformative role in regional economies.

A critical avenue for further research and experimentation relates to the development of suitable indicators to track the effective contribution of STPs to place-based innovation. This goes much beyond the evaluation of the "success" of STPs according to their own objectives, even if this is the primary point of attention for STP managers and funders. It requires a capacity to understand the additional effects of STPs in terms of generating new knowledge-intensive businesses and lines of activities, as well as the quality of internal and external connections generated by the innovation actors connected to the park.

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CHAPTER 7

Science Parks and Business Incubation in the United Kingdom: Evidence from University Spin-Offs and Staff Start-Ups

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7.1 Introduction

Business incubators and science parks are defined as property-based organizations with administrative centers focused on the mission of business acceleration through knowledge agglomeration and resource sharing (Phan et al. 2005). The rolwwwwe of university has clearly changed and they are now seen as complementary to innovation, where we see a lot of commercialization at universities (Aldridge and Audretsch 2010). The debate is about whether such initiatives enhance the performance of universities and how the economic development in a region further enhances the effect of incubators and science parks on university entrepreneurial

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outcomes. This link raises a question related to the strategic management of science parks and incubators. As such, the relevant government agencies in the United States (e.g., the National Science Foundation, the Association of University Technology Managers) and in the United Kingdom (e.g., Innovate UK initiatives, Higher Education Academy) have not collected systematic data on these institutions. We can see spin-offs and start-ups coming from universities. In this study, we discuss the state of research on the effect of science parks and business incubators and how their location on (off) campus facilitates university entrepreneurial outcomes.

As noted by Wright and Westhead (this volume), there is no publicly available data for comparative analysis or benchmarking in the UK which limits the analysis of the drivers and consequences of science park activity as well as data matching exercise. Data limitations make it difficult to measure the effect of such facilities and their impact on universities and regions.

To date, there is no systematic framework to understand how science parks and incubators change the nature of entrepreneurship activity at universities in particular start-ups and spin-offs located there (Lockett and Wright 2005). Our analysis of the effect of science parks and incubators on entrepreneurial outcomes is at two distinctive levels: the level of science parks and incubators located on campus and science parks and incubators located off campus, and the systemic level effect which concerns the characteristics of the regions where science parks and incubators are located.

Previous research on science parks and incubators also lacks dynamic analysis. Again, our study fills this void with data on university engagement with science parks and incubators during 2009–2016 for 131 public universities. Finally, the research on science parks and incubators was mostly studied within the research outcomes of university such as the patenting and licensing process for university-based start-ups (Bray and Lee 2000; Bercovitz et al. 2001; Siegel et al. 2003a; Siegel and Leih 2018) and not for entrepreneurial outcomes.

Our study suggests a number of further research directions based on our findings. First, we find that incubators have a stronger impact on entrepreneurship outcomes than science parks. Second, science parks on campus have a greater effect on start-ups and spin-offs than science parks located off campus. Finally, universities which are located in cities with higher economic development have lower spin-off and start-ups outcomes when science parks are located on campus.

Our results find the two missing pillars which condition the effect of science parks and incubators on entrepreneurial outcomes: location of science park (off and on campus) and type of entrepreneurial outcomes.

We identify that in the UK establishing a science park or incubator on campus is likely to be a strategic choice for building models of an entrepreneurial university (Wright et al. 2007; Guerrero et al. 2015, 2016) as well as facilitating knowledge spillovers from the public sector (Audretsch and Link 2019). It is also evident that science parks on campus have greater impact on spin-offs rather than science parks located off campus. It is clear that incubators and science parks take place in different environmental and institutional contexts, which are dynamic and which moderate the impact of science parks on university entrepreneurial outcomes. This study mainly addresses a call in the literature on the role of science parks and their location on different entrepreneurship activities and a need for further development of a structural contingency perspective that relates science parks and incubators to different geographical contexts.

The remainder of the study is as follows. We start with literature review and hypotheses testing. We describe data in Sect. 7.3 and main finding in Sect. 7.4. We discuss our results and conclude in Sect. 7.5.

7.2 Literature Review

In dynamic environments, universities adopt a commercialization orientation to transform existing routines into new ones that are useful to gain sustained competitive advantages (Teece 2007). Consequently, a university's commercialization activities require certain capabilities and infrastructure to create value. First, the identification of commercialization opportunities requires research capabilities of universities (Perkmann et al. 2011; Guerrero and Urbano 2012; Guerrero et al. 2015). Second, the identification of commercialization opportunities requires entrepreneurship infrastructure at universities. This infrastructure includes special interrelated institutions and organizations with identifiable administrative centers focused on business acceleration through knowledge spillovers and resource sharing. Many universities in developed and developing countries established science parks and incubators to foster the creation of entrepreneurial outcomes, specifically start-up firms with the participation of staff as well as start-ups based on university-owned or licensed technologies such as spin-offs (Link and Scott 2003).

Science parks and incubators have become an international phenomenon (Link and Link 2003; Phan et al. 2005). The Higher Education Funding Council for England (HEFEC) data reports that during 2009–2016 there were 30 university-based science parks in the universities in the UK and 43 sciences parks in collaboration with a university but located off-university campus. Our data reports there are 105 university-based business incubators in the universities in the UK and 88 business incubators located off-university campus.

This large number of science parks and incubators is the result of public–private partnerships, which means that multiple stakeholders (e.g., community groups, and regional and state governments) have influence over their activities and operations (Link and Scott 2003). Developing theories to characterize the precise nature of their business models and managerial practices, and their interplay with regional characteristics, which facilitate knowledge commercialization in universities where science parks and incubators are located has not proceeded far (Siegel and Wright 2015).

The continuous renewal and testing of commercialization activities require a transformation capability (Markman et al. 2008; Teece 2012; Klofsten et al. 2019). As patents and IP need time for transformations, entrepreneurship outcomes are more likely to benefit from university incubation and science park capabilities.

H1. University Business incubators and science parks facilitate entrepreneurial outcomes at university.

Prior research has demonstrated that locating in a business incubator does not guarantee success (Lumpkin and Ireland 1988). In fact, apart from the location and administrative support advantages, the value of business incubators compared to science parks has been questioned (Hansen et al. 2000). A substantial issue is that the typical dependent variable, the rate of firm survival (or failure), has little construct validity, since incubators are specifically designed to increase survival and testing of the product (Phan et al. 2005). It is important to compare survival rates among different incubators and science parks and their location within a university campus or outside.

It is quite easy for incubation to generate start-up activity, while it is more difficult to efficiently use university resources, hire researchers, deal with technology, patents, and licensing, which science parks can do as the most advanced form of the triple helix model (Miller et al. 2014). Bøllingtoft and Ulhøi (2005) demonstrated that 50% of the companies in the business incubator survive after four years.

We start with the notion that science parks and incubators are distinct organizations. Science parks will transform the value chain. They usually comprise a number of interconnected organizations whose activities are linked by the successive transformation of resource and knowledge inputs into marketable outputs. This commercialization of new knowledge at university is usually shortly after the creation of a new firm. Both science parks and incubators are the intermediate organizations that provide social environment, technological and organizational resources for the transformation of university technology into technology-based business ideas, and they provide for efficient commercialization of knowledge (Markman et al. 2008). Markman et al. (2005) outlined a model that links a university's knowledge assets (patents) to business creation in university-based incubators jointly with university technology transfer offices (TTOs) acting as the intermediaries. While both start-ups and spin-offs are important conduits of technology commercialization, we believe that science park is the strongest conduit. Thus, we hypothesize:

H2. University science parks facilitate university entrepreneurial outcomes to a greater extent than business incubators do.

Would university managers prefer a science park on campus or off campus? The answer is not simple and may depend on the type of technology, economic development, infrastructure, and other factors. As universities are responsible for a large share of the technology-oriented incubators and science parks, in particular in the US, strong collaboration with university TTOs and licensing activities (Mowery et al. 2001) may increase if TTOs and science park residents are co-located (Bercovitz et al. 2001). Location on a university campus may be attractive for start-ups at the elite research universities (e.g., Oxford, Harvard, Stanford, Cambridge, MIT), to directly work with scientists, use their premises and commercialize technology. Location within the least research oriented universities may be attractive for other reasons, such as a vibrant location in London or NYC, competitive rents and sponsorship by universities or governments aiming to increase knowledge transfer (Siegel et al. 2003b).

While the results of such co-location may not be generalizable to the larger population of universities it is known that knowledge spillovers and technology coming from the university is spatially bounded (Audretsch and Feldman 1996). Science park residents located on campus may have a greater exposure to research students via internships, and research fellows via joint events and experiments, than residents of science parks located off campus. Firms located off campus do not enjoy the same favorable environmental conditions as firms located on campus do.

To build a model of TTOs' industry collaboration, including a science park component, Belitski et al. (2019) demonstrated that entrepreneurial development at university requires direct industry partnership between a researcher and a firm. Co-location may facilitate this relationship. In addition, Markman et al. (2005) find that the most "attractive" combinations of technology stage and licensing strategy for new venture creation are least likely to be favored by the university, because universities and TTOs are focused on short-term cash maximization and are risk-averse. Co-location with TTO on campus will help to leverage these risks (Siegel et al. 2003b), in particular if firms are large, which is usually the case of a science park, rather than a business incubator. Science parks with their wealthier and technology-intense residents aiming at implementation of university technology will contribute more when closely collaborating with the university. This will likely be more feasible on campus than a location off campus. We hypothesize:

H3: University science parks located on campus facilitate university entrepreneurial outcomes to a greater extent than university science parks located off-campus.

Westhead (1997) and Westhead and Storey (1994) studied the differences between firms located on and off campus explaining that the causes and consequences of science parks and incubators may be idiosyncratic to their geographic locations, political and social contexts, and economic systems.

There is a paucity of research on the human capital of the entrepreneurs, and the opportunity identification process which is place dependent. Science parks and incubators will benefit by stronger demography of entrepreneurs, developed infrastructure, and labor markets compared to those involved in the creation of ventures outside economically developed locations.

Science park and incubator managers play an active role in identifying opportunities for expansion and collaborating locally with other firms. Existing studies indicate that managers scan the environment according to cognition and opportunities (Autio et al. 2001; Stenholm et al. 2013) and decide where to go and establish their business. These conditions are found to be related to the level of human capital and other resources available in a region (Glaeser et al. 2001) as well as other demographic factors (Audretsch et al. 2015; Belitski and Desai 2016). Thus, scientists in science parks and incubators may be those who have recognized the limited opportunities of location in a city and may perceive campus location as an opportunity in places where economic development outside campus is relatively low.

Knowledge spillovers, clusterization of knowledge, and ability to pool public resources to invest in technology transfer (Siegel et al. 2003a) will also determine location on campus. In addition, favorable regional conditions toward entrepreneurship and innovation also facilitate the development of universities' capabilities (Link and Sarala 2019). Therefore, we expect that regional conditions reinforce the effect of university capability on the different commercialization activities (Audretsch and Link 2019).

This means that in most developed cities, science parks will see more opportunities off campus, which will affect start-ups and spin-offs outcomes, while in more deprived areas, location on campus may bring additional benefits. We hypothesize:

H4. Regional economic development reinforces the effect of university science parks on university entrepreneurial outcomes.

7.3 Data and Methodology

7.3.1 Data and Sample

Given the nature of our study, one of the challenging aspects of measuring the university capabilities along with entrepreneurial and research outcomes of university is data for teaching, research, and entrepreneurial activities as well as its quality, particularly when the impact of created capabilities would be not evidenced at least for one academic year which is required to introduce changes in financial and academic plans, engage with stakeholders (Miller et al. 2014), and receive an approval by the various faculty and university-wide councils. Guerrero et al. (2015) recognize the relevance of static and dynamic approaches for measuring the economic impact of universities' activities. To be able to answer our research question, panel data is required that allows for estimation of the effects during several points in the time. For instance, Berman (1990) used at least two- to five-year time lags between the development of the entrepreneurial university's activities and its effects on economic development in research collaboration studies, while shorter lags (up to one year) could be applied when the effects are within a university. Shorter lags may be used as university stakeholders (e.g., co-owners, venture capitalists, industry sponsors, large corporates, and small firms) may not be able to wait long for the entrepreneurial and research outcomes to mature. This shortens the research commercialization circles departing from the traditional model of research commercialization (Bradley et al. 2013) to alternative models (Guerrero et al. 2016; Belitski et al. 2019). To tackle the data issues, we use five distinct, but matchable datasets which enable us to measure the university and regional capabilities using university-level data relating to universities in the UK and city-level data relating to economic development where these universities are located. We collected secondary data on university capabilities, and research/entrepreneurial outcomes from a number of official databases, namely, the Higher Education Funding Council for England (HEFEC) and HESA. We measured economic development proxied by the regional gross value added (GVA) from NOMIS, Business Register and Employment Survey (mid-year population estimates). Business Churn was obtained from Business Demography, population estimates at the Office of National Statistics (ONS), while employment rate was taken from the Annual Population Survey (residents analysis) in the Department for Trade and Investment (DETINI), and public services were obtained from the Business Register and Employment Survey at the ONS.

The university-level data was available for 169 public universities in the UK for the period 2009–2016. We use data for 131 public universities that reported all variables of interest and for whom we could identify their location. For example, the Open University in the UK has multiple locations with a substantial number of distant research and learning activities. As such, the Open University was excluded from this study.

Universities with no degree-awarding powers were also excluded. We believe that our sample of 131 public universities in UK is representative of entrepreneurial universities with degree-awarding powers who combine both research and teaching activities (McCormack et al. 2014) and is most up to date (Appendix).

7.3.2 Variables

Previous measurement models of entrepreneurial universities employed the input-output approach, which focuses on a limited number of independent variables representing both teaching and research university capabilities (Guerrero et al. 2015, 2016). We expand the list of variables to be able to test the effect of university and regional capabilities on entrepreneurial and research outcomes of universities. The list of variables and their description and sources is presented in Table 7.1.

Table 7.1 Descriptive statistics, source of data

Variable	*Description (Source)*	*Mean*	*Std. Dev.*	*Min*	*Max*
Spin-off sales	Dependent variable: Spin-offs turnover with no-HEI ownership, in logs	3.93	4.11	0.00	11.81
Staff start-ups sales	Dependent variable: Staff start-ups turnover, in logs	1.47	2.85	0.00	11.29
On-campus incubator	Binary variable=1 if business incubator is located on campus (with or without HEI involvement), 0 otherwise	0.58	0.49	0.00	1.00
Off-campus incubator	Binary variable=1 if business incubator is located off campus (with or without HEI involvement), 0 otherwise	0.55	0.50	0.00	1.00
On-campus science park	Binary variable=1 if science park is located on campus, 0 otherwise	0.18	0.39	0.00	1.00
Off-campus science park	Binary variable=1 if science park is located off campus, 0 otherwise	0.25	0.44	0.00	1.00
University staff	Employment at university, in logs	6.64	1.13	3.71	8.96
Russell Group	Binary variable =1 if university belongs to the Russell Group, 0 otherwise	0.17	0.37	0.00	1.00
STEM undergraduate	Share of STEM undergrad students in total	0.06	0.06	0.00	0.59
STEM postgraduate	Share of STEM postgraduate students in total	0.02	0.03	0.00	0.26
Bio & medicine undergrad	Share of undergrad students in biology and medicine in total	0.07	0.06	0.00	0.37
Bio & medicine postgrad	Share of postgrad students in biology and medicine in total	0.03	0.07	0.00	0.60
Business undergraduate	Share of business undergrad students in total	0.07	0.10	0.00	1.65
Business postgraduate	Share of business postgrad students in total	0.04	0.06	0.00	0.74

(*continued*)

Table 7.1 (continued)

Variable	*Description (Source)*	*Mean*	*Std. Dev.*	*Min*	*Max*
Regional controls					
Economic development	Gross value added per capita, in thousand £ (lagged 2 years) (ONS)	28.82	9.03	14.54	49.93
Business churn	Business churn rate (lagged 2 years) (ONS)	2.24	3.33	−4.71	11.44
Employment rate	Employment rate (%) (lagged 2 years) (NOMIS)	69.78	4.17	60.20	80.65
Public services	The number of jobs in public services as % of total jobs (lagged 2 years) (NOMIS)	28.00	5.96	19.75	49.67

Source: Authors' creation based on data from the Higher Education Funding Council for England (HEFEC) 2009–2016, https://www.gov.uk/government/organisations/higher-education-funding-council-for-england; NOMIS, Business Register and Employment Survey; https://www.nomisweb.co.uk/articles/971.aspx; and Business Demography, Department for Trade and Investment (DETINI) at the Office of National Statistics (ONS), https://www.nomisweb.co.uk/articles/971.aspx. All data accessed May 1–2, 2019

Number of observations 746 during 2009–2016

Our two dependent variables are related to entrepreneurial activities, and the outcomes are measured by the following two variables: log-transformation of spin-offs turnover with non-high educational institution (HEI) ownership (Krabel and Mueller 2009; Clarysse et al. 2005) and log-transformation of turnover by HEI staff start-ups (Bramwell and Wolfe 2008; Chrisman et al. 1995). These measures follow the works of Guerrero et al. (2015) who measured entrepreneurial activities as the ratio of active HEI spin-offs owned by the universities to the country's population as well as spin-offs without university ownership as the ratio of active spin-offs not owned by the universities to the country's population.

Our independent variables were grouped according to each university's capabilities such as incubation and science park capabilities on campus and availability of incubators ad science parks off campus. Regarding teaching activities, the main outcome is the logarithm of total faculty employment at university (Bessette 2003) and the natural logarithm of the employment indicator per student and per university in the year of analysis (Martin 1998; Urbano and Guerrero 2013). With respect to research in STEM (Science, Technology, Engineering, and Math) activities, the outcomes are measured as the percentage of undergraduate and postgraduate students in Science, Technology, Engineering, and Math in the total number of undergraduate and postgraduate students (Souitaris et al. 2007). STEM-focused educational institutions are known to be one of the early adopters of entrepreneurship education, recognizing that STEM majors in particular have a disproportional potential to form high-growth ventures in high-tech industries with high-value prospects (Warhuus and Basaiawmoit 2014).

We measure university incubation (on campus) as a binary variable equals one if there is on-campus business incubator, zero otherwise. We measure university incubation (off campus) as a binary variable equals one if there is an off-campus business incubator, zero otherwise.

In addition to incubation facilities our independent variable is a binary variable denoting whether or not the science park is on or off campus.

Regional capabilities are measured as a NUTS-3 level gross value added (GVA) per capita. The GVA per capita is a measure of the value of goods and services produced in an area of an economy linked as a measurement to the GDP, identified at the NUTS-3 level for the region within which each analyzed university is located. Therefore, this proxy allows us to explore the economic effect of each entrepreneurial university's activities in the county/region it is located in, using a two-year time lag (Martin 1998; Roessner et al. 2013).

Other business related variables included business churn rate, employment rate, and a share of public services employment in total jobs. All four regional capabilities are taken with the two-year lag which enables us to avoid problems of simultaneity and endogeneity between our main independent and dependent variables.

Our main control variable for teaching activity is the logarithm of the total turnover of professional development courses (£ thousands) and wholly customized courses to address business and learning need at the university. These variables encompass the university staff teaching activity (Daim and Ozdemir 2015; O'Shea et al. 2005). We added a binary control variable depending on whether the university was a member of the Russell Group of leading universities. Based on the resource-based view approach, these control variables serve as a proxy for the capabilities that contribute to entrepreneurial university's outcomes (Wernerfelt 1995).

7.3.3 Model

To test our research hypotheses, we apply the generalized least squares estimator (GLS) adding year fixed effects in model (7.1). In both ordinary least squares and maximum likelihood approaches to parameter estimation, the assumption is a constant variance, that is the variance of an observation is the same regardless of the values of the explanatory variables associated with it, and since the explanatory variables determine the mean value of the observation, we assume that the variance of the observation is unrelated to the mean.

We use a one-year lag for all independent and control variables at university-level and a two-year lag for the four regional capabilities. This approach enables us to avoid problems of simultaneity and endogeneity between our main independent and dependent variables. This lagged relationship also reflects causality between an entrepreneurial university's activities in one period and its economic impacts in subsequent periods (Audretsch and Keilbach 2004). It is difficult to estimate the exact time within which the effects of regional development on research and entrepreneurial outcome of the university would be observed. For this reason, and to avoid additional bias produced by the current global financial crisis (2008–2011), we adopted a lag of two years and controlled for year fixed effects. Our model is as follows:

$$y_{it} = \beta_i x_{it-1} + \beta_i z_{it-1} + \theta m_{jt-2} + \lambda_t + u_{it-1} \tag{7.1}$$
$$\mathrm{E}[\varepsilon] = 0 \text{ and } \mathrm{Var}[\varepsilon] = \sigma^2 \mathrm{V}$$
$$i = 1,\ldots,\mathrm{N}; t = 1,\ldots,\mathrm{T}$$

where y_{it} is entrepreneurial and research outcomes of a university i at time t. β and Θ are parameters to be estimated, x_{it} is a vector of explanatory university-level capabilities lagged one year, z_{it} is a vector of exogenous university control variables while and m_{jt} is a vector of explanatory capabilities at region j at time t. u_{it} is independent and identically distributed.

V is a known $n \times n$ matrix. If V is diagonal but with unequal diagonal elements, the observations y are uncorrelated but have unequal variance, while if V has non-zero off-diagonal elements, the observations are correlated. Note that λ_t is a university-invariant vector which accounts for any time-specific effect not included in the regression. For example, it could account for government program intervention or economic crises that disrupt entrepreneurship outcomes of the university and effect research financing.

7.4 Results

Table 7.2 illustrates two sets of empirical results, with entrepreneurial outcomes measured as non-HEI spin-off sales (specification 1–3) and staff start-ups sales (specification 4–6).

Our H1 is supported as university business incubators ($\beta = 1.19–2.56$, $p < 0.01$) and science parks ($\beta = 1.46–2.58$, $p < 0.01$) located on campus increase spin-off turnover. With regard to staff start-ups, both university business incubators on campus ($\beta = 1.09–1.45$, $p < 0.01$) and off campus ($\beta = 0.56–0.71$, $p < 0.01$) increase their turnover. Science parks located on campus ($\beta = 0.65–0.91$, $p < 0.05$) also facilitate staff start-ups sales, but not off-campus science parks. We conclude that location on campus is likely to be more important for science parks than for business incubators to facilitate spin-offs, while any form of business incubation jointly with a university or outside university will increase staff start-ups. This finding again confirms Audretsch and Feldman (1996) as well as Marshall-Arrow-Romer externalities (Caragliu et al. 2016), who stressed the importance of co-location of entrepreneurs with the source of knowledge, in this case academic entrepreneurs and science parks as a source of knowledge in the UK.

Our H3 is partly supported. We find statistical differences in the marginal effect of university science parks located on campus and off campus for both spin-off activity (specification 1–4, Table 7.2) and start-up activity (specification 5–8, Table 7.2). H2 is rejected as t-test on regressors does not find any significant differences between the effects of university business incubators and science parks (off and on campus) on start-ups and spin-off sales. Interestingly that p values are higher for off-campus locations, while only the t-test for on-campus locations is reported. The differences may originate in research outcomes (patenting, licensing, etc.) since science parks may be more efficient due to their technology creation and transfer. Entrepreneurial outcomes are equally affected by science parks and incubators located both on and off campus.

Our H3 is partly supported. We find statistical differences in the marginal effect of university science parks located on campus and located off campus for spin-off sales ($p < 0.05$) (specification 1–4, Table 7.2). We do not find statistical differences in the marginal effect of university science parks located on and off campus for staff start-ups. The findings partly support the empirical evidence discussed above, and highlights the importance of co-location between entrepreneurs and researchers for spin-off activity with an element of university technology transfer (Link and Sarala 2019).

Table 7.2 GLS estimation results. Dependent variable (DV)—entrepreneurial outcomes

Specification	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
Dependent variable	*Spin-off sales*				*Staff start-ups sales*			
On-campus incubator (H1)	2.56***	1.19***	1.27***	1.18***	1.45***	1.09***	0.98***	0.98***
	(0.31)	(0.30)	(0.30)	(0.31)	(0.21)	(0.21)	(0.21)	(0.22)
Off-campus incubator (H1)	0.54*	0.06	0.29	0.29	0.71***	0.56**	0.59**	0.59**
	(0.30)	(0.29)	(0.28)	(0.28)	(0.22)	(0.23)	(0.23)	(0.23)
On-campus science park (H1)	2.58***	1.46***	−7.00	−8.18*	0.91***	0.65*	−3.22	−2.63
	(0.36)	(0.32)	(4.30)	(4.36)	(0.34)	(0.36)	(5.74)	(6.37)
Off-campus science park (H1)	1.04***	0.37	0.20	2.44	0.21	0.06	0.04	−2.90
	(0.34)	(0.28)	(0.29)	(4.08)	(0.31)	(0.31)	(0.32)	(4.99)
University staff		1.25***	1.32***	1.28***		0.46***	0.47***	0.46***
		(0.15)	(0.14)	(0.14)		(0.09)	(0.09)	(0.09)
Russell Group		1.67***	1.51***	1.65***		0.24	0.32	0.35
		(0.41)	(0.41)	(0.40)		(0.44)	(0.44)	(0.45)
STEM undergraduate		7.65***	5.83**	5.81**		2.65	2.47	2.28
		(2.76)	(2.59)	(2.51)		(2.60)	(2.65)	(2.64)
STEM postgraduate		3.05	4.32	3.89		−1.02	−0.36	−0.40
		(5.52)	(5.26)	(5.14)		(5.20)	(5.01)	(5.01)
Bio & medicine undergrad		−1.62	0.50	0.43		−2.23	−3.41**	−3.52**
		(1.93)	(1.93)	(1.96)		(1.45)	(1.51)	(1.51)
Bio & medicine postgrad		3.44	1.87	1.95		−1.09	−0.82	−0.86
		(2.60)	(2.45)	(2.44)		(0.77)	(0.77)	(0.77)
Business undergraduate		−2.35	−2.02	−1.80		−1.008	−0.95	−0.83
		(1.62)	(1.42)	(1.35)		(0.84)	(0.87)	(0.84)
Business postgraduate		−1.76	−2.39**	−2.30*		−0.06	0.07	0.13
		(1.19)	(1.20)	(1.20)		(0.85)	(0.84)	(0.85)
Economic development			0.09***	0.07***			0.01	0.01
			(0.03)	(0.03)			(0.02)	(0.02)

Business churn			0.14	0.21*			0.01	0.02
			(0.11)	(0.12)			(0.09)	(0.09)
Employment rate			−0.17**	−0.16**			−0.02	−0.03
			(0.03)	(0.04)			(0.03)	(0.03)
Public services			0.06**	0.07**			0.03	0.04
			(0.03)	(0.04)			(0.02)	(0.03)
On-campus science park x econ. development (H4)			−0.10**	−0.11**			−0.13**	−0.12**
			(0.04)	(0.04)			(0.05)	(0.05)
On-campus science park x business churn			0.07	0.12			−0.21*	−0.20*
			(0.11)	(0.10)			(0.11)	(0.12)
On-campus science park x employment rate			0.12*	0.12*			0.16*	0.15
			(0.07)	(0.07)			(0.09)	(0.10)
On-campus science park x public services			0.09**	0.11***			−0.12**	−0.12**
			(0.04)	(0.04)			(0.05)	(0.06)
Off-campus science park x econ. development (H4)				0.08**				0.01
				(0.04)				(0.04)
Off-campus science park x business churn				−0.21**				−0.04
				(0.09)				(0.10)
Off-campus science park x employment rate				−0.02				0.05
				(0.06)				(0.07)
Off-campus science park x public services				−0.08*				−0.02
				(0.05)				(0.05)
Constant	1.28***	−6.14**	0.12	−0.17	0.17	−2.48**	−2.42	−1.47
	(0.33)	(0.82)	(2.35)	(2.91)	(0.23)	(0.52)	(2.25)	(1.98)

(*continued*)

Table 7.2 (continued)

Specification	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
Dependent variable	*Spin-off sales*				*Staff start-ups sales*			
t-test for on-campus incubator vs. science park effects (H2)	0.23	0.56	0.55	0.45	0.22	0.50	0.51	0.49
t-test for on-campus vs. off-campus science park effects (H3)	0.01	0.02	0.01	0.01	0.49	0.52	0.50	0.59
Number of obs.	746	746	746	746	746	746	746	746
R2	0.27	0.47	0.50	0.51	0.15	0.18	0.22	0.22
RMSE	3.52	3.02	2.92	2.91	2.63	2.59	2.55	2.56
F-stats	33.89	65.54	66.76	66.20	17.92	10.93	8.22	7.09
Log-likelihood	−1994.2	−1875.0	−1846.2	−1840.8	−1775.2	−1760.0	−1745.1	−1744.4

Source: Authors' creation based on the data sources referenced in Table 7.1

Note: ∗∗∗, ∗∗, and ∗ significant at 1%, 5%, and 10% level. Std. Err. adjusted for 131 clusters in universities

Finally our H4 is supported. Higher regional economic development proxied by the GVA per capita reinforces the effect of university science parks on university entrepreneurial outcomes, however we find two separate effects. These effects are conditional on science park location (on campus or off campus) and the type of entrepreneurial outcome: spin-off sales or staff start-up sales. First, we find that economic development adversely affects spin-off activity in universities ($\beta = -0.10$–0.11, $p < 0.01$) where science parks are located on campus. Economic development increases spin-off activity in universities where science parks are located off campus ($\beta = 0.08$, $p < 0.05$). This finding can be explained by the fact that in regions with the highest economic development it is likely for science parks to have both multiple locations (to engage with stakeholders) and be located closer to infrastructure hubs (train stations, bus terminals, highways, or airports), while university campuses are often located outside city centers. Regions with higher economic development are more likely to establish science parks in a city center or business hubs, in other words, outside of universities. This may also increase science parks engagement with the business community in a city, and bring further spin-off development outside the university campus. Within the same vein, economic development decreases start-up sales in universities where science parks are on campus ($\beta = -0.12$–0.13, $p < 0.01$). The effect is not statistically significant for start-up sales in cities where science park is located off campus.

Our results demonstrate that science park location (off/on campus) in the UK plays a significant role in entrepreneurial outcomes at university with the effect varying depending on entrepreneurial outcomes (spin-off/staff start-ups) and regional economic development. Once regional factors are controlled for, we find that most regional indicators moderate the effect of science park location on entrepreneurial outcomes. These findings may be reflected in regional economic policy when policy makers decide on the mechanisms and channels on how to achieve higher entrepreneurial outcomes at universities (O'Shea et al. 2005; Urbano and Guerrero 2013; Wright et al. 2007) and better balance regional development (Audretsch et al. 2015) with entrepreneurship activity within a triple helix model (Miller et al. 2014).

Along with university science parks, incubation capabilities can be used to increase both entrepreneurship and research outcomes (Warhuus and Basaiawmoit 2014). Finally, regional economic activity aimed at enhancing the effect of university capabilities on various types of entrepreneurial outcomes is idiosyncratic. Regional capabilities are less associated with faculty start-up activities than are technology and spin-off outcomes, which may have direct policy implications.

7.5 Discussion and Conclusion

Three implications emerge from this research.

First, for academics, this study contributes to the strategic management debate about how universities are building their entrepreneurial capabilities (Klofsten et al. 2019), as well as the technology transfer debate within and between science parks and university (Wright et al. 2007).

Second, for university managers, the main implications is to be able to explain how co-location (or not) of incubators and science parks at university may change returns on entrepreneurial activity at university (Klofsten et al. 2019). Moreover, understand the dynamic role of certain environmental factors that affect entrepreneurial outcomes directly and indirectly (Audretsch and Link 2019) calls for more investment in university resource base, capabilities and infrastructure (Guerrero et al. 2015, 2016).

Third, for policy makers, the main implications are insights about the relevance of enhancing entrepreneurship outcomes and creating an entrepreneurship ecosystem (Audretsch and Belitski 2017) for building university commercialization capabilities (Link and Sarala 2019).

Fourth, for entrepreneurship research, we believe that the primary take away from this study is that cross-university patterns emerge, and insights can be gained from them and the two missing pillars of science parks research: its location and type of entrepreneurial outcome.

Professors of universities have little capability to start a company through the TTOs, due to resource availability. TTOs have to decide which project the university should commercialize. We recognize that many professors who have the ideas and then commercialize it may not involve the university.

This conclusion suggests future research in at least three areas. First, a similar study needs to be undertaken in other universities in other countries which can provide an overview that can be compared and contrasted with this. Second, more elaborate and in-depth studies on the type of science parks (specialized vs. multi-industry) and the type of business incubators are needed. For disciplines such as business, biology, and STEM, the effect of incubation and science parks on starting a business are different, as legal and technology limitations will be more pronounced. Third, research that affects economic growth should employ university staff for efficiency. More impact should be analyzed—patents, licensees, intellectual property, an in particular amongst scientists and engineers. Academic entrepreneurship brings potential conflicts between professors and universities, and the change in universities has spread across the UK, US and also in other countries.

Appendix: Universities Included in This Study

Anglia Ruskin University	Queen Margaret University, Edinburgh	The University of Edinburgh
Aston University	Queen Mary University of London	The University of Exeter
Bath Spa University	Ravensbourne	The University of Glasgow
Birkbeck College	Roehampton University	The University of Greenwich
Birmingham City University	Rose Bruford College	The University of Huddersfield
Bournemouth University	Royal Academy of Music	The University of Hull
Brunel University London	Royal College of Art	The University of Keele
Buckinghamshire New University	Royal College of Music	The University of Leeds
Cardiff Metropolitan University	Royal Conservatoire of Scotland	The University of Leicester
Cardiff University	Royal Holloway and Bedford New College	The University of Liverpool
Conservatoire for Dance and Drama	Royal Northern College of Music	The University of Manchester
Courtauld Institute of Art	SRUC	The University of Northampton
Coventry University	Sheffield Hallam University	The University of Oxford
De Montfort University	Southampton Solent University	The University of Portsmouth
Edinburgh Napier University	St. George's Hospital Medical School	The University of Reading
Glasgow Caledonian University	St. Mary's University College	The University of Sheffield
Glasgow School of Art	St. Mary's University, Twickenham	The University of Southampton
Goldsmiths College	Swansea Metropolitan University	The University of St. Andrews
Guildhall School of Music and Drama	Swansea University	The University of Strathclyde
Harper Adams University	The Arts University Bournemouth	The University of Sunderland
Heriot-Watt University	The City University	The University of Sussex
Heythrop College, London	The Institute of Cancer Research	The University of Wales, Newport
Imperial College of Science, Technology	The Liverpool Institute for Performing Arts	The University of West London

(*continued*)

(continued)

Institute of Education	The Manchester Metropolitan University	The University of Westminster
King's College London	The National Film and Television School	The University of Wolverhampton
Kingston University	The Nottingham Trent University	The University of York
Leeds Beckett University	The Open University	The University of the West of Scotland
Leeds College of Art	The Robert Gordon University	Trinity Laban Conservatoire of Music
Leeds College of Music	The Royal Central School of Speech an..	University College Birmingham
Leeds Trinity University	The Royal Veterinary College	University College London
Liverpool Hope University	The School of Oriental and African St..	University of Abertay Dundee
Liverpool John Moores University	The School of Pharmacy	University of Derby
London Business School	The University of Aberdeen	University of Gloucestershire
London Metropolitan University	The University of Birmingham	University of Hertfordshire
London School of Economics and Political sciences	The University of Bradford	University of London (Institutes)
London School of Hygiene and Tropical Medicine	The University of Brighton	University of Northumbria at Newcastle
London South Bank University	The University of Bristol	University of Nottingham
Loughborough University	The University of Cambridge	University of Plymouth
Middlesex University	The University of Central Lancashire	University of South Wales
Newcastle University	The University of Chichester	University of St. Mark and St. John
Newman University	The University of Dundee	University of Suffolk
Norwich University of the Arts	The University of East Anglia	University of the Arts, London
Oxford Brookes University	The University of East London	University of the West of England
Plymouth College of Art		York St. John University

Source: Authors' creation based on information from the Higher Education Funding Council for England (HEFEC), 2009–2016, https://www.gov.uk/government/organisations/higher-education-funding-council-for-england. Accessed May 1–2, 2019

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CHAPTER 8

Technoparks in Turkey: A Descriptive Study

Nilay Unsal

8.1 Introduction

University science and technology parks (STPs) are widely regarded as important infrastructures for innovation-based economic growth (Fikirkoca and Saritas, 2012; United Nations Educational, Scientific and Cultural Organization, 2015). Many developed and developing countries, and states within them, have invested in STPs to increase economic growth and international competitiveness (OECD 2007; National Research Council 2009; Yildiz and Aykanat 2015).

The government of the Republic of Turkey embraced STPs as national policy in the mid-1980s. During Turkey's sixth five-year (1990–1994) development plan by the State Planning Organization (DPT), Turkey acknowledged investments in research and development (R&D) as a priority for economic growth. According to the plan (DPT 1989: p. 309):

> 944. In order to establish research and development infrastructure, the number of research staff of 33,000 will be doubled and the number of research personnel per 10,000 people will be 15.

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> 945. Research and development expenditures will be increased to 1 percent of Gross National Product (GNP).[1]

Turkey's following development plans (1996–2000, 2001–2005, 2007–2013, and 2014–2018) had similar emphases. The goal was to increase research and development (R&D) expenditures as a percentage of GNP as well as to support regional development, skilled employment, technology production based on university-industry relations, technology transfers, and competitiveness of small and medium sized business (DPT 1995, 2000, 2006; OECD 2012; The Ministry of Development 2013; Demirli 2014).The aim for continuous government support of financial incentives was to have 1 percent of GNP going to R&D during the sixth five-year development plan. Although Turkey became one of the fastest growing countries in terms of real R&D expenditures since 1999 (OECD 2012), the country could not reach the intended level until 2016 (Kincal 2014). The ninth development plan indicated (DPT 2006):

> The share of R&D expenditures in Gross Domestic Product (GDP) is 0.67% as of 2002 which is quite low in science and technology compared to developed countries.

Thus, the government enacted the Technology Development Zones (TDZ) Law No. 4691 in 2001. A TDZ refers to (Law No. 4691):

> A site where academic, economic and social structures become integrated or a technopark which has these characteristics, where, by benefiting from the opportunities of a particular university or higher technology institute or R&D centre or institute, companies using high/advanced technology or companies that aim at new technologies produce/develop technology or software, where the companies work to transform a technological invention into a commercial product, method or service, thus contributing to the development of the zone, which is in the premises or close to the same university, higher technological institute or the R&D centre or institute.

Each TDZ is associated with at least one university or high technology institute or public R&D center or institute within the borders of the TDZ

[1] Sixth plan used Gross National Product (GNP), later plans used Gross Domestic Product (GDP). There is no clear source on why they took GNP in the sixth plan and changed it to GDP in later plans.

to be established. The law required this so that the TDZs have sufficient R&D and industry potential.

Although there is a considerable amount of qualitative research on Turkish technoparks, little quantitative research has been done due to the lack of national data. Moreover, a literature review by Hobbs et al. (2017a) recently reviewed 87 published articles on science and technology parks for over 30 years and only 1 publication about Turkish technoparks, a case study, appeared in their search.

The purpose of this chapter is to explore the population of technoparks in Turkey in detail and analyze potential indicators of technopark growth. Employment growth, which has regional economic benefits, is used to measure technopark growth. To the best of our knowledge, this chapter is the first that examines technopark growth in Turkey empirically. In addition, this paper contributes to the literature by introducing university quality as a control variable in a model of technopark growth. In the second section, we discuss the data sources and provide relevant descriptive statistics. In the third section, we posit an empirical model to investigate employment growth of Turkish technoparks. In the final section, we summarize findings and offer suggestions for future studies.

8.2 Literature Review

We have 11 papers that focus on technoparks in Turkey. Table 8.1 summarizes the type of the study, which Turkish technoparks were analyzed, and findings of the study. We grouped publications into three types: empirical studies (2), review (3), and case study (6). Seven of the 11 papers focus on the entire country, three focus on some technoparks in Ankara, and one focuses on the Istanbul region.

The literature on technoparks in Turkey has mostly focused on: (1) the impacts on the national economy (Kincal 2014; Olcay and Bulu 2016; Koc 2018), (2) the impacts on patenting performance (Pekol and Erbas 2011; Olcay and Bulu 2016), (3) the government incentives (Demirli 2014; Kayalidere 2014; Koc 2018), and (4) issues that technoparks face (Bengisu 2004; Fikirkoca and Saritas 2012; Basalp and Yazlik 2011). In general, studies were either review papers or case studies with descriptive analyses. Few econometric analyses were done on how technoparks impact patenting performance (Pekol and Erbas 2011).

Olcay and Bulu (2016) state that diffusion of knowledge and technology to industry is necessary for national economic growth. The survey they conducted showed that technoparks have high importance for innovativeness

Table 8.1 Literature related to technoparks in Turkey

Author(s)	*Type of the study*	*Technopark*	*Findings*
Bengisu (2004)	Case study	Turkey	Case study that looks at the innovation role of technoparks in Turkey. Finds that there is a lack of planning and coordination due to insufficient industrial infrastructure related to innovation
Basalp and Yazlik (2011)	Case study	Turkey	Case study of issues that technoparks face. Concludes that technoparks need support during the set-up phase and mass production after the prototype is produced
Demirli (2014)	Case study	Turkey	Case study of incentives for technoparks in Turkey. Examines the tax incentive for R&D personnel and entrepreneurs and the contributions of these incentives on R&D intensity and employment
Fikirkoca and Saritas (2012)	Case study	Ankara University Technopolis	Case study of technopark at Ankara University. Discusses the factors that impacts success of technoparks where complementarity, networking, and scalar dynamics could be useful guides
Kayalidere (2014)	Review	Turkey	Reviews the tax advantages provided to technoparks
Kincal (2014)	Review (Unpublished)	Turkey	Reviews direct and indirect impacts of technoparks on skilled employment and on capital inflow which contribute to stable economic growth
Koc (2018)	Review	Turkey	Explains tax exceptions on technoparks as solutions to R&D applications as well as contributions of R&D activities using theoretical approaches for economic growth
Olcay and Bulu (2016)s	Case study	Technoparks located in Istanbul	Case study of technoparks in Istanbul. Finds that existence of university-based technology transfer offices positively contributes to regional economic growth and innovativeness

(*continued*)

Table 8.1 (continued)

Author(s)	*Type of the study*	*Technopark*	*Findings*
Pekol and Erbas (2011)	Empirical	Istanbul Technical University (ITU), Scientific and Technological Research Council of Turkey (TUBITAK), Ankara, and Middle East Technical University (METU)	Analyzes determinants of the number of patents which impacts innovation and economic growth. Finds that having tenants with a separate department or personnel for patenting has a positive impact on number of patents
Varol et al. (2009)	Case study	Cyberpark, Hacettepe, and METU	Case study of innovative strategies in Turkey. Discusses instruments and institutional arrangements to encourage technology development
Yildiz and Aykanat (2015)	Empirical	Turkey	Analyzes the relationship between perceptions of clusters and innovation for tenants. Finds that firms clustered in technocities are more inclined to make innovations than their non-clustered competitors

Source: Author's creation based on information in the references listed in the table

and economic growth. Review papers (Kincal 2014; Koc 2018) argue that technoparks are essential for sustainable economic growth because of intensive technology and technology transfer to industry.

The relationship between Turkish technoparks and patenting is another common subject in the literature. A survey by Olcay and Bulu (2016) showed that the number of patents was around 15–22 per year per technopark and up to 20 percent of patents were licensed. Pekol and Erbas's (2011) empirical analysis showed that the benefits provided from TDZs have a positive and significant association with the probability of having a patent.

Review papers on government incentives focused on the financial assistance for entrepreneurs and R&D personnel as well as tax exemptions for technoparks which are valid until 2023 (Demirli 2014; Kayalidere 2014; Koc 2018). However, the United Nations Educational, Scientific and Cultural Organization (UNESCO) 2015 report emphasized the difficulties in turning R&D performance into economic gains which is an obstacle for Turkey to achieve its development targets.

Papers on issues that technoparks face review the reasons why a technopark would not successfully achieve its goals. Fikirkoca and Saritas (2012) present the three-dimensional policy framework (complementarity, networking, and strategic scalar positioning) for success which was established by Ankara University. Bengisu (2004) states that planning and coordination related to innovation is critical for technoparks to succeed. Thus, instead of increasing the number of technoparks, there is a need to increase technological production and establish technoparks close to universities with skilled researchers and high research capacity. Basalp and Yazlik (2011) emphasize that there is a need to increase support for business incubation and mass production stages.

The literature in Turkey lacks empirical analyses in general. In particular, there is a need for evaluations on technoparks' performances that impact economic indicators. In this paper, we focus on employment growth in technoparks. In the international literature, employment growth in technoparks has been a widely evaluated outcome (Link and Link 2003; Hobbs et al. 2017b; Chen and Link 2018; Link and Yang 2017).

8.3 Empirical Overview

There is a national registry of technoparks (http://teknoag.sanayi.gov.tr/) from which one can determine the number of tenants and employees within the park, and the year the technopark become active. This information was updated with the current website statistics. From the websites, the year each technopark was founded was obtained.

There are currently 81 technoparks in Turkey, but 20 of them are not currently active which means they have no tenants and no employees. Table 8.2 provides descriptive information on the 61 active technoparks including their region, the year they become active, the distance (in kilometers) between the technopark and the main campus of the associated university, and the current number of employees. The table is ordered based on year becoming active.

Regions are classified based on the Nomenclature of Territorial Units for Statistics (NUTS). In Turkey, there are 12 NUTS regions which are

Table 8.2 List of technoparks

Technopark	*Regions*	*Year becoming active*	*Distance (km)*	*Employment*
Cyberpark	West Anatolia	2002	0	3906
Hacettepe Teknokent	West Anatolia	2003	0	3463
METU Teknokent	West Anatolia	2003	0	7200
ITU Ari Teknokent	Istanbul	2003	0	6859
Gebze Organize Sanayi Bolgesi Teknopark	East Marmara	2003	48.9	1259
TUBITAK Marmara Teknokent	East Marmara	2003	7.6	2006
Teknopark Izmir	Aegean	2004	0	1000
Konya Teknokent	West Anatolia	2004	4	398
Anadolu Teknoloji Arastirma Parki	East Marmara	2004	14.2	596
Kocaeli University Tecknopark	East Marmara	2004	20	560
Antalya Teknokent	Mediterranean	2005	0	640
Ulutek Teknopark	East Marmara	2006	0	983
Goller Bolgesi Teknokent	Mediterranean	2006	0	107
Technoscope-Mersin Teknokent	Mediterranean	2006	0	411
Erciyes Teknopark	Mid Anatolia	2007	1	1243
Cukurova Teknokent	Mediterranean	2007	0	214
Gazi Teknopark	West Anatolia	2008	20.3	1156
Trabzon Teknokent	East Black Sea	2008	4	150
Gaziantep Teknopark	Southeastern Anatolia	2008	0	194
Ankara University Techopolis	West Anatolia	2009	21	733
Yildiz Technical University Teknopark	Istanbul	2009	0	6945
Firat Teknokent	Mid-Eastern Anatolia	2009	3.7	150
Trakya Teknopark	West Marmara	2009	5.2	68
Bogazici University Teknopark	Istanbul	2010	0	220
Ata Teknokent	Northeastern Anatolia	2010	0	189
Sakarya Teknokent	East Marmara	2010	0	395
Pamukkale Teknokent	Aegean	2010	0	339
Bolu Teknokent	East Marmara	2011	0	29

(*continued*)

Table 8.2 (continued)

Technopark	*Regions*	*Year becoming active*	*Distance (km)*	*Employment*
Cumhuriyet Teknokent	Mid Anatolia	2011	3.9	87
Duzce Teknopark	East Marmara	2011	0	82
Istanbul University Teknokent	Istanbul	2012	29.1	957
Malatya Teknokent	Mid-Eastern Anatolia	2012	3	96
Dicle Teknokent	Southeastern Anatolia	2012	2.5	39
Kahramanmaras Teknokent	Mediterranean	2012	0	82
Dokuz Eylul University Technology Development	Aegean	2013	11.6	1700
Tokat Teknopark	West Black Sea	2013	0	130
Namik Kemal University Teknopark	West Marmara	2013	0	133
Kutahya Teknokent	Aegean	2013	17.5	31
Istanbul Teknopark	Istanbul	2013	51.7	4347
Samsun Teknopark	West Black Sea	2014	0	137
Canakkale Teknopark	West Marmara	2014	6.6	119
Sanliurfa Teknokent	Southeastern Anatolia	2014	8.7	18
Ege Teknopark	Aegean	2015	0	399
Marmara University Teknopark	Istanbul	2015	0	15
Yuzuncu Yil University Teknopark	Mid-Eastern Anatolia	2015	0	39
Kirikkale University Teknopark	Mid Anatolia	2015	0	97
Corum Teknokent	West Black Sea	2015	17.1	15
Bozok Teknopark	Mid Anatolia	2015	0	21
Izmir Sciencepark	Aegean	2015	33.9	107
Innopark	West Anatolia	2016	20.3	88
Zafer Teknopark	Aegean	2016	0	30
Nigde Teknopark	Mid Anatolia	2016	0	27
Bilisim Vadisi	East Marmara	2017	0	281
Teknopark Ankara	West Anatolia	2017	15.8	1065
Manisa Teknokent	Aegean	2017	0	230

(*continued*)

Table 8.2 (continued)

Technopark	*Regions*	*Year becoming active*	*Distance (km)*	*Employment*
Adnan Menderes University Teknokent	Aegean	2017	0	39
Ostim Teknopark	West Anatolia	2018	12.8	5
Zonguldak Teknopark	West Black Sea	2018	5.8	3
Kapadokya Teknopark	Mid Anatolia	2018	0	36
Mehmet Akif Ersoy University Teknokent	Mediterranean	2018	0	3
Gaziantep Organize Sanayi Bolgesi TDZ	Southeastern Anatolia	2018	24.6	1

Source: Author's creation based on information in the Turkish registry of technoparks as reported at http://teknoag.sanayi.gov.tr/. Accessed January 29, 2019

Istanbul, West Marmara, Aegean, East Marmara, West Anatolia, Mediterranean, Mid Anatolia, West Black Sea, East Black Sea, Northeastern Anatolia, Mid-Eastern Anatolia, and Southeastern Anatolia. Figure 8.1 shows that Aegean (which includes the city of Izmir), East Marmara, and West Anatolia (which includes the city of Ankara) have the greatest number of parks across the regions; this distribution is consistent with the regional population and industrialization.

Although the development plans prioritized investments in R&D, due to the low participation of the private sector in R&D activities, the goals of the development plans were delayed. Thus, the government enacted Law No. 4691 in 2001. This is the reason why the earliest year for an active technopark was 2002 as shown in Table 8.1. The law includes monetary support for TDZs to construct infrastructure, administration building, and incubation centers as well as technology transfer office services. In addition, the law includes financial incentives of income, stamp, and corporate tax exemptions which are valid till December 31, 2023. Figure 8.2 shows the number of technoparks that became active between the years 2002 and 2018. There is a continuous increase in the number of technoparks. The years with the lowest number of technoparks established were 2002 and 2005 and the year with the highest number was 2015.

Some universities have multiple campus locations which could be further away from main campus. If the park is located off of the main campus,

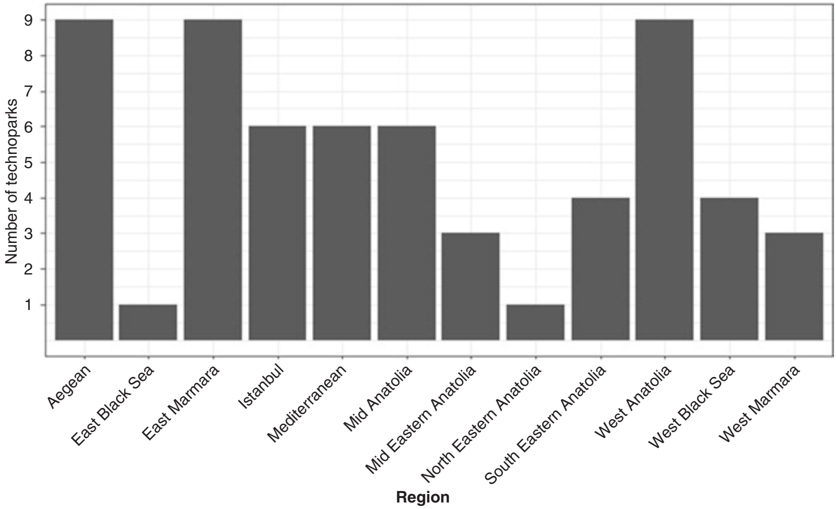

Fig. 8.1 Number of technoparks by region. (Source: Author's creation based on information in the Turkish registry of technoparks as reported at http://teknoag.sanayi.gov.tr/. Accessed January 29, 2019)

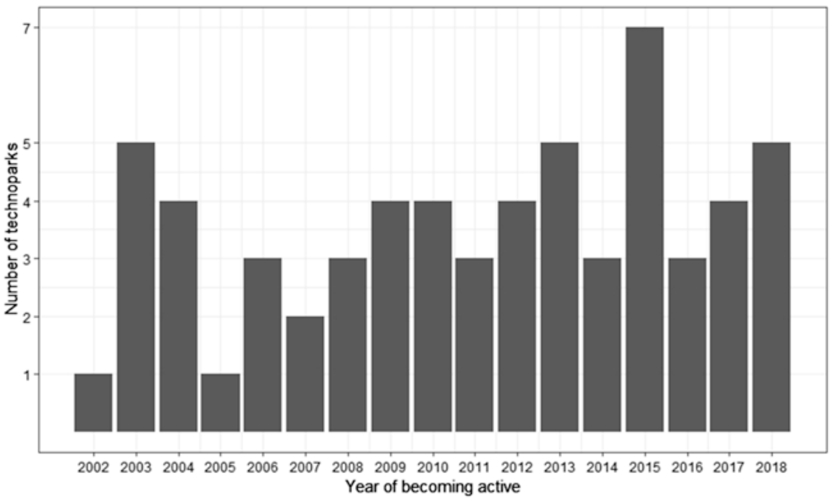

Fig. 8.2 Number of technoparks by year becoming active. (Source: Author's creation based on information in the Turkish registry of technoparks as reported at http://teknoag.sanayi.gov.tr/. Accessed January 29, 2019)

we calculated the distance of the park from the main campus in terms of kilometers. In addition, the park could have multiple university associations. For those, we calculated the distance of the park from the main campus of the nearest university. Table 8.2 shows that there are 27 parks that are not located on the campus of their associated university.

Table 8.2 also includes the current number of employees. Twenty-one technoparks provided up-to-date employment information on their websites. We used government websites for the rest for which we do not have the employment information. The caveat with the government website is that the year when data was collected is not clear. Figure 8.3 shows the current mean number of employees by the year that the technopark became active. Clearly, mean employment is greater in those parks that became active in 2002 and 2003, immediately after the passage of Law No. 4691 in 2001. In addition, Turkey experienced impacts of the Great Recession (2007–2009) with a delay which resulted in employment decline in years 2010–2012. Although we see a turnaround in 2013 with a substantial employment increase, the trend did not continue in the following years. One potential reason might be technoparks became active only with a small number of employees in those years.

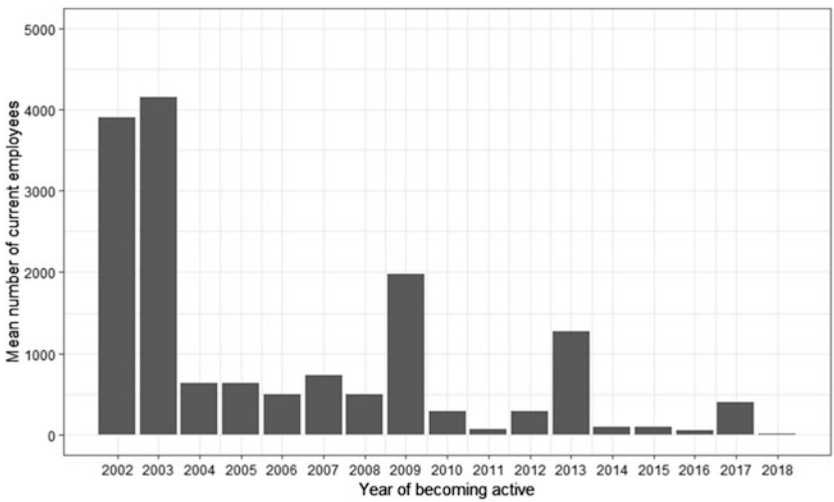

Fig. 8.3 Mean number of employees by year becoming active. (Source: Author's creation based on information in the Turkish registry of technoparks as reported at http://teknoag.sanayi.gov.tr/. Accessed January 29, 2019)

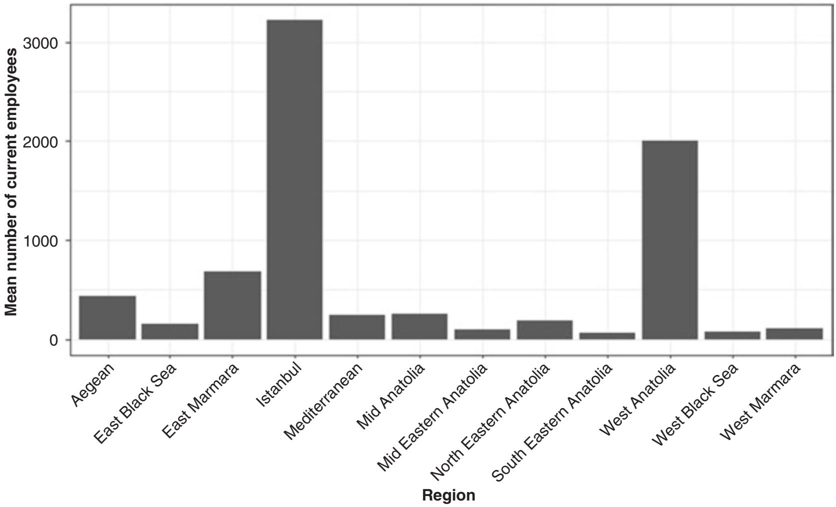

Fig. 8.4 Mean number of employees by region. (Source: Author's creation based on information in the Turkish registry of technoparks as reported at http://teknoag.sanayi.gov.tr/. Accessed January 29, 2019)

In addition, Fig. 8.4 shows that the greatest mean number of employees is in the Istanbul and West Anatolia regions. These are the two regions of the country with the greatest population and the largest universities.

8.4 Empirical Analysis

The empirical goal of this paper is to investigate covariates with employment growth across Turkey's technoparks. The dependent variable is the log of current employment. We focused on three main explanatory variables. The first variable is the distance in kilometers of the technopark to the main campus of the university: *distance*. We hypothesize that there is a negative relationship between distance and employment growth. The closer the technopark to the university, the greater the employment growth in the park due to easier knowledge sharing among scientist and university (Link and Scott 2006; Hobbs et al. 2017b).

The second variable is the age of the park which is the number of years that the park has been active: *park age*. We hypothesize that the older the park, the greater the employment growth due to the longer time period to grow (Chen and Link 2018).

The third variable is the ranking score of the university that provides information on university quality. This is measured using two different methods: by University Ranking by Academic Performance (URAP) and URAP international and national scores.[2] We hypothesize that the higher the score, the greater the research quality at the university and thus the greater the employment growth of the technopark.

The use of employment growth as a performance metric for a technopark follows other studies of science parks, as discussed above (European Commission 2014; Hobbs et al. 2017b). Table 8.3 presents descriptive statistics on relevant variables. In the regression models all variables are measured as logs for ease of interpretation of the estimated coefficients; each estimated coefficient is interpreted as an elasticity.

Table 8.3 Descriptive statistics

	Observation	*Mean*	*Standard deviation*	*Minimum*	*Maximum*
Number of employees (R&D and others)	61	850.36	1670.44	1.00	7200.00
Log number of employees	61	5.19	1.98	0.00	8.88
Technopark's distance to the main campus in km	61	6.80	11.67	0.00	51.70
Log of distance	61	−1.53	3.54	−4.61	3.95
Age of the park—active years	61	8.03	4.85	1.00	17.00
Log park age	61	1.83	0.81	0.00	2.83
URAP international scores	61	169.76	60.18	56.87	299.34
Log international URAP scores	61	5.07	0.38	4.04	5.70
URAP national scores	56	524.96	121.60	260.77	805.37
Log national URAP scores	56	6.24	0.24	5.56	6.69

Source: Author's creation based on data and information in Table 8.2

[2] URAP has two different measuring methods. One of the scores is used for international comparison where a total score of 600 is distributed to indicators of number of articles (21%), citation (21%), total documents (10%), article impact total (18%), citation impact total (15%), and international collaboration (15%) (http://www.urapcenter.org/2018/country.php?ccode=TR&rank=all). The other one is used to rank only Turkish universities. It includes total reference, total scientific document, score of number of PhD graduates, and score of number of students per faculty where each domain has equal weight on the total score (http://tr.urapcenter.org/2018/2018_t9.php).

The results from alternative specifications are presented in Tables 8.4 and 8.5. The model in Table 8.5 controls for the region in which the technopark is located.

The results in Table 8.4 show that distance is not a significant covariate with employment growth. Following Link and Scott (2006), Hobbs et al. (2017b), and Chen and Link (2018) it is possible that the importance of distance on employment growth in science parks declined after the information communication technology revolution began in 2000. After that, tacit knowledge could be transferred between scientists without face-to-face communication. Park age is a significant covariate with employment growth. The results in column (1) of Table 8.4 suggest that a 10 percent increase in park age is associated with a 12.3 percent increase in employment growth. The estimated elasticity of park age in column (2) is 13.2 percent. Finally, the quality of the university associated with the technopark is also a significant covariate. From column (1), a 10 percent increase in international URAP points is associated with a 17.9 percent increase in employment growth; the estimated elasticity in column (2) is even larger—25.6 percent.

The specifications in Table 8.5 are identical to those in Table 8.4, except regional control dummies are added as independent variables. The

Table 8.4 Regression for employment growth

	(1)	*(2)*
	Log number of employees	*Log number of employees*
Log of distance	−0.015	−0.001
	(0.047)	(0.049)
Log park age	1.229***	1.317***
	(0.253)	(0.250)
Log international URAP points	1.789***	
	(0.479)	
Log national URAP points		2.562***
		(0.825)
Constant	−6.158***	−13.221***
	(2.272)	(4.930)
Observations	56	60

Source: Author's creation based on the data underlying the descriptive statistics in Table 8.3

Notes: Standard errors are in parenthesis. $*p < 0.10$, $**p < 0.05$, $***p < 0.001$

Table 8.5 Regression for employment growth—controlled for regions

	(1)	*(2)*
	Log number of employees	*Log number of employees*
Log of distance	−0.036	−0.016
	(0.051)	(0.053)
Log park age	1.458***	1.474***
	(0.278)	(0.255)
Log international URAP points	1.165*	
	(0.637)	
Log national URAP points		0.985
		(0.993)
Istanbul	−3.104	−2.493
	(3.353)	(6.062)
West Marmara	−3.589	−4.172
	(2.883)	(5.859)
Aegean	−2.849	−3.173
	(3.011)	(5.942)
East Marmara	−3.394	−3.733
	(3.029)	(5.979)
West Anatolia	−2.693	−2.824
	(3.290)	(6.233)
Mediterranean	−4.319	−4.427
	(3.090)	(5.803)
Mid Anatolia	−3.620	−3.751
	(2.927)	(5.849)
West Black Sea	−3.984	−4.424
	(2.995)	(5.965)
East Black Sea	−4.562	−4.740
	(3.371)	(6.159)
Northeastern Anatolia	−4.343	−4.393
	(3.398)	(6.187)
Mid-Eastern Anatolia	−4.181	−4.528
	(3.090)	(6.025)
Southeastern Anatolia	−4.668	−5.169
	(3.015)	(5.849)
Observations	56	60

Source: Author's creation based on the data underlying the descriptive statistics in Table 8.3

Notes: Standard errors are in parenthesis. $*p < 0.10$, $**p < 0.05$, $***p < 0.001$

estimated results are similar to those in Table 8.4 with respect to distance and park age. The size of the elasticities for URAP points is lower as is the significance of each measure. None of the regional controls are statistically significant suggesting that the results in Table 8.4 are more robust.

8.5 Discussion

We have information on one employment count per technopark that is measured at a given time. Our growth model looks at how distance to a university, park age, and quality of associated university impact employment growth. In the literature, the focal explanatory variable for employment growth is distance (Link and Scott 2006; Hobbs et al. 2017b; Chen and Link 2018). After 2000, the negative association between distance and employment growth has been eliminated in technoparks due to the effects of information and communication technologies (Hobbs et al. 2017b). However, in Turkey, all of the technoparks in the sample became active after 2001. Thus, the distance variable does not provide information on the effect of the new millennium. The distance coefficient is negative but not significant in any of the estimations. Estimation results for technopark age are consistent with the literature where there is a positive and significant association between technopark age and employment growth (Chen and Link 2018).

The university quality measure contains information on research quality which potentially impacts the performance of technoparks. This chapter shows that there is a positive and significant association between university quality and employment growth. Including university quality in the model is not common but necessary when evaluating technopark performance in this literature.

There are three contributions of this chapter. First, to the best of our knowledge, this chapter is the first to examine growth of Turkish technoparks using an empirical analysis. Second, this chapter introduces university quality as a contributor to technopark growth. Third, we can generalize our findings for the country because the sample includes all active technoparks in Turkey.

There are three limitations of this study. First, we do not observe the exact year when the employment counts are updated, especially the ones from the government's website. Second, the employment counts include total employment and we do not have information on R&D employment counts. Third, there are no benchmarks to compare our findings with. To overcome these limitations, detailed data collection and more research are needed on the growth of technoparks in Turkey.

Technoparks are important sources for R&D investment, and thus for economic growth. Strategies to increase employment growth of technoparks are important for developing countries as well as emerging economies that focus on economic growth with technology transfer. This chapter shows that technopark employment growth can be achieved by collaborating with high quality universities. A developing country at an early stage of establishing technoparks can take advantage of this strategy. Regardless of the country focus, future research should explore the relationship between university quality and technopark performance.

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CHAPTER 9

Heterogeneity as a Key for Understanding Science and Technology Park Effects

Alberto Albahari

9.1 Introduction

Science and Technology Parks (STPs) are a particular subset of non-spontaneous agglomerations, aimed at encouraging the formation and growth of on-site technology- and knowledge-based firms. One of the main differences between STPs and other spontaneous agglomerations and clusters is the existence of a management team, which is engaged actively in achieving the park's goals.

Despite the wide diffusion of STPs, there is intense debate among academics, practitioners and policy makers as to their effectiveness as instruments of innovation and local development policy.

Detractors of STPs argue that park location has no relevant impact on firm results since it does not deliver significant added value to tenants (e.g., Macdonald 1987). Some question the STP model (Hansson et al. 2005;

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Massey and Wield 1992) and some authors consider STPs to be 'high-tech fantasies' (Quintas et al. 1992). There are several empirical studies that find no significant differences in the performance of on- and off-park firms, support these opinions (e.g., Colombo and Delmastro 2002; Ferguson 2004; Liberati et al. 2016; Löfsten and Lindelöf 2002; Westhead 1997).

Others claim that STPs provide a supportive environment for new knowledge- and technology-based firms, facilitating technology transfer, promoting firm growth, attracting leading-edge technology firms, and fostering strategic alliances and networks (del Castillo Hermosa and Barroeta 1998; Hommen et al. 2006; Siegel et al. 2003a). Previous empirical studies show that on-park location generates externalities which can have positive effects for the innovation activity of firms in relation to inputs to the innovation process (Fukugawa 2006; Leyden et al. 2008; Yang et al. 2009), increase research productivity (Siegel et al. 2003b; Yang et al. 2009), increase patent rates (Hu 2008; Huang et al. 2012; Squicciarini 2009, 2008) and new product developments and innovation sales (Chan et al. 2011; Díez-Vial and Fernández-Olmos 2015; Montoro-Sánchez et al. 2011; Motohashi 2013; Siegel et al. 2003b; Vásquez-Urriago et al. 2016, 2014).

This rather mixed evidence does not allow conclusions about the effectiveness of STPs. However, in my view, rather than asking whether STPs have a positive impact or not on tenant firms, it is more important to address the question of *when* and under what conditions are STPs effective. This highlights the need to take account of park heterogeneity.[1]

Most quantitative studies assess the average (homogeneous) effect of STPs on firms. That is, the authors assume implicitly that all STPs have the same effect on tenants and that all the tenants benefit in the same way from on park location.

This restrictive assumption must be overlooked to achieve a more detailed understanding of the STP phenomenon.

A few years ago, when I was embarking on my doctoral studies, I interviewed someone from the Spanish government with responsibility for STP policy. He told me that:

[1] An alternative and complementary view points to the existence of heterogeneous effects also on the demand-side of STPs. That is, some firms may benefit more than others from the on-park location. See, for instance, Vásquez-Urriago et al. (2016), Díez-Vial and Fernández-Olmos (2015, 2017), Liberati et al. (2016) and Huang et al. (2012).

> *we perfectly know that there are parks which work well and help firms' creation and growth and parks which don't. We must understand when and why this happens*

In this chapter, I propose several sources of park heterogeneity and theorize about their potential impact. Where available, I provide empirical evidence of their effect on the added value of on-park location.

9.2 Parks' Heterogeneity: Are All the Parks the Same?

Parks heterogeneity is not a new concept. The *United Kingdom Science Park Association* stated almost three decades ago that:

> *no two science parks are alike and it would be unwise to generalise on the success or otherwise of the science park movement by considering one or two examples however famous or prestigious they may be.* (Grayson, 1993, p. 119, cited in Westhead 1997)

Similarly, Albert Link wrote:

> *If you've seen one research park … you've seen one research park* (Link 2009)

There are several distinctive STP characteristics which increase their heterogeneity (Fig. 9.1).

9.2.1 Age

STP age may have an impact on effectiveness. Older parks rely on more accumulated knowledge and a better understanding of tenants' needs, which can translate into better services for tenants. Also, it takes time to build mutual trust between park management and park tenants. Therefore, some argue that a period of 15 to 25 years is needed to allow a comprehensive evaluation of the full impact of an STP (Castells and Hall 1994). On the other hand, there is the risk that older parks might experience ossification of routines, non-learning processes, blindness and conservatism (Durand and Coeurderoy 2001) which would result in lower quality business support for firms.

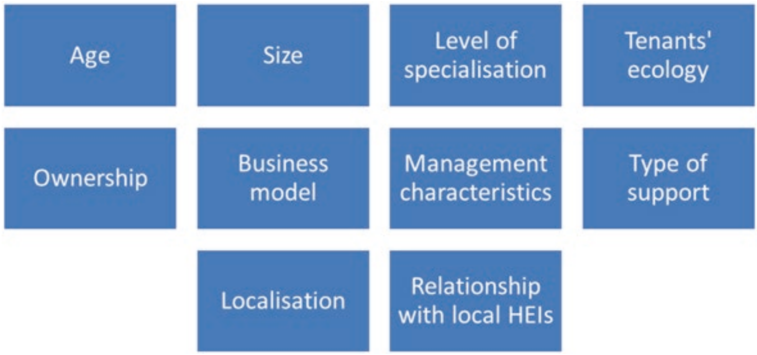

Fig. 9.1 Potential sources of heterogeneity of parks. (Source: Author's creation based on own interpretation of the science park literature as reviewed in Link 2009)

Although the effect of age on firm performance has been analysed in some depth (Huergo and Jaumandreu 2004), few studies take explicit account of the effect of park age on tenants. There is some agreement that STPs need time to affect tenants' performance. Link and Scott (2005) show that older parks seem more able over time to create an entrepreneurial environment, which facilitate formation of university spin-off companies. Liberati et al. (2016) show that only older parks have a positive effect on tenant firms' sales and added value. In a recent paper (Albahari et al. 2018a) we showed that park age has a non-linear effect on tenants' innovation performance (at least in terms of sales from new products), with firms in younger and older parks outperforming those in middle-aged parks. We explained this finding as due to a positive short-term effect related with marketing issues, such as increased visibility and reputation, which is overtaken in the longer term by a positive effect related to the business support delivered by the park.

9.2.2 Size

For STPs, similar to other types of agglomerations, size plays an important role. The classical economic geography argument is that co-location with other firms generates agglomeration economies which increase with the number of firms in the same location (Arthur 1990). Larger agglomerations can rely on a larger stock of knowledge available on-site, and on greater regional social capital (Malecki 2012), which enhances innovation, learning processes, knowledge transfer and entrepreneurship. On the other hand, larger STPs can suffer diseconomies of agglomeration, generated by greater competition for the limited available space, specialized workforce and utilities (Folta et al. 2006).

We demonstrate the effect of STP characteristics on tenants' innovation performance (Albahari et al. 2018a) and show that STP size is positively related to the innovation performance of tenants. This is in line with Squicciarini (2009) who shows that park size positively affects tenants' patenting activity. However, Hu (2007) and Zhang and Sonobe (2011) find evidence of diseconomies of agglomeration and a negative relation of park size to labour productivity growth and productivity. Thus, the evidence is mixed about the existence or not of congestion effects, while there is a greater consensus on the achievement of a minimum critical size for the STP to have a positive effect on its firms.

9.2.3 Level of Specialization

In the case of level of specialization, the fundamental question is whether firms benefit more from location on a specialized single-purpose STP or a generalist multi-purpose STP. The debate here revolves around Marshall and Jacobs externalities (see Beaudry and Schiffauerova 2009). Specialized STPs, where most firms belong to the same industry, follow a rationale based on Marshall externalities. The concentration of firms belonging to the same industry facilitates knowledge spillovers, dissemination of ideas among neighbouring firms and the movement of highly skilled personnel (Glaeser et al. 1992). Specialized parks also may have stronger brand identity (Salvador 2011). Generalist STPs follow a rationale based on Jacobs' externalities where the cross-fertilization of ideas from different industries is the most important source of knowledge spillovers (Beaudry and Schiffauerova 2009).

Again, the empirical evidence is scarce. Liberati et al. (2016) show that generalist parks are more effective than specialized parks for improving tenants' sales performance, while specialized parks have a positive effect on the investments made by the firms they host. Squicciarini (2009) finds no significant differences in the patenting likelihood for firms in specialized or non-specialized parks.

9.2.4 Tenants' Ecology

The tenant selection criteria matter and can be a potential source of park heterogeneity. Since park space is limited, selecting the most efficient firms with the biggest growth potential is very relevant (Chen and Huang 2004).

An important issue is the ideal composition of the firms in a park to maximize the park effect. In addition to the level of specialisation of the park, we need to know whether the on-park effect on its firms is modulated by the types of firms. For example, should parks host only technology-based start ups or include also mature firms? Should they have a certain percentage of consultancy firms? Should they try to attract more prestigious firms which might attract other firms? Should they host only independent firms or also branches of established firms located elsewhere?

Empirical evidence is lacking. There are some authors who state that successful STPs include a prominent percentage of consultancy and technical services firms (Cabral 1998), but it is unclear why tenants would buy services from on-park firms rather than from the best provider which might be located outside the park (Albahari et al. 2018a).

9.2.5 Ownership

STPs are heterogeneous, also, in the shareholder composition. This tends to be related to the park's historical development and can vary according to the country. For example, while UK STPs tend to be owned by universities (Siegel et al. 2003a; Westhead and Storey 1995), in Spain they are promoted mainly by local administrations. In previous research, we compared Italian and Spanish STPs systems (Albahari et al. 2013) and found that 56% of Spanish STPs and 37% of Italian STPs do not have a university shareholder. Link and Scott (2005) report that 69% of American STPs are not run by a university. Also, the presence of private shareholders varies hugely. For example, 83% of Italian STPs, but only 28% of Spanish STPs have private companies among their shareholders. This is not a secondary issue because parks with a different main shareholder (university, local administration or private companies) are likely to have different goals and it is important to take account of parks' aims when evaluating their impacts (Bigliardi et al. 2006).

Few papers provide quantitative assessments of the impact of different shareholder composition on tenants' outcomes. Liberati et al. (2016) find that public parks outperform mixed or private parks measured by tenants' sales and added value, which suggests that mixed governance is not a necessary condition for an STP. In Albahari et al. (2017), we show that greater formal involvement of universities in the park has a twofold effect on tenants: a negative effect on innovation sales and a positive effect on patenting activity.

9.2.6 Business Model

The business model followed by STPs is likely to affect outcomes and the effect on tenants. Some papers (Dew et al. 1995; Durão et al. 2005; Rowett et al. 1996) defend a virtual STP model where firms may be located at a distance from each other. There are some virtual STPs in Barcelona, Spain (22@Barcelona) and Norrköping, Sweden (Norrköping Science Park) and many traditional STPs offer virtual tenancies (e.g. Plymouth Science Park, UK). In a study of Italian STPs we found that among the 52 STPs analyzed, 22 had a non-traditional property-based business model (Albahari et al. 2013). The main difference between a traditional and a virtual STP is the existence or not of a specific perimeter which makes it clear whether a firm is a park tenant.

In a case study of a Swedish region (Albahari et al. 2018b), we found no significant differences in how the traditional and the virtual STP create value for tenants. However, in that case study, the virtual STP included firms located in the same city.

Another feature of STPs related to the business model is whether they are 'managed' or 'non-managed STPs (Siegel et al. 2003a; Westhead 1997). Managed STPs have a full-time manager on-site, who is responsible for the management of the park. However, this differentiation has become less important since, according to the definition provided by the International Association of Science Parks and Areas of Innovation (IASP), STPs must have a management function actively engaged in achieving the park's goals.

9.2.7 Management Characteristics

Parks differ, also, in terms of their management teams. The existence of a management team is one of the distinguishing characteristics of a STP. It has been argued that a formal integrated management structure constitutes a more secure basis for firms' long-term development (Westhead and Batstone 1998) and that the park managers can contribute to providing a supportive environment for entrepreneurs by augmenting their networks and facilitating technology transfer (Siegel et al. 2003a). Cabral (1998) suggests that common to the most successful parks is a strong, expert managerial team. Colombo and Delmastro (2002) highlight the importance of the internal organization of the park. This should be lean and agile since too large a management team could result in too much bureaucracy and over-regulation. However, we found that a larger management structure is beneficial for tenants (Albahari et al. 2018a).

9.2.8 Type of Support

Since their emergence in the US in the mid-20th century, STPs have evolved from an organizational model based mainly on land tenancy—described pejoratively by some as 'firm hotels' (Löfsten and Lindelöf 2002), to an interactive and multifaceted organizational model involving more complex roles and relationships (Cadorin et al. 2019). It is commonly accepted that the services provided by parks, either directly or via external providers, help young technology-based firms to overcome the 'liability of newness' (Freeman et al. 1983; Stinchcombe 1965), which makes access to funding complicated (Ferguson 2004; Storey and Tether 1998). However, the support provided varies in the types and quality of services provided.

Our earlier study of park characteristics (Albahari et al. 2018a) found no significant effect on tenants' innovation performance of general consulting services or services facilitating internationalization.

To my knowledge, there are no other published papers that explicitly consider the effect of the park services provided on park tenants' performance. This might be due to problems related to collecting systematic data on tenants (Phan et al. 2005) or the impossibility of knowing whether and to what extent tenants take advantage of the services available.

9.2.9 Localization

Another source of STP heterogeneity is the level of economic and technological development in the region. It would seem reasonable to expect STPs located in advanced and in less developed regions to have different significance. In more advanced regions, STPs benefit from more opportunities for links to extra-park organizations and spillovers, and might be regarded as regional poles of excellence. In less developed locations, STPs might be considered 'innovation enclaves' (Felsenstein 1994).

Liberati et al. (2016) point to a strong effect of the park location on tenants' sales in the case of STPs located in the centre-south of Italy, which, historically, is a less developed part of Italy. Also, Albahari et al. (2018a) found a stronger effect of STPs on tenant firms' innovation performance, in less technologically developed regions. It seems that in such regions, STPs compensate for the otherwise scarce inputs to the innovation process whereas, in more advanced regions, where conditions are more favourable to innovation, park location has a smaller impact.

9.2.10 Relationship with Local HEIs

Links between parks and local universities and other higher education institutions (HEIs) are important for delivering value to park tenants. The STP's relationships with these institutions facilitate the transfer of academic knowledge and technology to tenants (Link and Scott 2006; Storey and Tether 1998).

Numerous studies assess the existence and extent of links between tenants and universities, but provide mixed evidence. Some studies find no statistically significant difference between on-park and off-park firms and links to HEIs (Malairaja and Zawdie 2008; Quintas et al. 1992). Some even find a negative effect of on-park location and, using an off-park sample, show that these firms are more likely to establish links with universities (Radosevic and Myrzakhmet 2009). However, other works find a positive effect of on-park location on the patters of collaboration with universities (Felsenstein 1994; Phillimore 1999). Motohashi (2013), Löfsten and Lindelöf (2003, 2002) and Vedovello (1997) show that STPs facilitate the establishment of informal links, but have no influence on firms' capacity to establish formal links with universities. Alongside these works, several provide evidence of on-park location increasing firms' propensity to establish formal links and engage in joint research with universities (Colombo and Delmastro 2002; Fukugawa 2006; Minguillo et al. 2015).

However, there is little direct information on the strategies and operating practices adopted by parks to enhance the links between their tenant firms and local universities. This might be a potential source of heterogeneity which should be taken into account. For example, we can expect firms located in STPs that focus on promoting knowledge and technology transfer between universities and firms, to be more likely to establish collaborations with HEIs, compared to firms in parks that are geographically proximate to these institutions, but do not actively promote cooperation.

9.3 Conclusions

In this chapter, I suggest a non-exhaustive set of sources of park heterogeneity which might affect the added value delivered to tenants.

If quantitative work does not consider these potential sources of heterogeneity, then it will be reporting average effects, which is useful to neither policy makers nor managers.

Evidence on the different sources of park heterogeneity is scarce. I believe that more analyses of park heterogeneity would contribute to our understanding about how STPs work and create value for their tenants. In my view, these questions have not been adequately addressed.

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CHAPTER 10

Science and Technology Parks as Drivers of Place-Based Innovation Ecosystems: Two Examples from Europe

Gabriel Rissola

This chapter starts from the premise that there is a need to identify the most relevant dimensions of analysis about science and technology parks (STPs) as *local innovation ecosystem animators or orchestrators* before embarking on their impact or performance measurement through appropriate, quantifiable indicators.

10.1 Place-Based Innovation Ecosystem: A Conceptual and Analytical Approach[1]

Why does innovation take place in certain places and not in others? Which are the contextual conditions and public interventions enabling such innovations to happen in a specific site? To approach these questions, one

[1] Based on Rissola G., Hervas F., Slavcheva M. and Jonkers K., *Place-Based Innovation Ecosystems: Espoo Innovation Garden and Aalto University (Finland)*, EUR 28545 EN, European Union, 2017, doi:https://doi.org/10.2760/31587.

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needs to consider how a place-based innovation ecosystem is articulated and orchestrated; how embedded local networks work and how they are facilitated, how actors in the innovation processes are empowered in a way that stakeholders' tacit knowledge is mobilised and incorporated into decision-making and prioritisation; as well as spatial aspects favouring collaboration. In our conceptual framework, we put the territorial dimension of innovation at the centre and developed an integrated approach to understand the local knowledge dynamics, the centrality of entrepreneurship in the local innovation system, the activation and governance of the entrepreneurial discovery process (EDP)—a key dimension of the Smart Specialisation concept discussed later—and even its spatial implications. This framework combines a conceptual model for building innovation ecosystems (Oksanen and Hautamäki 2014) with an overarching framework for the analysis of the relationships between contexts and entrepreneurial innovation (Autio et al. 2014) and the theory and practice of smart specialisation.

As Oksanen and Hautamäki (2014) point out, 'An innovation ecosystem consists of a group of local actors and dynamic processes, which together produce solutions to different challenges'. Innovation takes place in a precise location, which suggests that the physical proximity of innovation players is extremely important. It also means that there are certain specific local conditions that—individually or in combination—make such an innovation ecosystem flourish. An analysis of a place-based innovation ecosystem needs to consider how actors in the innovation processes are empowered and interact in order for innovation to happen, how embedded local networks work and how they are facilitated, including spatial aspects such as proximity, and an analysis of the most prominent nodes in the network (Rissola et al. 2017).

Dynamic innovation ecosystems do not only support regional actors in their development; they also attract new companies, investments and talent. There is a dynamic process—often not easily recognisable from outside—that makes such innovation ecosystems develop, which leads to the question about who are those sustaining such a process—whatever we call them (e.g. *animators*, *facilitators*, *orchestrators* or even *process entrepreneurs*).

Core organisation(s) coordinating the process of nurturing a place-based innovation ecosystem can be regional governments, innovation agents, universities or firms, which, often in interplay, orchestrate the interaction between the different actors. The lack of one, or several, coordinating actors can impede the development of an innovation ecosystem. These organisations—or talented/leading individuals within them—may also take up the role of policy entrepreneurs, who, by identifying policy opportunities and taking risks, set in motion new policy initiatives, programmes and institutional arrangements that can generate positive developments.

Other enabling factors include the continuous movement of ideas and people, fluid interaction and 'cross-fertilisation' between business and academia, academia and government, government and business, organisations and individuals. Dynamic companies play a pivotal role in the ecosystem, but services supporting knowledge transfer and commercialisation of products and developing innovation networks are equally needed. The latter is precisely the role played by intermediary organisations like STPs, enterprise incubators and a vast range of territorial innovation agents or intermediaries rooted in the local society.

When most or all of those conditions are met, place-based innovation ecosystems usually emerge and consolidate over time, developing hand-in-hand with local society. Indeed, a sense of community and belonging grows among local actors, who associate their success to that of the local or regional community. The location itself—usually a metropolitan area—consolidates as a brand, which, building on a historically grown knowledge base, progressively attracts interest, talent and investment from outside (e.g. Cambridge, Amsterdam, Barcelona, Berlin, to name some noticeable examples in Europe).

The location, or better, the *context* is especially relevant for the flourishing of entrepreneurial innovation (Autio et al. 2014). These authors argue that, by associating entrepreneurship with innovation, governments and national systems on innovation (NSA) have generally adopted policies and initiatives to stimulate innovation in entrepreneurial firms (including university-based start-ups) without paying sufficient attention to *when* and *where* entrepreneurs innovate. Focusing mostly on structures and institutions, they have neglected the micro-processes of entrepreneurial innovation, the weight of individual agency in them, and how those are regulated by the context. Context explains, for example, why entrepreneurial innovation may vary across regions within a country, or across industries. In turn, by focusing on patents, innovation literature has paid limited attention to softer forms of innovation (organisational, business models). Entrepreneurship literature, on the other hand, has been more interested in the non-linear bottom-up trajectories of entrepreneurial individuals and teams, forgetting to consider how context regulates their behaviour, choices and performance.

Autio et al. (2014) propose to consider successful place-based entrepreneurial innovation ecosystems as the result of a context-tailored co-creation process between policy and institutional top-down interventions, and bottom-up, decentralised, non-linear processes, social networks and resource orchestration. Thus, these authors highlight some elements characterising entrepreneurial innovation, which have been relevant for the analysis carried out in our case studies:

- Individuals/teams are not isolated but operate within a context that includes social, institutional, business and spatial networks.
- Innovation agents operate within a multi-dimensional, multi-level and multi-actor process.
- Innovation is co-created by the multiple actors and evolves with the ecosystem.
- At policy level, these inter-dependencies, potential synergies and conflicts point out to the need of a 'policy mix' tailored to a 'context mix'.

The Smart Specialisation instrument (see Chap. 6 in this volume) is precisely helping to identify collaboratively the most appropriate 'policy mix'. Operationalised in Europe through regional research and innovation (R&I) strategies, Smart Specialisation builds on the economic strengths, collective intelligence and distinctive assets of a certain territory and—through an entrepreneurial discovery process involving a wide diversity of stakeholders—identifies the strategic areas of intervention to make innovation flourish locally (Foray 2015). It is potentially a useful instrument to foster the development of entrepreneurial innovation ecosystems as they are characterised above. By means of an inclusive and interactive process that gathers together stakeholders from different environments—that is, governments, firms, higher education institutions, civil society—the EDP pursues the integration of entrepreneurial knowledge fragmented and distributed over many sites and organisations. It builds connections and partnerships in a coordinated effort of discovery of markets and technological opportunities that are also informative for governments' policy and decision-making processes.

With all the above considerations in mind, the Joint Research Centre (JRC) case studies series explores how place-based innovation ecosystems support innovation and stimulate collaborative innovation locally. In doing so, the series scrutinises how different typologies of actors representing different helices of the quadruple helix model[2] may empower a place-based innovation ecosystem, like it does an entrepreneurial university (in Espoo, Finland), big industrial players (in Gothenburg, Sweden), an innovation support agent (in Ljubljana, Slovenia), citizen innovation centres (in Barcelona, Spain) or a municipality setting up innovation districts (in Boston and Cambridge, United States).

For the analysis of these cases a range of factors influenced by the above literature was identified:

- core organisations:
  - leading industry actors, academia, universities and research institutes, public sector;
  - innovation support actors, such as science parks, incubators, technology transfer offices, venture capital, and various network organisations and associations;
- how these interact and link to smart specialisation;
- systemic conditions for collaboration, such as local culture and institutional framework;
- other political, market-related, socio-cultural and technological factors.

Then, all case studies in the series followed a similar structure:

1. Initial scoping and actors' mapping based on desktop research, fact-finding visit to the target places and scoping interviews, generating

[2] While the triple helix model emphasised the role of interactions between universities, industries and governments, including new intermediary institutions such as technology transfer offices and science parks for innovation (Etzkowitz and Leydesdorff 1995; Etzkowitz 2008), the quadruple helix model adds a fourth component that emphasises the role played by civil society and non-governmental organisations in those interactions. However, sometimes this fourth helix is merely involved as representing the views of the 'users' of emerging technologies in an attempt to avoid or limit the risk that the latter would not meet the demands and needs of society (Carayannis and Campbell 2009).

a broad list of actors, a limited number of which were chosen for more in-depth interviews;
2. These interviews and some additional data were then summarised in a more detailed description of main actors and platforms;
3. A cross-sectional analysis of the material gathered in the first steps was performed, focusing on the *contextual enabling conditions*, *ecosystem governance*, *quadruple and triple helix collaboration*, *links to smart specialisation*, and *strategic choices and vision for orchestration of the ecosystem*.

Two examples extracted from the JRC series are summarised below in order to illustrate how STPs may play a prominent role in their respective local innovation ecosystems and positively influence local entrepreneurship, effectiveness of technology transfer and regional economic development. The first example selected for this chapter, **Lindholmen Science Park**, was found to be a prominent facilitator of collaborative innovation projects partnered by locally based industry, academia, regional and city governments in the innovation ecosystem developed in Gothenburg city under the influence of Volvo companies. The second example selected, **Technology Park Ljubljana,** in turn, was found to play a crucial agency role by connecting the Slovenian government-led innovation ecosystem (based on the country's Smart Specialisation Strategy) with the booming start-up ecosystem in the capital city of Slovenia, which the technology park contributed to boost. See Fig. 10.1.

While the analytical categories applied to the analysis of those cases were conceived to scrutinise whole ecosystems, we can envisage a further research line where individual ecosystem actors like STPs are analysed as nodes in a network, our analytical categories serving to identify those quantifiable STP attributes and relationships that are most relevant to assess STPs from an ecosystem perspective.

10.2 Lindholmen Science Park (LSP)[3]

In our investigation of the role of industry nurturing and leading an innovation ecosystem in Gothenburg (Sweden), we explored how AB Volvo and Volvo Cars influence the structure of the ecosystem and how the former benefit from the latter for their innovation work. We also explored

[3] Based on Rissola, Sörvik, Zingmark, and Ardenfors (2018).

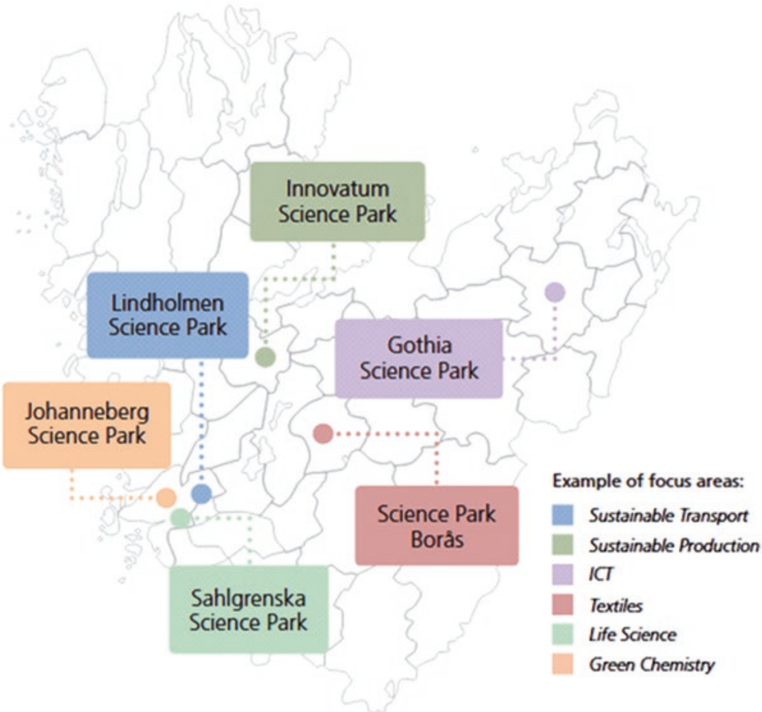

Fig. 10.1 Science parks of Region Västra Götaland. (Source: Author's creation based on information from Götalandsregion 2014)

institutional and technological factors and links to the regional Smart Specialisation Strategy that shapes the innovation ecosystem. The study focused both on these companies and their interaction with the other helices, with an emphasis on local and regional relationships, outlining a number of important innovation actors in the system, from research institutes, testbeds, regional and municipal actors, to research funding and other types of innovation intermediaries that support individual actors and foster collaborative efforts. Among them, the case study unveiled the critical role played by Lindholmen Science Park, particularly from the industry's viewpoint, as one of the main enablers and 'orchestrators' of the studied place-based innovation ecosystem. See Fig. 10.2.

Fig. 10.2 Map of key regional actors located around Lindholmen Science Park. (Source: Author's creations based on information in Rissola 2018)

Gothenburg is Sweden's second largest municipality (city: 570,000 inhabitants; metropolitan area: 1 million inhabitants) and is part of the county of Västra Götaland (1.7 million inhabitants in 2017) in West Sweden.[4] The region has a diversified business environment, with two important sectors—automotive manufacturing and trade. The manufacturing industry has a significant presence in West Sweden compared to the country's other metropolitan areas, and Västra Götaland is a centre of industry, trade and logistics that plays a central role for its economy (Business Region Göteborg, Region Halland and Västra Götalandsregionen 2017).

Sweden is one of the European countries with the highest proportion of research and development (R&D) expenditure as a share of Gross domestic products (GDP), and the majority of investments in R&D are made by the industry. West Sweden is ranked as a regional innovation leader and therefore has an innovation performance above the European Union (EU) average (Regional Innovation Scoreboard 2017). A number of national R&D innovation systems/cluster programmes are implemented in the region. Thanks to the revival of the automotive sector in West Sweden, several new companies set around the vehicle industry are attracting fresh capital and expertise into the region. An increasingly

[4] West Sweden region (NUT2 level) also includes the county of Halland, with additional 300,000 inhabitants.

NUT2: Nomenclature of Territorial Units for Statistics (from French: Nomenclature des unités territoriales statistiques). European Union's geocode standard for referencing the subdivisions of countries for statistical purposes. For each EU member country, a hierarchy of three NUTS levels is established by Eurostat; NUT2 refers to the first sub-national level (typically member countries' regions).

dynamic entrepreneurial ecosystem is generating new innovation intermediaries who provide added-value functions. The emergence of these innovation intermediaries is being driven by political, market-related, socio-cultural, relational and technological factors. These include societal challenges and trends that drive political interest, such as environmental issues and climate change. There is also a political interest in adapting to globalisation, to secure regional competitiveness and resilience. New technology developments include the electrification of vehicles, automation and connected vehicles. This is driving an interest from industry and academia in attracting qualified professionals and securing competences. There is also a tradition and experience of collaboration in the region, and Volvo Group (AB Volvo) and Volvo Cars are very interested in continuing to nurture the regional ecosystem by attracting other companies to the region.

The Gothenburg innovation ecosystem is a system with multi-level governance, where the two Volvo companies interact with the city and the region to develop the regional innovation ecosystem locally and to attract other types of funding and talent. The innovation support structure consists of a variety of organisations and measures to support the development of innovations and business ideas, from the conceptual stage through to market launch. No single actor controls the innovation ecosystem around the automotive industry in the Gothenburg area, but rather a number of actors and agencies are playing different roles. Local interviewees agree that the needs of the stakeholders should drive the setting up of innovation support actors or collaborative projects; these initiatives should support not only single companies but also many actors in the system, and be conducive to collaborative activities.

In order to stimulate innovation, a number of science parks have been established through cooperation between public and private stakeholders. Science parks in Västra Götaland are dynamic hubs for innovation within thematic focus areas linked to the regional growth strategy VG2020 (Västra Götalandsregionen 2013), and differ from many traditional science parks in Europe in having a much broader scope. They provide collaborative environments for joint research and innovation, entrepreneurship and support for start-ups and Small and Medium Enterprises (SMEs).

The regional Smart Specialisation Strategy was developed as part of the VG2020 process; during this process a number of priority areas were identified, one of these being sustainable transport (Västra Götalandsregionen 2014). Region Västra Götaland (VGR) finances thematic programmes linked to priority areas. The programmes are not detailed roadmaps, but broad guides to what funding will be provided. Beyond this, the region tries to be flexible and attentive to industry needs.

Central to regional efforts is Lindholmen Science Park (LSP), for which VGR has adopted informal responsibility for initiating and driving new collaborative projects. The science park is both a project developer and a meeting place for reconciling interests between different stakeholders. For VGR, it is crucial to maintain constant dialogue with stakeholders in the industry, and they meet in many formal and informal settings. This type of a mediating and facilitating role is perceived by VGR as their key role. VGR does not have any formal board or steering group for the transport programme but relies more on these interactions.

Indeed, LSP appears to be a strong enabling operating actor, providing good knowledge of the ecosystem and promoting trustful and fruitful relationships with all key actors. It is specialised in intelligent mobility and transport systems, Information and Communication Technologies (ICT), and modern media and design. It is a collaborative environment for research, innovation and education situated in the centre of Gothenburg.

The development of LSP as a knowledge environment began during the 1990s. Thanks to joint efforts by public and private partners, the area began to develop. Today, there are 24,000 people, working in 400 companies (14,000), studying at Chalmers or Gothenburg University (9000), attending six different secondary schools and vocational training, or living at Lindholmen.

Lindholmen Science Park runs many national and regional R&I programmes where collaborative projects between industry, public sector and academia are being developed. The transport and IT industries are major owners of the science park and, with their support and trust, the park has been able to act as a cluster node for activities within, for example, automation and vehicle ICT.

LSP was set up to revitalise an abandoned shipyard area, but was kick-started by the establishment of Ericsson, which set up its second biggest research department in Sweden at Lindholmen. The Ericsson CEO saw the potential in the area and the project, but put pressure on the city and Chalmers to co-invest to build a cluster around the company. In this context, they formed the company Lindholmen to develop the area in 2000. At that time the city had a property company, but not an organisation to develop innovation and collaboration. In the beginning LSP was mainly focused on ICT and Ericsson; however, over time, mobility has increased in importance and ICT is an important component in the vehicle industry.

The company is run not-for-profit, with the aim of delivering results other than financial. It is instrumental in the continued development of Lindholmen as an ecosystem. It does not own any buildings, have any financial resources of its own, or have any mandate or power. Its owners are the City of Gothenburg, Business Region Göteborg, Chalmers University, Ericsson, AB Volvo, Volvo Cars, TeliaSonera, Saab AB, Telenor Sverige AB and Toyota Material Handling. There are also strategic partnerships with Gothenburg University and the local Traffic Office.

LSP's Board is formed by influential actors: leading politicians and opposition leaders, principals from the two universities, people from executive management teams and from the boards of Volvo and Ericsson. It has also had backing from a strong and tough mayor of the City of Gothenburg, which has helped it make brave decisions that have kept things going, like supporting a strategy to attract large companies that can nurture smaller ones. In other locations, the early focus was on SMEs and start-ups; here, the part began working with the big companies—Volvo, Ericsson, and so on. By targeting them and getting them involved in projects and locating activities to Lindholmen, they got a momentum going, which subsequently also attracted the SMEs and start-ups. They are still close to the big companies, but at the same time have doors open to small companies. They do not have their own incubators, but help these and other forms of business support actors to find offices at Lindholmen and act there. They run many dialogues with property companies and actors to match-make establishments. Usually companies do not want to communicate externally that they are coming before they do, but want to have informal contacts that LSP can help with.

One of the most important tasks of LSP is precisely to support and strengthen the local innovation ecosystem. It works as an engine to set up collaborative efforts, with a devoted staff of 30 people. The park acts as a neutral facilitator to host collaborative effort. Beneficiaries are not requested to locate the initiatives at LSP (as examples, the park works with Ericsson in Kista, and Saab in Linköping), but if LSP is helpful, the initiatives will most probably locate there in the end. The park is also interested in leading and initiating national level projects, so it spends time liaising with the ministries at the national level, sometimes being contacted back by them for guidance in different matters.

LSP receives base funding from Region Västra Götaland, the City of Gothenburg and shareholders, which provides a long-term contribution for operations but it is not enough. A second-level funding comes for programmes and arenas. To set up a programme, a base funding for three to four years is needed to guarantee operations. Additionally, the park runs projects with mixed funds—EU, private and public funds.

As there is a dense agglomeration of knowledge around Lindholmen and Gothenburg related to the automotive industry, its main theme is mobility of people and goods (combined with developments in connectivity and electrification), and its strengths comprise triple helix-based network and project management knowhow in this area. Lindholmen is the seat for the Geely (the Chinese owner of Volvo Cars) international R&D centre, and as an intermediary connecting potential partners, LSP has been key in initiating the project ElectriCity, a demonstration project for future transportation. Currently, LSP is engaged in setting up a national centre for electric mobility, which will focus on electric drivelines.

Before LSP, Volvo worked directly with the funding agencies. Now they have seen the beauty of working with LSP—having a neutral agent to talk to the public sector.

The two Volvo companies have been fundamental in creating the ecosystem. This relates to the LSP strategy of attracting large companies that can nurture others and has proven to be successful. Because of the presence of important companies like the two Volvos, suppliers and consultants are attracted, who in turn are interesting for other actors, and generate spin-offs and start-ups. It is the key to a dynamic environment. Even Scania, which traditionally has not been present in Gothenburg, has now located some people there and may expand further.

From the perspective of our analytical categories, *digitalisation* has been identified in this case as an important **contextual enabling factor** as it is nowadays a strong driver for the automotive industry. A key digitalisation area that has been identified by actors in the Västra Götaland region is artificial intelligence (AI), where a large consortium of actors has come together to set up an artificial intelligence centre, data factory and arena, hosted by LSP and funded by a mix of public and private money.

In terms of the **formal governance model**, it was said that no single actor controls the innovation ecosystem around the automotive industry in the Gothenburg area, but a number of actors and agencies play different roles. However, regional actors have a number of shared interests and collaborate in order to strengthen the development of the ecosystem and modify it. They use their own resources, but also draw upon available funding schemes. There are a number of platforms that facilitate discussion among actors and can determine industry and societal needs, and that can play into the development of new platforms and joint initiatives to drive the long-term competitiveness of the industry in the regional setting (although this also has a national angle). In this ecosystem, LSP plays an important role as a mediator and meeting place, working deliberatively through formal and informal contacts with stakeholders to formulate collaborative efforts; they initiate them with help of local, regional and industry funding, and then eventually leverage the projects with other sources such as national and EU funding. They have this operative role in enhancing the development of the ecosystem, while the region works more strategically.

With regard to **quadruple helix versus triple helix**, in the Gothenburg innovation ecosystem there are indeed a number of projects and processes where end-users, citizens and various specific interest groups are involved in development projects and influence them, speeding up development processes and improving the results. Both Chalmers University and LSP organise a range of forms of quadruple helix type activities. Chalmers does so mainly through various forms of seminars, but it is also involved in research projects in electricity, where it explores user behaviour. The team also includes the public transport office and companies that will take the risk of investing in the development of new technologies based on the project findings. In turn, LSP organises various forms of workshops, innovation competitions and something called Innovation Bazaar, where they mobilise actors in the quadruple helix. Broad invitations are issued, but they tend to be accepted by the usual actors interested. It has generated results; for example, Region Västra Götaland participated in a development project where they tested mobility services. The outcome was a Mobility-as-a-Service (MaaS) company UbiGo.[5] Users participated in this project in a real way and the company was founded as a result. The service is now being used by the public transport companies of Gothenburg and Stockholm. There are similar examples in ICT and app development. Quite often in these processes, the interested parties and potential suppliers are already in the room. However, these examples can probably not be considered true quadruple helix projects or arenas.

In terms of **consensus and commitment**, the innovation ecosystem in the Gothenburg area is a decentralised process, which develops progressively through the interaction between stakeholders. Key to this are trust and good relationships, and a sense of common interests. There are a

[5] http://ubigo.se

number of arenas for brokering the interests of the different actors, and for creating consensus and commitment; when it comes to the innovation support system, LSP stands out as the central actor in the sustainable transport area.

The Region views the science park as a platform that takes greater responsibility than just developing and managing projects. As an example, the CEO of LSP has a lot of respect in the industry and can talk with industry and academia actors as peers, which can facilitate and catalyse important processes. VGR can provide funds to support the initiation of projects, which then receives leverage from other funds, from the Energy Agency, Vinnova, and so on. LSP is instrumental in the continued development of Lindholmen as an ecosystem.

In terms of **strategic choices and vision for orchestration of the ecosystem**, in Västra Götaland, the Region takes more of a facilitating, funding and strategic role; activities that are more operational have been delegated to science parks. These are considered innovation support infrastructures that can both support start-ups and innovation, but also take roles in deliberating and taking the lead on collaborative efforts, serving as neutral grounds. They can also house the initiatives and help them communicate, and make existing efforts visible. The science park is an intermediary level between the region and projects. It gives more long-term perspectives to projects, as it can build on experiences gained through previous projects, even if they are now closed, and bring that to future ones. Lindholmen Science Park is central as a broker institution, as it hosts a number of projects and centres related to innovation in the transport sector, and has taken a long-term development perspective.

10.3 Technology Park Ljubljana (TPL)[6]

Slovenia is a strong innovator (European Innovation Scoreboard 2017), the only Central and Eastern European country in this group. Its performance in several input indicators has been above the EU average, yet the innovation output and its impact on economic results have often been criticised. One of the commonly noticed barriers to a more efficient innovation ecosystem is the weak coordination across responsible departments and collaborative links between major stakeholders in innovation policy. Slovenia as a transition country and a member of EU from 2004 has developed its innovation system under strong influence of the EU innovation

[6] Based on Bučar and Rissola (2018).

policies as well as inspired by the good practices observed in other, more advanced innovation systems. This evolution had an important impact both on the policies and instruments, as well as on the main stakeholders and the development of their role. While taking the advice from more experienced countries and applying the prescribed instruments could speed up the process of developing a more advanced innovation system, this process also requires a careful adaptation of the "imported" solutions to the specific country/region's situation and localisation of the solutions, if the optimal results were to be achieved. This was not always the case, leading to frequent changes of the instruments and the support provided to different stakeholders. See Fig. 10.3.

Yet with Slovenia being a relatively small country, Ljubljana itself cannot be approached in isolation from the country system as such. Ljubljana's innovation ecosystem is inherently determined, and is determining the Slovenian innovation ecosystem: one cannot be defined without the other. Central Slovenia and Ljubljana, as the capital, host the biggest Slovenian university, University of Ljubljana with a high concentration of academic researchers. In addition, some of the largest public research institutes are located in Ljubljana. Several important intermediary institutions, like the technology park of Ljubljana, university incubator, regional development agency, ABC accelerator and so on, are located in Ljubljana. Main governmental agencies have their headquarters in the city. An interesting

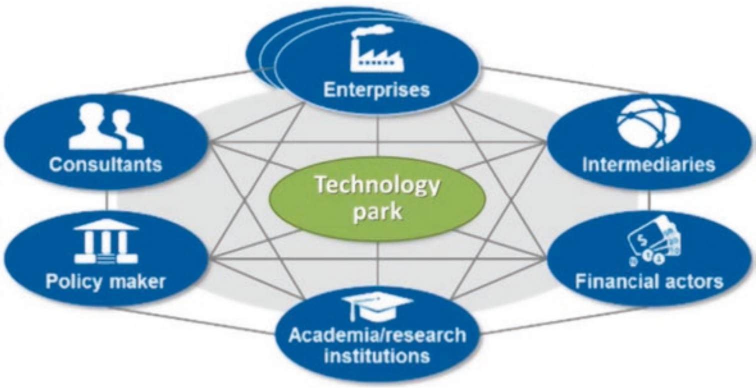

Fig. 10.3 The role of Technology Park Ljubljana. (Source: Author's creation based on her own interpretation of the technology park literature as summarised in Bučar and Rissola 2018)

phenomena, which can be observed in Ljubljana's start-up environment, is the growth of various kinds of new initiatives, some bottom-up from entrepreneurial activity, others stimulated by public policy, but all aimed at providing stimulating support to start-ups, from co-working spaces, Geek House, hackathon and so on. All together they create a dynamic network, which spreads beyond Ljubljana's region across Slovenia, but also much wider across Western Balkans and to EU and United States. This network is developing in parallel, with or without the support of formal institutions and/or governmental support. We will present more closely how this 'system' has evolved and where it overlaps with the official public institutions, aimed at supporting start-ups.

The first idea of establishing Technology Park Ljubljana (TPL) was a result of discussions back in 1994 within some of the Slovenian public research organisations (PROs), especially Institute Jozef Stefan (IJS) and the National Institute of Chemistry. Initially, the Park was located within the premises of IJS. With the entry of the Municipality of Ljubljana[7] as one of the key founding members in 2003, the possibilities to expand to better accommodate the needs of start-up companies significantly improved. The TPL was able to apply for structural funds' support,[8] since one of the priorities of Slovenia during the period 2004–2007 was the establishment of innovation infrastructure. This enabled the TPL to open four new buildings in 2007 and offer space to new arrivals. With the merger with the Centre for the Development of Small Industry, TPL has fortified both in terms of staff and operations. In 2011, more intensive partnership was established with the Venture Factory, resulting in several new initiatives in the area of entrepreneurship and start-ups. The most important one is definitely the Start:up Slovenia Initiative, where the two organisations play a central role.

Today the park has more than 300 members,[9] who provide employment to more than 9000 people. The 75,000 m^2 of premises of high quality infrastructure represent what they like to call 'Smart city': not only due to the high concentration of start-ups and high tech SMEs but also due to the provision of adjoining services like pharmacy, kindergarten, restaurant, tourist agency and so on.

[7] The municipality contributed with the ground on which the current premises are located.

[8] €8 million were provided through the European Regional Development Fund, with additional resources from commercial loans (€33 million for phase II and €15 million for phase III).

[9] http://www.tp-lj.si/en/members/members-list

The activities of the TPL are wide and spread from providing support to members in all phases of their development to overall promotion of entrepreneurship in Ljubljana, Slovenia and the region. They define themselves as the leading regional innovation hub for knowledge and technology transfer.[10] TPL is cooperating with several stakeholders in Ljubljana's and Slovenia's innovation ecosystem in the design of start-up policies (they are co-founder of Start:up Initiative and have also actively participated in the government working group on start-ups), policies in the area of entrepreneurship promotion (cooperation with Slovenian Agency for the promotion of entrepreneurship, FDIs and technology development [where FDIs stands for Foreign direct investments] (SPIRIT),[11] SEF[12] and the MEDT[13]), was actively involved in EDP through cooperation with the Chamber of Industry and Commerce, is involved in a number of EU projects (especially several Interreg projects) as well as in cooperation with public research organisations. They provide advice to foreign investors as well as actively seek investors for their start-up community.

Their ambition is to be the central enabler of the innovation ecosystem, locally as well as nationally and act as the main integrator (see picture below). With their model, they have the ambition to expand regionally also, especially in the Western Balkans.

According to the interview with the deputy manager,[14] TPL is legally a public association,[15] but is in fact run very much like a business entity, since it is supported only in about 20–25% of its activities with public money.[16] Other resources need to be generated through various projects,[17] be it national, EU or international, and the services they offer to companies. This mix is needed if they want to survive and grow, but has proven an important source of new ideas and opens opportunities not only to TPL, but its members as well. On the down side, it means that sometimes the projects they undertake do not contribute to their

[10] http://www.tp-lj.si/en/about-us/tp-ljubljana-in-2020

[11] SPIRIT: National Agency for the promotion of entrepreneurship, Foreign direct investments (FDIs) and technology development.

[12] SEF: Slovene Enterprise Fund.

[13] MEDT: Ministry of Economic Development and Technology.

[14] Interview by Gabriel Rissola and Maja Bučar was held on May 10 with deputy manager Marjana Majerič.

[15] Majority owner is the Municipality of Ljubljana with 70% share, IJS with 21, the remainder spread among several institutions.

[16] SPIRIT/ Ministry of Economic Development and Technology (MGRT) programme for the support of innovation infrastructure and SEF support for the Start:up Initiative.

[17] http://www.tp-lj.si/en/projects

core activity. In view of the relatively small staff,[18] such strategy is recognised by themselves as not optimal.

TPL includes a co-working space called Tobogan, where young entrepreneurs can rent office space and Geek House, both being a part of the Start:up Slovenia Initiative programme. TPL provides consultancy services to its members: most of the services are provided free of charge to the individual enterprise, if they are covered within the programmes supported by SPIRIT and Slovenia Enterprise Fund. TPL is also engaged as an intermediary when a particular service is being needed by one of the members: with their network of consultants and mentors they can suggest appropriate help. One of their regular activities is preparation of different types of workshops and conferences for their members as well as hosting workshops and conferences for other institutions (needing only infrastructure support).

TPL's network is extensive, from cooperation with the government in designing appropriate entrepreneurship policy and internationalisation to cooperation with other stakeholders in specific projects and programmes. They work closely with all the partners in Start:up Slovenia Initiative, especially Venture Factory (Start-up Competition, PODIM[19]) as well as with ABC accelerator, located in Business Trade Centre (BTC), on individual projects of scaling-up start-ups born in TPL.

They have provided the platform for several meetings on Slovenia's Smart Specialisation Strategy (S4), especially in collaboration with the Chamber of Industry and Commerce, and with the Government Office for Cohesion Policy and Development. In view of the progress made on S4, their opinion is that Strategic Research and Innovation Partnerships (SRIPs) work better if led by industry.

Their cooperation with public research organisations is developed mainly on project basis, when individual researchers from units within PROs or university have the ambition to engage in start-ups and TPL helps them in the initial phases. Otherwise, systematic collaboration is established with the National Institute of Biology.

At the international level, the collaboration of TPL is extensive in various Interreg projects, especially with partners from Italy, Austria and Germany. A specific line of their activity is promotion of TPL as a location for foreign partners and providing support to potential foreign investors, seeking contacts in Slovenia. They have engaged in establishment of con-

[18] Currently, TPL employs 17 people all together.

[19] PODIM is the most influential start-up and tech event in the Alps-Adriatic and Western Balkans region, based in Slovenia. It is the gateway from/to the region for efficient networking, making deals and sharing experience (https://podim.org/en-us/).

tacts with selected foreign partners from China and India, which could support the growth and internationalisation of their members. The experience and the model of TPL is being actively promoted in several Western Balkan states, from Montenegro, Macedonia, Serbia and Bosnia and Herzegovina, both by inviting representatives of these countries to TPL for workshops and by offering their consultancy services directly or through the EU to the governments of these countries.

TPL sees itself as a promoter of network building and sees its role as a bridge between its members and the government as well as with other relevant stakeholders in the local/Slovenian ecosystem. Their flexibility is considered as a good practice they have developed over the years. The ability to adjust to different external environments has enabled them not only to survive but also to develop. Looking for possibilities to cooperate as widely as possible has led them to the current wide partnerships, which often result in positive synergies, opening doors to further collaborations nationally and internationally.

The specific drawback that they see in the ecosystem is the attitude, commonly present in the local culture, which is highly risk averse. Even young entrepreneurs are often hindered in their growth by this: they rather stay small than risk external capital participation in fear of losing control. But with an improved support network which has been developing in recent years, gradually, this is changing. Here lies an important role for TPL and other intermediaries to provide tailor-made assistance to start-ups.

In terms of **contextual enabling factors**, the formation of the start-up ecosystem which we observe in Slovenia today and the broad network of different stakeholders, acting in a coherent manner, is a result of many factors. Slovenia started early on after its independence with support to different intermediary organisations like technology parks and technology centres, to be followed by incubators and regional development agencies. In addition, support was provided by the Slovene Enterprise Fund and the Centre for Promotion of Small and Medium Size Enterprises (a predecessor to SPIRIT). But the comprehensive ecosystem started to flourish only when the collaboration of the intermediary institutions, government support agencies and business community was established through a Start:up Initiative, and is now creating a lively community within TPL and several other entities across the country. By now, there is sufficient interest among the business community to provide support through mentorship and funding of accelerators. The business angels are more active, so are several larger Slovenian corporations and investor funds from the region and from outside.

One could therefore conclude that while it is important to have a network of different enabling institutions, establishing a working platform for their open collaboration—like Start:up Initiative—is of key importance. The bottom-up initiatives from the business community itself have provided sufficient motivation for all other stakeholders to form a complementary support system, addressing the needs of the start-up community not only through the lenses of their own activity but also through building a comprehensive systematic support in which each one of them plays a specific role. Such a coordinated ecosystem provides room for each stakeholder to do what they do best in the mosaic of services start-up enterprise needs: from providing advice on development of a creative idea in a business plan (a role of the incubator), providing basic entrepreneurial training and a place to (co-)work (TPL; Venture Factory), supporting the initial stages (SEF), taking a start-up on a growth path (ABC and other accelerators) to providing support to internationalisation (SPIRIT).

The platform got further engaged in policy-making by proposing to the government what should be changed in the legal and fiscal system and how the support instruments could be better adjusted to the needs of SMEs in general, not only for start-ups but also for scale-ups.[20] Each of the key actors in the platform (TPL, Venture Factory) are expanding their network, engaging the business community, potential investors and international partners to further strengthen the entrepreneurial ecosystem. The networks are not only virtual, but have led to the creation of several physical spaces for collaboration. TPL has developed Tobogan, a co-working area at its location, ABC accelerator has introduced common space for workshops and meetings within a lively shopping and business mall, and Venture Factory has co-working possibilities. Interestingly enough, following their example several regional initiatives have followed.[21] This type of foundation provides facilitating and enabling factors to empower innovation and entrepreneurial spirit in practice. Provision of appropriate physical space with some knowledge support and advice from facilitators

[20] In 2018, an initiative was given to the Ministry of Economic Development and Technology to follow the good experience of the working group on start-ups, establish a new working group on scale-ups, where the necessary regulative and legal improvements could be discussed by government representatives, intermediary institutions, researchers and most importantly, representatives of the scale-up community.

[21] All together there are now 11 co-working spaces registered across Slovenia, 20 so called 'entities of innovation environment' registered with SPIRIT (most technology parks or incubators), which are receiving partial support from the agency as well as 6 transfer of technology offices.

with a flexible mind-set and attitude could significantly promote the culture of creativity, new values and business models. In addition, experienced entrepreneurs are attracted both as mentors as well as funders, providing support to start-ups as well as scale-ups.

The experience in creating the local start-up ecosystem could be further replicated in other innovation areas, including cooperation between public research organisations and business enterprises. Thus, for example, TPL sees itself as playing a strategic role in building collaboration space for all of the main stakeholders of the innovation ecosystem, interlinking all of them in an attempt to further develop the system, foster the commercialisation of knowledge and technologies to advance the competitiveness of the participating business entities. Flows are not one way only, but constant interaction among the actors is what builds a strong regionally based innovation ecosystem. The challenge for TPL is to position itself as a leading actor in development of the local ecosystem, especially in an environment where there is at least as much competition as there is readiness to cooperate.

While the main mission of TPL, as self-stated, is to address challenges at all levels of the innovation ecosystem (see Fig. 10.4) during the process of innovation and cooperation with each other, this long-term strategy is facing a number of barriers, most of them related to daily subsistence issues. While pursuing its role as a catalyst, TPL still needs to provide

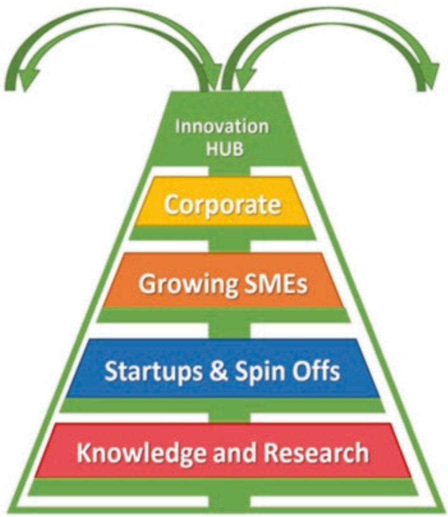

Fig. 10.4 Collaboration pattern in the innovation ecosystem. (Source: Author's creation based on her own interpretation of the technology park literature as summarised in Bučar and Rissola 2018)

financial resources for its operation: government support[22] covers at best 20% of the total budget of TPL. Engagement in other activities and projects, where some may fit well within the overall strategy of TPL, but many do not, may affect their ability to implement their mission. When analysing the current activities of TPL, we can observe that in particular, the activities related to start-ups are well developed, increasingly also the growth of SMEs (through various workshops and business meetings) and the gradual involvement of the corporate sector. The segment, which may still require a lot of effort and a specific strategy, is the collaboration of TPL with universities and public research organisations—traditionally less interested in entrepreneurial ideas.

In terms of **consensus and commitment**, the active involvement of TPL in facilitating the entrepreneurial discovery process during the preparation of the *Smart Specialisation Strategy* could be considered as an important element of building the network with 'generators of new knowledge' in the public sector. This may well prove to be the most complex task, since insufficient collaboration of the PROs and business has often been identified as one of the main problems of the Slovenian Research, Development and Innovation (RDI) system (Bučar and González Verdesoto 2017; Bučar et al. 2018).

The **strategic choices and vision for orchestration of the ecosystem** are articulated around the Slovenia's Smart Specialisation Strategy, which may have an important impact on the establishment of another platform(s), much needed in the innovation ecosystem—a platform for sustainable collaboration of business entities and public research organisations. Its main instrument—Strategic research and innovation partnership—aims at providing a collaboration space in each of the nine selected priorities of S4. The partners are coming from big businesses, but also the SMEs and PROs.[23] This way one of the key challenges of the Slovenian innovation ecosystem is being addressed: insufficient collaboration of the business sector with public research. The SRIPs are engaged in developing a joint R&D agenda within their specific priority, and in doing so, the exchange on existing and planned research, industrial development and challenges that business entities are facing, is occurring.

[22] TPL is listed as one of the 'entities of innovation environment' and is thus supported by SPIRIT.

[23] Since SRIPs are also coordinating their activities with the government, we could consider them as an example of triple helix. In some cases, SRIPs' activities also engage civil society (like SRIP Health and SRIP Circular economy), thus having already entered the quadruple helix mode.

Many partnerships have already been formed in EDP, resulting in the proposals for joint projects in particular priorities. The monitoring of the process of formation of SRIPs confirms that thematic collaboration platforms are established. While currently established SRIPs have already decided on different solutions and entrusted the management to a business entity, a chamber of commerce or a public research organisation, there have been additional proposals for the government to be in charge of coordination or potentially intermediary organisations, like, for example, TPL.

The integration of S4 with the Slovenian development strategy could take the impact of S4 even further, especially if the broader framework of the **quadruple helix** is employed. In part, this type of cooperation among different stakeholders already exists and was applied when discussing the social elements of the development strategy. Yet, this type of citizens' involvement is still at the rudimentary level and happens around a specific event, but is not yet systematically applied in policy design or in its implementation. What has by now become a more regular activity is a triple helix collaboration, which could be best observed during the discussions around Research and Innovation Strategies for Smart Specialisation (RIS3) (EDP), where the three main actors, the business community, researchers and government, actively worked on the identification of the priorities. More diversified collaborations can be identified in the innovation ecosystem as well, from different co-creative processes being developed within Start:up Initiative, within various co-working spaces, hackathons, living labs, activities promoting circular economy. Especially the latter integrates the civil society on a regular basis, be it though local communities or/and environmental Non-Profit Organisations (NGOs).

The promotion of innovation and entrepreneurship needs to be done by the governments, but to be successful, as the practice of TPL shows, it needs engagement of a broader community. The government can draw the strategy, provide support to the institutions as well as improve the legislative framework for SMEs and start-ups and assure stability of policies. But it is the collaboration of many partners, which gradually brings about the change in the environment and even research and business culture towards a more innovative and entrepreneurial system.

Since Western Balkans constitute one of the priorities of Slovenian foreign policy as well as Slovenian international development cooperation, several Slovenian actors are actively present in these countries. This also holds true for the stakeholders in the Slovenian innovation ecosystem, be it government offices, public non-profit organisations or even private investment funds. Among them, Technology Park Ljubljana is actively promoting their model to Western Balkan countries, both through direct bilateral contacts as well as through participating in broader regional initiatives. The experience of TPL in building the local innovation ecosystem, especially the start-up ecosystem, is certainly valid for the Western Balkan countries, where a capable technology centre could play a mobilising role in setting the scene for the entrepreneurial innovation process. Two issues, however, deserve to be mentioned here. First, while TPL's role may be considered as an important factor in enabling the emergence of the local innovation system, it could not be successful in a vacuum: several other elements and stakeholders need to be present as well. Second, building physical spaces for collaboration is important, yet not sufficient to create an innovation ecosystem. TPL's premises provide a productive environment for collaboration, but it is the facilitation services provided by TPL that put them on the innovation ecosystem map.

10.4 Conclusions

The rationale of this book is that while measurement of success of STPs is fundamental for public policy evaluation as well as continued public policy support, academics have long tried to create consistent indicators to measure the performance of STPs but there is no clear consensus yet on which criteria should be used to gauge such success.

This chapter intends to contribute to nurturing the debate on quantitative evaluation of STPs bearing in mind that individuals/teams are not isolated but operate within a context that includes social, institutional, business and spatial networks; that innovation agents operate within a multi-dimensional, multi-level and multi-actor process; that innovation is co-created by the multiple actors and evolves with the ecosystem; and that innovation policy needs to take stock of these inter-dependencies, potential synergies and conflicts (Autio et al. 2014).

Therefore, we propose deepening our categories of analysis for the study of STPs as *innovation agents operating in a specific context*—in particular in their role as *animator or orchestrator of the local innovation ecosystems* in which they are rooted and their *collaboration dynamics* with other local actors—namely:

- Contextual enabling factors
  - Regulatory and institutional enabling factors
  - Formal governance model

- Quadruple or triple helix collaboration
  - Coordination and implementation
  - Consensus and commitment
- Strategic choices and vision for orchestration of the ecosystem
  - Links to Smart Specialisation (and any other related innovation policy/strategy)

While distilling our categories into quantifiable variables and (composite) indicators will prove to be a difficult and hard task, the attempt may pay off in view of policy-makers' need for evidence for the design of flexible innovation policy mixes that take stock of the diversity of contexts and places in which STPs operate.

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CHAPTER 11

Toward a Framework to Advance the Knowledge on Science Park Contribution: An Analysis of Science Park Heterogeneity

Laura Lecluyse and André Spithoven

11.1 Introduction

As technology-based firms contribute significantly to innovation, employment growth and economic development (Wong et al. 2005), policy makers all over the world have engaged in initiatives to support the growth and development of such firms (Mian et al. 2016). One of the earliest and most notable initiatives in this regard involves the establishment of science parks (henceforth "SPs"). SPs emerged in the early 1950s in the US with the establishment of Stanford Research Park (California, 1951)—located in the

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region that is now called Silicon Valley (Annerstedt 2006). This park was developed with the aim of linking university researchers to the regional economy in order to create an inventive and entrepreneurial technical community (Annerstedt 2006) and to foster commercialization of university research (Nauwelaers et al. 2014). The early SP success stories largely raised interest in the phenomenon in the US in the 1960s and subsequently reached Europe. The European pioneering SPs were located in Denmark, France and the UK (Rowe 2014). Thereafter, the SP phenomenon quickly expanded and from the mid-1980s, it became one of the most appealing regional development initiatives worldwide (Anttiroiko 2004). To date, there are about 400 SP initiatives in Europe (Rowe 2014) and over 300 in the US and Canada (Battelle Technology Partnership Practice 2013).

Following the long tradition and worldwide spread of the SP phenomenon, the contribution of SPs has become the focus of a vibrant academic debate. The seminal work of Monck et al. (1988), which aimed to uncover whether or not SPs contribute to their tenants and eventually to the broader economy, was soon followed by numerous studies seeking to (dis)confirm the added value of SPs for their tenants. Particularly, SP residence is widely believed to enable positive externalities, information exchange and knowledge spillovers for tenants and to provide them with unique benefits such as image development and easier access to customers and skilled labor (Gwebu et al. 2019). However, while some studies found that SP residence is positively related to firms' innovation performance (e.g. Siegel et al. 2003; Squicciarini 2008, 2009; Yang et al. 2009; Huang et al. 2012; Lamperti et al. 2017; Vásquez-Urriago et al. 2014, 2015), others refute this premise (e.g. Westhead 1997; Colombo and Delmastro 2002; Lindelöf and Löfsten 2002, 2003). Similarly, some scholars report higher growth rates among SP tenants compared to other off-park firms (Löfsten and Lindelöf 2001, 2002; Colombo and Delmastro 2002; Lindelöf and Löfsten 2003; Dettwiler et al. 2006), while others do not notice significant differences in firm growth rates between SP tenants and non-SP firms (Monck et al. 1988; Shearmur and Doloreux 2000; Ferguson and Olofsson 2004). Additionally, while many studies demonstrate that SPs encourage the engagement of tenants in university-industry linkages (Colombo and Delmastro 2002; Löfsten and Lindelöf 2002; Lindelöf and Löfsten 2004; Fukugawa 2006; Hung 2012; Vásquez-Urriago et al. 2016), other studies do not find evidence for this assertion (Joseph 1989; Massey and Wield 1992; Malairaja and Zawdie 2008).

In sum, despite abundant research into the benefits and impact of SPs for tenants, there is to date no clear consensus on whether, when and how SPs contribute to their tenants. This study illuminates three shortcomings in the SP literature and accordingly proposes avenues for future research. As such, we present a framework which will enable future work to extend the understanding of SP contribution for tenants. Particularly, this framework recognizes that, in order to move the literature forward, future SP studies should consider (1) new approaches to assess SP contribution for tenants, (2) provide insights into the mechanisms by which SP residence provides benefits for tenants, and (3) unravel the conditions under which SP residence is able to provide benefits for tenants. Moreover, by means of empirical analyses and the SP literature, we demonstrate the importance of considering conditions by elucidating the substantial heterogeneity in SP characteristics which may affect the extent to which tenants will benefit from their SP residence. We do so by providing an overview of the key characteristics of SPs based on a unique dataset of 42 SPs from three different countries.

This study makes several contributions to the SP literature. Particularly, it provides an overview of the shortcomings in extant SP studies and proposes a future research agenda that is aimed at improving our understanding on SP contribution. Synthesizing these insights, we present an integrative framework to further our understanding of SP contribution for tenants. Further, we highlight one aspect of this framework, namely the importance of considering SP-level conditions when assessing SP contribution, which has frequently been neglected in SP studies (Ng et al. 2019).

11.2 An Integrative Framework of SP Contribution

Despite abundant research, there is to date no consent on whether, when and how SPs contribute to their tenants. To advance our knowledge on SP contribution, we present shortcomings in the literature and correspondingly propose avenues that allow for gaining deeper insights in this topic. We unite these new pathways in an integrative framework of SP contribution, which is presented in Fig. 11.1. As such, we build on the recent literature review of Lecluyse et al. (2019) which points out that in order to fully understand SP contribution, we have to consider conditions (or inputs), mechanisms (or mediators) and outcomes of SPs. While Lecluyse

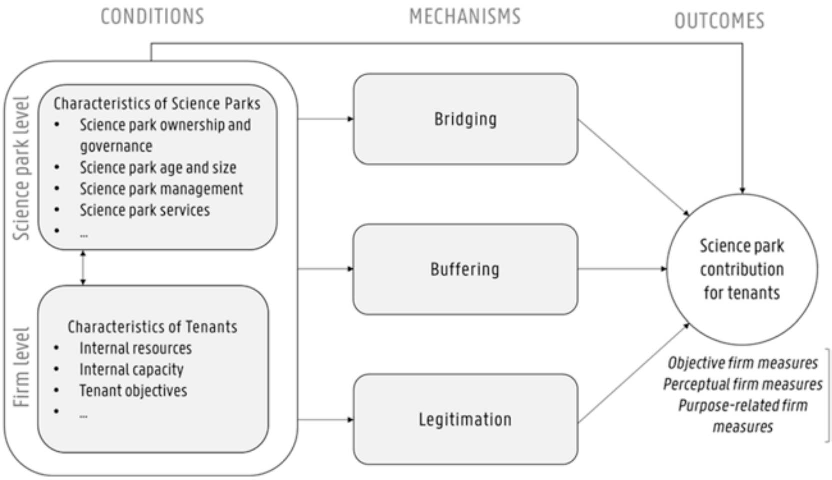

Fig. 11.1 Integrative framework of SP contribution for tenants. (Source: Authors' creation based on information in Lecluyse, Knockaert and Spithoven 2019)

et al. (2019) provide a general literature review and future research agenda on these topics and SP contribution for multiple stakeholders, we extend this agenda by providing future research avenues that specifically allow for gaining more insights into SP contribution for tenants.

First, a critical challenge in assessing the contribution of SP residence for tenants lies in the selection of appropriate ***outcome*** measures (Bigliardi et al. 2006; Gwebu et al. 2019; Siegel et al. 2003). In order to measure whether or not SPs contribute to tenants, studies have predominantly assessed the influence of SP residence on firm growth or performance (i.e. *objective firm measures*), such as innovative or financial performance (e.g. Lamperti et al. 2017; Lindelöf and Löfsten 2003; Squicciarini 2008, 2009; Westhead 1997). While these studies provide highly relevant and important insights, it is possible that this approach does not necessarily reflect all potential benefits tenants may experience from SP residence for four distinct reasons. First, many of the expected benefits SPs provide, such as image development, access to skilled labor and value-added services, may not immediately nor directly be followed by enhanced firm growth or performance. Some benefits of SP residence may take years to unfold before affecting firm performance, or may only support the operations of the firm without influencing growth or performance. Second, although traditional methods—such as matched sampling and comparative analyses whereby outcomes of on-park firms are compared to outcomes of similar off-park firms (Ferguson and Olofsson 2004; Löfsten and Lindelöf 2002; Vedovello 1997; Westhead and Batstone 1998)—have provided important insights, it is rather complex to fully disentangle the SP effect from other factors that might affect firm growth or performance. Similarly, it is also possible that SPs may attract those firms that are more likely to perform well, irrespective of potential contributions of SP residence (Vásquez-Urriago et al. 2015). Third, as SP tenant populations vary widely in terms of, among others, firm age, size and sector (Good et al. 2018), it is no sinecure to select firm performance or outcome measures that are appropriate and relevant for the wide variety of SP tenants. For instance, patenting behavior, which is often employed in SP studies to assess innovative performance (e.g. Westhead 1997; Squicciarini 2008, 2009), largely varies across sector, firm size and country (Hagedoorn and Cloodt 2003). Also, financial outcome measures may sometimes provide less adequate indicators of firm performance as young technology-based firms often have no products nor sales in the beginning of their lifecycle. In order to address these potential issues and complement traditional approaches, we advocate the use of *perceptual firm measures*, which have been frequently used in the entrepreneurship literature, yet have been largely ignored in the SP literature. In comparison to the traditional outcome variables, perceptual measures enable us to directly relate particular outcomes to SP residence. Finally, selecting appropriate objective firm measures can also be precarious due to differences in firm objectives (Bigliardi et al. 2006). Particularly, it is acknowledged that not all firms have the same objectives: while some firms aim at developing codified knowledge and play on a market for technology, others target at producing products (goods and services) and play on a market for products (Gans and Stern 2003). Whereas firms of the first type would typically outperform the latter in terms of patenting output, the latter can also be successful in achieving its desired objectives. Consequently, we also call for *purpose-related firm measures* when assessing SP contribution through tenant performance. In sum, we argue that integrating insights from objective, perceptual and purpose-related firm measures will provide a more comprehensive picture of SP contribution for tenants.

Second, the SP literature has predominantly devoted attention to examining the direct relationship between SP residence and firm outcomes. As such, there remains a lack of clarity regarding the ***mechanisms*** by which

SPs actually provide benefits to their tenants (Amezcua et al. 2013). While the broader literature has theoretically postulated several mechanisms by which tenants might be supported, in particular by bridging, buffering and legitimation (Amezcua et al. 2013; Jourdan and Kivleniece 2017), empirical evidence on these mechanisms is either mainly inconsistent or lacking. First, given its role to compensate for the lack of networks firms can typically engage in (Howells 2006), SPs bear a *bridging* function focused on the facilitation of interaction and relationships among tenants (Felsenstein 1994; Schwartz and Hornych 2010; Montoro-Sánchez et al. 2011; Phillimore 1999), between tenants and the partner university (Colombo and Delmastro 2002; Díez-Vial and Fernández-Olmos 2015; Fukugawa 2006; Hung 2012; Vásquez-Urriago et al. 2016) or between tenants and other parties outside the SP (Chan et al. 2010; Vásquez-Urriago et al. 2016). Second, the *buffering* function of SPs implies that by providing tenants with (access to) resources, SPs can buffer their tenants' resource dependency upon the wider external environment and as such mitigate the tenants' resource scarcity and dependence. Third, in providing tenants with a prestigious and high-image location, SPs may contribute to the tenants' *legitimation* (Ferguson and Olofsson 2004). In the SP literature, empirical evidence on the bridging role of SPs has provided rather contradictory results and the two latter types of mechanisms, buffering and legitimation, have so far largely been neglected. However, in order to better understand the "why" and "how" of SP contribution, we urge future studies to consider and study the *mechanisms* through which firms can gain benefits from SP residence.

Finally, the conflicting findings with respect to the contribution of SPs to their tenants suggest that the effects of SP residence are ***conditional*** upon different factors (Gwebu et al. 2019). Particularly, SP tenants are largely a heterogeneous group of organizations (Good et al. 2018), hence have different characteristics and needs, which implies that not all tenants will benefit equally from SP residence (Albahari et al. 2018). Yet, only recently studies have started to consider this tenant heterogeneity, hereby disentangling the relationship between firm age, size and innovation capabilities on the one hand and SP contribution on the other hand (Huang et al. 2012; Vásquez-Urriago et al. 2016). In this light, we explicitly acknowledge that SP residence is not equally valuable to each tenant (Gwebu et al. 2019) and urge studies to identify *firm-level conditions* that affect the benefits tenants receive from SP residence. For instance, as depicted in Fig. 11.1, the level of internal resources a tenant possesses will likely influence how valuable SP residence is for that focal tenant. On the one hand, firms with limited internal resources may experience more SP contributions as these firms may benefit more from the access to resources that SP residence entails (e.g. through the services and networking contacts offered on park). On the other hand, a higher degree of internal resources could be favorable to effectively exploit SP residence as this may facilitate the firms' ability to acquire and develop novel resources and take advantage of SP benefits (Gwebu et al. 2019). As a second example, SP contribution could also be influenced by tenants' internal capacities such as absorptive capacity (Cohen and Levinthal 1990). For instance, firms with high levels of absorptive capacity, which refers to firms' capacity to absorb external knowledge, may be better able to successfully assimilate and exploit the knowledge present at the SP than firms with lower levels of absorptive capacity (Gwebu et al. 2019). Finally, SP contribution could also depend on the tenants' objectives. Tenants with specific (SP-related) objectives (e.g. interacting with the SP's partner university or using particular facilities on SP) could perceive more benefits from SP residence than tenants without such objectives. Therefore, we argue that future studies should incorporate the heterogeneous tenant characteristics (such as internal resources, capacity and objectives) when evaluating SP contribution. At the same time, given the extensive tradition and global spread of SPs, the SP phenomenon shows considerable variety and countless different SP models exist (Nauwelaers et al. 2014). Nevertheless, many studies disregard the substantial heterogeneity among different SP initiatives, as such yielding mixed findings regarding SP contributions. Accordingly, we call for studies to unravel which *SP-level conditions* seem most favorable for tenants to benefit from SP residence.

In what follows, we specifically focus on the latter issue, namely SP-level conditions, and highlight the heterogeneity among SPs by providing an overview of the differentiating characteristics of SPs. Particularly, we evaluate 42 SPs in three European countries based on their key SP characteristics, as identified by Lecluyse et al. (2019). In their literature review, Lecluyse et al. identify SP ownership and governance structure, SP age and size, SP management and SP services as key SP characteristics. As these characteristics are frequently neglected in SP contribution studies (Albahari et al. 2018), we illustrate *how SPs differ in terms of these characteristics* and indicate *why these characteristics may influence SP mechanisms and eventual SP contribution*.

11.3 Method

11.3.1 Data and Sample

Given our aim to elucidate the substantial heterogeneity in SP characteristics, we build on a unique database containing information on SPs in Europe. First, we selected three countries based on their categorization in the Innovation Union Scoreboard (European Commission 2018)[1] and their geographical location. Particularly, we selected Denmark ("innovation leader", northern Europe), Belgium ("strong innovator", central Europe) and Spain ("moderate innovator", southern Europe). The gross domestic expenditure on R&D (Research and Development) (% of GDP (Gross Domestic Product), in 2018) in Denmark is 3.05, in Belgium 2.58 and in Spain 1.20 (European Commission 2018). Relative to the European average, the total R&D expenditure of Denmark in the business sector is 146% and 175% in the public sector, in Belgium this is 130% in the business sector and 130% in the public sector, and in Spain this is, respectively, 48% and 72% (European Commission 2018). When considering how the R&D expenditures within the three countries are organized, we notice that in Denmark 65% is dedicated to the business sector and 35% to the public sector. In Belgium, these percentages are respectively 68% and 32% and in Spain, these are 55% and 45% (European Commission 2017). Hence, each of these countries has their specific innovative ecosystem (or knowledge base) which is (partially) crystallized in their SPs.

Subsequently, within each country, we randomly selected one or two NUTS-1 (Nomenclature of Territorial Units for Statistics, level 1) regions, namely Denmark (DK0), Flemish Region (BE2), Community of Madrid (ES3) and East Spain (ES5). Then, we compiled a list of the SPs in these regions using secondary sources (including reports by UNESCO (United Nations Educational, Scientific and Cultural Organization), the European Commission, international, national and regional SP associations and general internet searches). Our final sample consists of 42 SPs within these four NUTS-1 regions.[2]

[1] The European Innovation Scoreboard provides a comparative analysis of innovation performance in the European countries. More information: https://ec.europa.eu/growth/industry/innovation/facts-figures/scoreboards_en

[2] In Denmark and Spain, some SPs are scattered across different cities. Given their different characteristics (e.g. different number of tenants, different services offered on SP), these different locations were included as separate entities in the analyses.

We contacted the managers of all 42 SPs and could arrange interviews with the managers of 35 of them. In these semi-structured interviews, we evaluated the SPs' key characteristics as defined by Lecluyse et al. (2019). As such, we collected information about SP ownership, governance, age, size, management and services. At the end of each interview, the SP manager was also asked to fill out a survey, containing more detailed questions on, for instance, SP ownership and park size. This primary data was further complemented with secondary data from annual reports, brochures and the SP website.

11.3.2 Data Analysis

The first stage of our analysis intends to gain a profound understanding of each SP individually. For each characteristic, we analyzed all information stemming from our different data sources and summarized this in large extensive tables. By doing so, qualitative and quantitative data are integrated to develop a complete understanding of each SP.

In the second stage of our analysis, we aim to understand the variety of SP characteristics among the different SPs. For the quantitative data, we create descriptive statistics and develop figures and tables to illustrate how SPs vary in terms of the different characteristics. For some characteristics, we complement the statistics with the qualitative, narrative information providing deeper insights into the emerging findings.

11.4 Findings

In this section, we present an overview of how SPs vary in terms of the SP characteristics that have been identified by Lecluyse et al. (2019), namely SP ownership and governance structure, SP age and size, SP management and SP services. In their literature review, Lecluyse et al. also present SP image as an important SP characteristic, however, as this cannot be objectively assessed by the interviewees, we disregard this characteristic in the analysis. Additionally, we indicate *why* each characteristic could influence SP mechanisms or SP contribution and summarize the scarce literature.

11.4.1 SP Ownership and Governance Structure

Following the SP literature, there are multiple groups that can have *ownership* over SPs, including universities, the government, private companies and

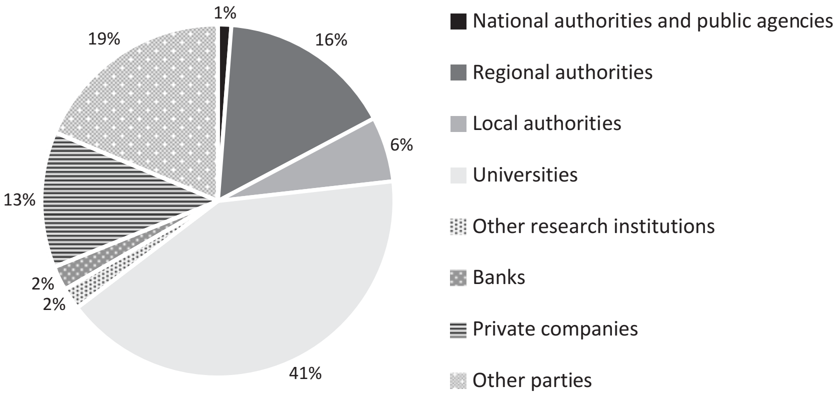

Fig. 11.2 Average ownership percentage of SPs. (Source: Authors' creation based on interview data of SP managers, *n* = 33 (Lecluyse 2019))

banks (Shearmur and Doloreux 2000). Throughout our interviews, we could discern eight specific shareholders, namely (1) national authorities and public agencies, (2) regional authorities, (3) local authorities, (4) universities, (5) other research institutions, (6) banks, (7) private companies and (8) other parties. In our sample, 27% of the SPs are fully owned by the university and 9% of the SPs are fully owned by regional authorities. In total, 55% of the SPs are owned by a combination of these shareholders. Figure 11.2 shows the average ownership percentage of the SPs studied. The SPs in our sample are, on average, mainly owned by universities (41%), other parties (19%) and regional authorities (16%). Following our interviews, we know that the category "other parties" mainly include (trust) funds, (research) foundations or even other SPs. In Denmark, private companies are important shareholders of the sampled SPs. In Belgium and Spain, regional authorities and universities seem to be on average the most important shareholders.

Furthermore, we notice a lot of heterogeneity in the *governance* of the SPs in our sample. As indicated in Fig. 11.3, 32% of the SPs in our sample are private limited companies, which is the most prevalent legal structure for SPs in Denmark. About 43% of the SPs in our sample are foundations, which is the most prevalent legal structure in Spain. Finally, 19% of the SPs in our sample are no separate legal entity as they are an integrated part of the university's structure. This seems to be the most prevalent strategy in Belgium.

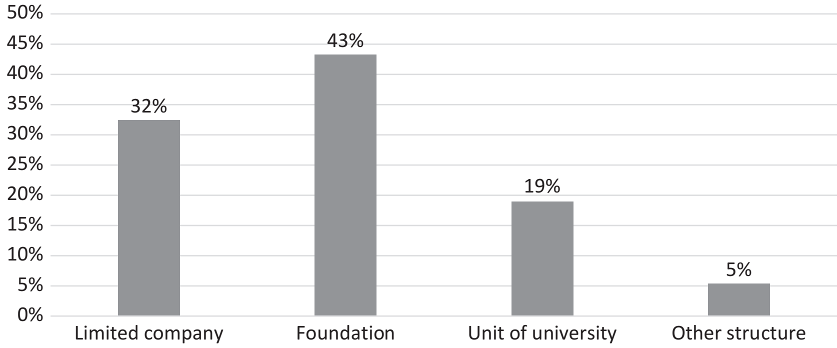

Fig. 11.3 Governance structure of SPs. (Source: Authors' creation based on interview data of SP managers, $n = 37$ (Lecluyse 2019))

Additionally, while 41.4% of the SPs in our sample indicates to be "for profit" (mainly the limited companies, most prevalent objective in Denmark), 58.6% says to be "nonprofit" (most prevalent objective in Belgium and Spain).

In general, it is widely acknowledged that an organization's ownership and governance structure have a substantial impact on the organization's operation, activities and performance (Greenwood and Miller 2010). Therefore, SP structures will seemingly have a crucial impact on the SPs' operation, activities, mechanisms and contribution (Good et al. 2018). However, even though our analysis reveals that there is substantial heterogeneity in the ownership and governance structure of SPs, there are to date only limited insights in this area. For instance, in SPs in which the partner university is more ingrained in the structure (e.g. high ownership percentage of the university or SPs being integral units of the university), there could potentially be more bridging opportunities for tenants with the partner university (affecting the bridging mechanism), more university equipment and facilities available for tenants (affecting the buffering mechanism), and this close link between the SP and partner university might provide tenants with more credibility (affecting the legitimation mechanism). At the same time, more private sector involvement in the SP could be related to the presence of more experienced business managers on the SP who can provide tenants with high-quality services, advice and networking contacts (Sofouli and Vonortas 2007). The limited evidence available indicates that more involvement of the private sector in SPs is beneficial in promoting innovation (Koh et al. 2005; Miao and Hall

2014) and may spur the establishment of innovative companies (Sofouli and Vonortas 2007). Liberati et al. (2016) demonstrate that residence in purely public SPs (compared to non-public SPs (i.e. mixed or private ownership)) increases the sales and added value of tenants. Huang et al. (2012)'s study in Taiwan shows that SPs organized by the central government are better able to achieve tenant innovation than SPs organized by the local government.

11.4.2 SP Age and Size

With the oldest SP in our sample established in 1962 as one of the first European SPs and the youngest SP established in 2010, there is a large variety in *SP age*. The SPs in our sample are on average 22.10 years old (i.e. established in 1997, s.d. (standard deviation) 11.84), with the sampled SPs in Denmark on average being the oldest and the ones in Spain the youngest. In Fig. 11.4, we show the distribution of SPs along their founding date.

In line with the literature (Annerstedt 2006), almost all interviewees indicate that the primary objective to establish the SP was to commercialize the science developed in the university and to create synergies between scientists and practitioners. At the same time, in Belgium and Spain, particular government regulations and incentives played a crucial role in creating SPs. Particularly, the legislation on SPs in Flanders, Belgium dates from 1971 (Vandecandelaere and Spithoven 2009) and declared that every university in Flanders that contains an applied, medical and/or agricultural

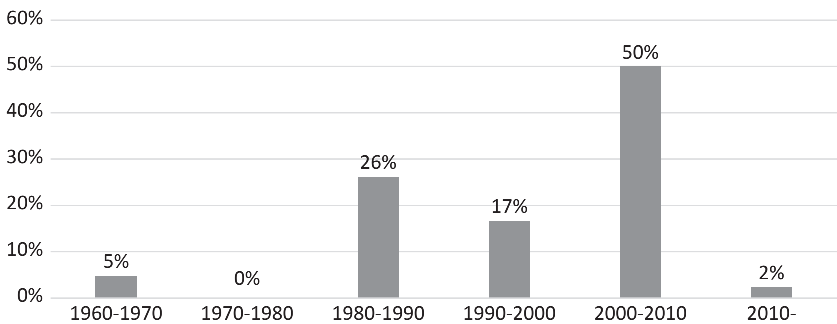

Fig. 11.4 Percentage of SPs established in different periods of time. (Source: Authors' creation based on interview data of SP managers, $n = 42$ (Lecluyse 2019))

sciences department was entitled to develop an SP (then called "research park"). In Spain, the development of SPs rose much later, namely in the mid-2000s when the Spanish central government issued highly attractive loans to Spanish universities intended for the creation of SPs, which explains that SPs in Spain are on average the youngest.

While it is apparent that SP age will affect SP mechanisms and SP contribution, the impact of SP age is typically neglected in extant SP studies (Albahari et al. 2018). For instance, in older SPs, SP managers have typically had more time to understand the tenants' needs hence might provide better support and more adequate resources (affecting the buffering mechanism) (Squicciarini 2009). Also, SP age could be related to more effective bridging given the longer period of potential interactions between tenants and other parties (e.g. other tenants and the partner university), which builds mutual trust and reduces the risk of dishonest behavior. Further, as it could be argued that SPs need a certain amount of time to develop a reputable image, SP age could affect the legitimation building mechanism of the park. By contrast, older parks may face the risk of falling into routines, conservatism and non-learning processes (Albahari et al. 2018), and could be more susceptible to slip into decline (Tan 2006), which is in turn harmful for SP contribution. Also, Squicciarini (2009) argues that younger SPs can more effectively accomplish their supporting role as they can avoid the mistakes made by pioneering SPs. Empirical evidence in this regard is scarce and far from unanimous depending on which indicator is used. One empirical study shows that firms in younger as well as in older parks perform better in terms of innovative performance (i.e. sales from new to market products) compared to firms in middle-aged parks (Albahari et al. 2018). Liberati et al. (2016) find that the effect of SP residence on tenants' sales and added value is stronger in older parks compared to more recent parks. Contrarily, Squicciarini (2009) finds that firms situated in older parks perform worse in terms of patenting activity.

In the literature, *SP size* is typically measured as the number of tenants on SP or the total surface of the SP. Table 11.1 provides the descriptive statistics of the size of the SPs in our sample. The results demonstrate that there is considerable heterogeneity in SP size. While the sampled SPs in Denmark are on average the largest in terms of tenants, the ones in Spain are on average the largest in total surface. The sampled SPs in Belgium are on average the smallest. Furthermore, SPs largely differ in terms of density as shown by the number of tenants per 1000 m^2 in Table 11.1.

Despite this considerable heterogeneity, many studies have neglected to study the impact of SP size and density. However, as the potential positive

Table 11.1 Descriptive statistics of SP size and density

	Min	*Max*	*Mean*	*Median*	*s.d.*
Number of tenants on SP	5	153	58.95	50	40.11
Total surface of SP in m^2	1000	520,000	76,028.54	17,520	116,535
Number of tenants per 1000 m^2	0.01	30	4.74	4	5.49

Source: Authors' creation based on interview data of SP managers, $n = 42$ (Lecluyse 2019)

externalities related to the co-location of firms increase with the number of clustered firms (Arthur 1990; Gwebu et al. 2019), SP size will likely exert an influence on SP mechanisms and SP contribution. Particularly, the number of tenants on SP determines the pool of resources and knowledge available on park, and additionally, larger SPs will be more likely to attract a wider customer market and more potential partners such as venture capitalists and suppliers (Gwebu et al. 2019), hence influencing the buffering mechanism of SPs. Further, the number of tenants on SP also represents the number of potential collaboration partners on SP, yet at the same time, affects the degree of competition among tenants (Albahari et al. 2018). Therefore, SP size may exert an influence on the bridging mechanisms and eventual SP contribution. Additionally, as Glaeser et al. (1992, p. 1126) noted that "*intellectual breakthroughs must cross hallways and streets more easily than oceans and continents*", SP density might influence SPs' mechanisms and contribution as tenants that are more closely co-located may encounter more opportunities for face-to-face interactions. Indeed, McEvily and Zaheer (1999) argue that in dispersed clusters, interaction among firms is likely to be limited. Greater interaction frequency would result in more efficient information flows allowing tenants to bridge, learn and develop new knowledge (Daft and Lengel 1986). A limited number of studies find that firms in larger parks outperform those in smaller parks (Albahari et al. 2018; Squicciarini 2009) (in terms of, respectively, sales from new to market products and patenting activity). By contrast, Gwebu et al. (2019) find that there is no significant relationship between park size and tenant firm performance (in terms of sales and sales growth).

11.4.3 SP Management

Although it is often assumed that the presence of a knowledgeable SP management has a critical role in the success of SPs (Cabral 1998; Ratinho and Henriques 2010), it appears from our data that SPs vary substantially

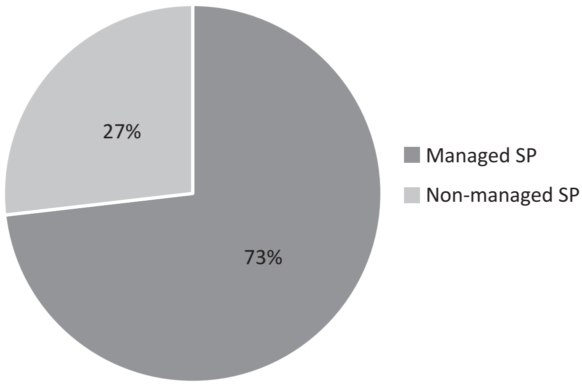

Fig. 11.5 Percentage of "managed" versus "non-managed" parks. (Source: Authors' creation based on interview data of SP managers, *n* = 41 (Lecluyse 2019))

in terms of how they are managed. In accordance with Westhead and Batstone (1998), we define a "managed park" as an SP that has at least one full-time manager and a "non-managed park" as a park that is managed by an informal team consisting of SP partners or stakeholders with no (full-time) presence on park. Figure 11.5 indicates that 73% of the SPs in our sample meet the definition of "managed" parks and 27% of the SPs are "non-managed". In Denmark and Spain, the majority of SPs in our sample are "managed" whereas in Belgium, the majority of SPs is "non-managed".

Later studies have recognized the heterogeneity among SP management and argued that SP managers should hold a broad set of skills in order to provide value-added contributions to tenants (Cabral 1998; Löfsten and Lindelöf 2003; Ratinho and Henriques 2010).

During our interviews, we asked respondents to describe the top management of the SP.[3] On average, the interviewees indicated that the top management consists of 3.86 members (s.d. 2.10). The sampled SPs in Spain have on average the largest top management and the ones in Belgium the smallest. Furthermore, since many studies argue that SP managers should ideally hold a broad set of skills (Cabral 1998; Chang et al. 2009;

[3] We first presented the interviewees with the definition of the SP top management (i.e. "the people who take strategic decisions and are responsible for the management of the SP, hereby excluding persons only sitting in the board of directors (Amason and Sapienza 1997)"). This question was asked irrespective of whether this management was formal or informal.

Table 11.2 Experience of SP general manager

	Min	*Max*	*Mean*	*Median*	*s.d.*
Years of experience in managing SPs, business incubators, accelerator programs, etc.	1	26	8.71	8	5.06
Years of experience in "management"	1	28	14.14	14	6.25
Year of experience in "R&D"	0	27	5.22	0	8.19

Source: Authors' creation based on interview data of SP managers, $n = 38$ (Lecluyse 2019)

Ratinho and Henriques 2010), we present more detailed information about the experience of the SP general manager[4] in Table 11.2. About 40.5% of the SP general managers in our sample have entrepreneurial experience (i.e. have ever established or bought a company) and about 30.7% hold a PhD degree.

These statistics reflect the variety in management of SPs. Yet, while some studies have discussed best SP management practices based on successful SP cases (e.g. Cabral 1998; Chang et al. 2009), there is only limited evidence on the impact of SP management on tenants. Since each manager enhances the organization's pool of resources by adding skills, knowledge and network contacts (Shane and Stuart 2002), the size of the SPs' management as well as the managers' experience could possibly affect the bridging and buffering mechanisms of SPs and SP contribution. One empirical study in this regard found that SP top management team size is positively related to the innovation performance of tenants (Albahari et al. 2018). Particularly, they argue that a larger SP management augments the tenants' network and facilitates technology transfer (Albahari et al. 2018).

11.4.4 SP Services

First, SPs typically offer a package of *property-related services* to their tenants, for instance, including shared receptions, meeting and conference facilities and shared restaurants. These services are generally perceived as advantageous as they allow lowering tenants' overhead costs (Guy 1996; Westhead and Batstone 1999; Siegel et al. 2003; Sofouli and Vonortas 2007; Benneworth and Ratinho 2014; Rowe 2014). Particularly, our sur-

[4] The "general manager" refers to the person most in charge with the (daily) management of the park. This could therefore be the CEO of the SP, the general director, or the president of the (informal) management.

vey contained a list of 16 property-related services and we asked the respondents to indicate which of these services they provide to their SP tenants. On average, the SPs in our sample offer 11 of these 16 services (s.d. 4.47, min: 0, max: 16). Figure 11.6 demonstrates the percentage of SPs that provide a particular type of property-related services. While parking possibilities, control and security, and conference and meeting facilities are very frequently offered by SPs, banking facilities, library and sports facilities are offered much less. In general, the sampled SPs in Denmark provide the largest range of services to their tenants and the ones in Belgium the smallest range.

Second, in addition to property-related services, SPs may also offer *advice and consulting* to tenants in areas such as marketing, business planning, intellectual property (IP) and research activities. SPs may also play

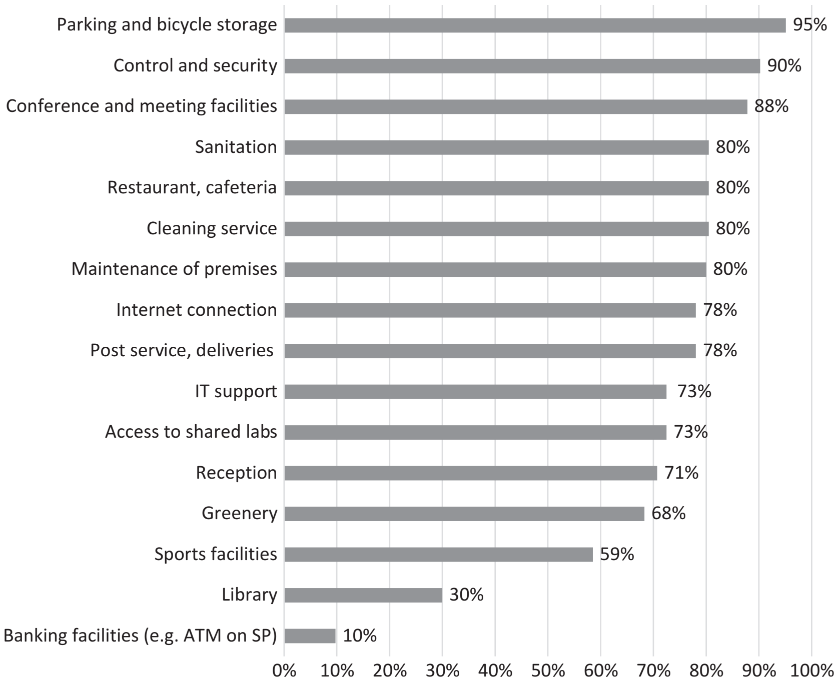

Fig. 11.6 Percentage of SPs that offer particular property-related services. (Source: Authors' creation based on interview data of SP managers, $n = 42$ (Lecluyse 2019))

an important role in informing firms on how to gain access to public or private finance (Salvador 2011). Our survey contained a list of 11 types of advice and consulting and we asked the SP managers to indicate which of these types they provide on their SP. On average, the SPs in our sample offer 4 of these 11 types of advice and consulting (s.d. 3.83, min: 0, max: 11). Figure 11.7 then demonstrates the percentage of SPs that provide a particular type of advice or consulting. While quite a lot of SPs in our sample offer training sessions to their tenants, other types of advice and consulting are offered way less often. The sampled SPs in Denmark provide on average the widest range of advice and consultancy services to their tenants and the ones in Belgium the smallest range. Additionally, 25% of the SPs in our sample operate their own fund by which they can invest in tenant companies. This occurs most frequently in the SPs in Denmark.

Third, SPs are also expected to (co-)*organize events* on SP during which relevant topics are dealt with and allowing tenants to connect with other tenants and with external parties (Good et al. 2018). These events are typically set up to facilitate interaction and networking (Koçak and Can

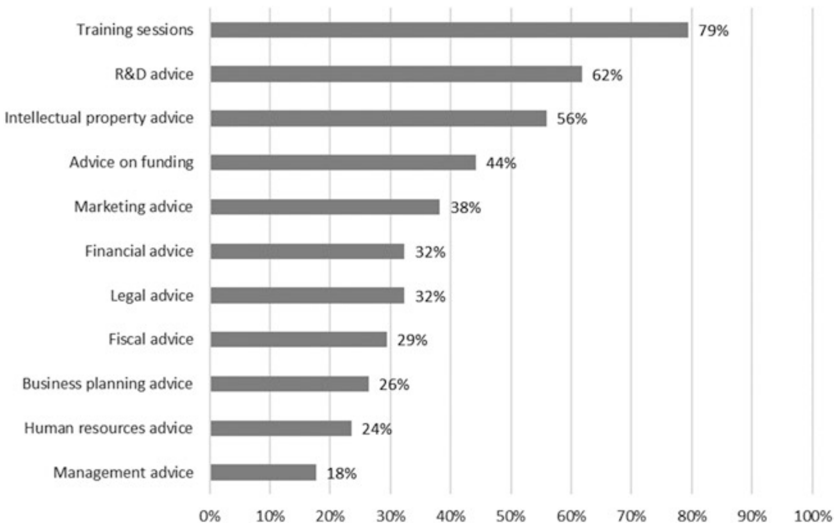

Fig. 11.7 Percentage of SPs that offer advice and consulting. (Source: Authors' creation based on interview data of SP managers, n = 34 (Lecluyse 2019))

2013). On average, the SPs in our sample organize 45 events per year (s.d. 58.58, min: 0, max: 260). The studied SPs in Denmark (co-)organize events most frequently.

These statistics indicate that SPs vary considerably in range and type of services they provide to tenants. Particularly, offering services could affect the buffering role of SPs, as providing more resources on SP could decrease the tenants' dependency on additional resources outside the environment of the SP. Additionally, activities such as organizing events on SP could stimulate bridging among tenants and with other parties invited to these events. Yet, empirical evidence on this topic is again limited and does not provide unequivocal results. A range of studies find SP services to be valuable for tenant firms (Monck et al. 1988; Westhead and Batstone 1998, 1999), especially for young firms (Lindelöf and Löfsten 2003), and argue that participation in networking events leads to more knowledge sharing among tenants (Koçak and Can 2013). By contrast, another study finds the impact of consultancy services on tenants' innovative performance to be negative (Albahari 2015; Albahari et al. 2018). They attribute this counterintuitive finding to the assumption that services on the market might be of better quality than those offered on SP.

11.5 Conclusion

The purpose of this study is to present an integrative framework which enables us to advance the current understanding of SP contribution. We do so by illuminating shortcomings in the SP literature and propose new pathways for future SP research. Particularly, our framework highlights that future SP studies should consider new approaches to assess SP contribution for tenants, provide insights into the mechanisms by which SP residence provides benefits for tenants, and unravel the conditions under which SP residence is able to provide benefits for tenants. By simultaneously taking into account these considerations, new insights can be gained on whether, when and how SPs contribute to their tenants.

Subsequently, this study focuses on the latter pathway and exhibits the importance of considering SP-level conditions in SP studies. Particularly, by building on a unique database containing information on 42 SPs in Europe, we demonstrate that there is substantial heterogeneity among key SP characteristics, including SP ownership and governance, SP age and size, SP management and SP services, in different SPs. Furthermore, as we pinpoint why these characteristics can influence SP mechanisms and SP contribution, we urge future studies to take into account at least these (and alternative) characteristics when studying the impact of SPs. As such, we vouch for the statement: "*If you have seen one science park, you have seen one science park*".

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CHAPTER 12

Lessons Learned and a Future Research and Policy Agenda on Science Parks

Mike Wright, Albert N. Link, and Sara Amoroso

12.1 Introduction

The purpose of this volume has been to review existing methodologies to evaluate the performance of science and technology parks (STPs) and to explore new concrete ways to systematically collect information on public and private organizations related to their support of and activities in STPs, including incubation to start-up and scale-up, and collaborations with centers of knowledge creation. Only through a systematic collection of knowledge about such organizations and related data is it going to be

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possible to conduct current and especially future analyses on the impact of STPs on entrepreneurship, effectiveness of technology transfer and regional economic development. These are important topics to consider not only for implementing place-based policy but also for analyzing the evolution of the STP concept in the new knowledge economy and the emergence of new areas of innovation.

The chapters assembled herein present frameworks of analysis and quantitative and qualitative evidence from several countries of the impact of STPs both on tenant firms and territorial development. In this final chapter we provide a synthesis from the body of chapters and we also initiate a discussion of lessons for future policy and research on the evaluation of the impact of STPs.

12.2 Frameworks of Analysis

Several chapters develop methodological frameworks, notably the chapter by Diaz (Chap. 5), Wright and Westhead (Chap. 4), Lund (Chap. 2), Rissola (Chap. 10) and by Albahari (Chap. 9). Although these contributions have their differing perspectives, they have several notable aspects in common.

First, they recognize the importance of taking into account the multi-dimensional environmental context within which STPs operate. Autio et al. (2014) set out a framework for entrepreneurial and innovation ecosystems that involves several contextual dimensions: spatial, temporal, social, organizational, industry and technological, and institutional and policy. Second, the frameworks emphasize the importance of understanding interactions and networks among the various stakeholders involved with STPs. Third, the frameworks point to the multiplicity of types of STPs identified by their ownership and goals, business models and strategies, and resources. STPs also vary in terms of age and size.

Figure 12.1 presents a high level schematic view of the relationships involved that form a basis for identification of data sources. In what follows we outline each of these elements. Note that these elements are time variant.

12.3 Territorial Heterogeneity

The contributions to this volume highlight the heterogeneity of territorial contexts for STPs. The volume contains studies of STPs that encompass a variety of countries: Belgium, Denmark, Finland, Netherlands, Slovenia,

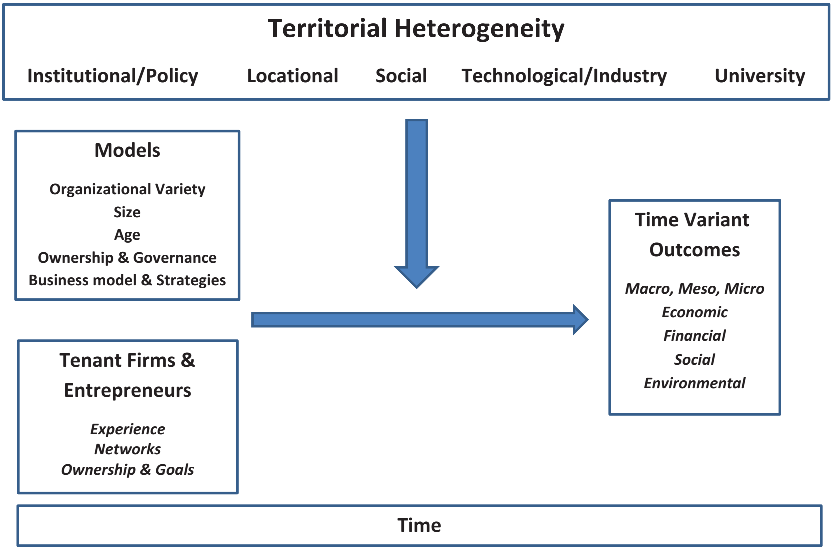

Fig. 12.1 Relationships between STP models, entrepreneurs, territorial heterogeneity and outcomes. (Source: Authors' creation based on own interpretation of the chapters in this volume)

Spain, Sweden, Turkey, the UK and US. These studies ask a number of relevant questions. To what extent are STPs in emerging economies replicating 'best practice' based on traditional models in developed economies? Alternatively, are approaches in emerging economies able to leap-frog traditional support models to adopt more recent forms? To what extent do these models involve spillovers of knowledge and technology from developed to emerging economies? Where there may be potential for such spillovers, do emerging economy STPs and accompanying policy stances provide the absorptive capacity to incorporate the knowledge and technology?

The studies also help identify the various dimensions of territorial heterogeneity. *Location* within a particular territory is important. Chapters identify evidence on STPs in particular cities or regional areas within countries, such as Ljubljana in Slovenia and Gothenburg in Sweden. Particular cities or regions may also include different types of STPs, as for example in the case of Gothenburg in Sweden and Ljubljana in Slovenia in Chap. 11. Further, STPs may be located in dense urban areas or non-urban areas (Lund, Chap. 2) or on- or off-university campuses (Audretsch and Belitski, Chap. 7).

The nature of *social* contexts relates to the networks and interactions between actors in the STP ecosystem. Rissola in Chap. 10 views social contexts from the perspective of triple and quadruple helices involving corporations, universities, governments and civil society, but which also involve interactions with a variety of financial institutions and other intermediaries.

The *institutional and policy* context of an STP concerns both the formal institutions, and informal institutions within which it operates. These may be set at national but also at local levels, as the chapters covering the country evidence referred to above indicate. Given, as Nauwelaers et al. observe in Chap. 6, STPs are expected to contribute to regional and local development, data on their institutional and policy context is important as a benchmark against which to measure STP additionality.

The *university* context concerns not just whether or not an STP works with a university but also the research quality of the universities associated either directly or indirectly with a particular STP or group of STPs in a particular locality. Evidence from Turkey in Chap. 8 highlights the importance of the quality of the university. For STPs associated with more technologically oriented ventures, universities may be broad based leading research universities and specialist research institutions. However, advances in information and communication technologies (ICT) and digitization have opened up entrepreneurial opportunities in arts and social science disciplines, accompanied by lowered costs and financial needs for new ventures. These ventures may still need support from incubators and accelerators, helping to extend the variety in STPs.

The *industrial and technological* context concerns the structure and life-cycle phases of industry in a particular location as well as its architectural attributes. As Lund points out in Chap. 2, this concerns not only the particular sectors but also whether the STP works mainly upstream with universities or downstream with companies. An important *temporal* dimension emerges in relation to the policy and practice of STPs. STPs are not static. They emerge and grow but may also reconfigure, decline and fail. As Lund notes in Chap. 2, STPs need to evolve so that they are not only attractive for companies or research institutions but also attractive to the creative class of highly mobile individual knowledge workers. STPs may be divested or closed by public or private owners if they are not achieving their goals. Long term mega trends in the nature of IP and entrepreneurship may mean that the nature and location of physical space demanded by entrepreneurs is changing. The configuration and composition of STPs may also need to change over time to enable them to remain viable from, say, a focus on knowledge-intensive start-ups to become, say, a real estate park for units of established businesses.

12.4 The Changing Landscape of Support Models

The landscape of support models is changing and new complementary urban models are now emerging, leading to innovation districts: geographical areas where anchor institutions and companies connect with the classical components of STPs, such as start-ups, incubators and accelerators (Katz and Wagner 2014). In Chap. 3, Link showed, using primarily US evidence, that while the supply of traditional STPs appears stable in the short term, demand for them is waning. Chapter 9 describes a transition from STPs to innovation areas or districts, whereby the most traditional STP elements (incubators, accelerators, design centers, flexible office facilities, etc.) are being used to revive entire neighborhoods or city areas that had been in decline.

At the same time, the demand and supply of new organizational forms aimed at stimulating high tech entrepreneurship are increasing. As we saw in Chap. 7, new organizational arrangements include accelerators offering limited length support programs to cohorts of early stage ideas and ventures. These may be general or sector focused, and they may be associated with corporations, financial firms or the public sector (Wright and Drori 2018). Further, support spaces including work spaces, hack spaces and the like oftentimes in cities and innovation districts are growing as a location where high tech entrepreneurs can develop their venture ideas. Digitization is also reshaping the ecosystem of support mechanisms as well as the nature of ventures and their support needs (Autio et al. 2018; Nambisan et al. 2019).

Universities are also developing physical spaces for faculty and student entrepreneurship. Although these spaces involve varying degrees of facilities and mentoring support between different universities and locations, a clear evolution from enthusiastic professors and student clubs toward more formalized and integrated support mechanisms and the development of an entrepreneurial ecosystem is occurring (Wright et al. 2019).

One might reasonably argue that prior studies have lacked sufficient attention to the variation within the broad umbrella of STPs. Evidence is needed that provides comparative insights into the impact and drivers of this impact across the landscape of STPs.

Recognition of the importance of understanding the variety of formats has important implications for policy. For example, approaches associated with smart specialization that identify what cities or regions might specialize in and build appropriate ecosystems need to incorporate a portfolio of different types of STP support mechanisms. Studies might usefully explore the effectiveness of different configurations of STPs in particular geographical locations.

The variety of STP models and their evolution also highlights the need to be clear about their goals and business models when evaluating their impact. For example, assessing the impact of an STP aimed at supporting the creation of new ventures in a particular locale may be quite different from evaluating an STP's effectiveness as a central player in stimulating an entrepreneurial ecosystem.

12.5 Tenant Firms and Entrepreneurs

Examination of the interactions between STPs and the contexts in which they operate without considering the characteristics and behaviors of tenant entrepreneurs and firms would, as William Baumol almost said, be like expunging the Prince of Denmark from a study of Hamlet. Phan et al. (2005) highlighted the importance of examining entrepreneurs' role in STPs but little work has been done in this area. Wright in Chap. 4 identifies the important need to obtain data on entrepreneurs and tenant firms. STPs need to consider their target firms and entrepreneurs as this has implications for the selection process, the composition and impact of STPs.

Tenant firms and entrepreneurs on STPs vary considerably. Albahari in Chap. 9 raises questions regarding whether parks should host only technology-based start-ups or include mature firms, prestigious firms, independent firms or branches of established firms, or a certain percentage of consultancy firms. Similarly in Chap. 2, Lund highlights that the choice between targeting start-ups that can be nurtured through business incubation and acceleration and attracting more mature established firms represents two fundamentally different approaches. Entrepreneurs may be in the process of establishing their first venture or they may have created, purchased and owned several ventures either simultaneously or concurrently or indeed successfully or not. These differences may impact their financial resources, their expertise and their social networks. Their goals may vary in terms of their time horizons and in relation to their social versus financial objectives. As a result of this variety, each will have their own resource needs from the STP. A further concern relates to the height of mobility barriers that may constrain the ability of firms and entrepreneurs to exit or switch STPs. The changing STP landscape introduces different types of territorially based structures and is accompanied by an increasing variety of entrepreneurs and firms seeking out support. We would suggest that to understand the impact of these support structures it has become more and more important to have insight into the diversity of those who use them. This is an important area that continues to be largely neglected in STP studies and is worthy of further research.

12.6 Measures of Success

As we saw in Chap. 4, outcomes from STPs relate to economic, financial, social and environmental dimensions. They need to be measured at macro (country, region, city), meso (STP) and micro (tenant firm and entrepreneur) levels, and over appropriate periods of time to be meaningful. Chapter 8 presents an analysis of the impact of all active technoparks in Turkey, finding that distance to a university is insignificantly related to employment growth on the parks while age of the park has a significant positive effect. This study also finds that the research quality of the university associated with the park has a significant positive relationship with employment growth. In Chap. 7, Audretsch and Belitski, using UK data, highlight the importance of understanding differences in geographical and institutional context on the nature and extent of outcomes. They show that incubators have a stronger impact on entrepreneurship outcomes relating to sales turnover in spin-offs and start-ups than science parks and that science parks located on university campuses have a greater effect on start-ups and spin-offs than science parks located off-campus. They also find that universities located in cities with higher economic development have lower spin-off and start-up outcomes when science parks are located on campus.

12.7 Data and Databases

It is evident that data needs to be collected on a consistent longitudinal basis in order for trends and evolutions of STPs to be monitored over time, as well as to enable analysis of causalities of outcomes to enable policy effectiveness to be assessed.

Given the need for spatial comparisons, data collection efforts need to ensure that data from different regions and countries can be combined. This would entail agreement on core variables that need to be collected and consistent methods of data collection between geographical areas. It would also involve the need for commitment to fund the consistent collection of such data over a long enough period for meaningful evaluations to be made.

As we have seen from the various contributions, since there is variety both from within and between different countries in relation to types of STPs that are observed, there is a need to ensure that measurement captures this variety, otherwise there is a risk that analyses result in misleading insights being drawn.

Developing databases that capture all the variables identified in Fig. 12.1 that are likely to be needed now and in the future is clearly fraught with difficulties. As it is difficult to "boil the ocean", it is important that the databases developed are flexible and can be connectable to other data sources. One particular area of note is that, while consistent measurement can facilitate cross-country comparisons of STPs, it is also important to be able to access data on firms that are not located on STPs as well as those that may once have been located on STPs but which have exited. For some measures and respondents, data collection may raise confidentiality issues. However, there are well-established means, for example, using governmental secure datalabs, to connect confidential sources of information as long as provision is made to include common identification codes.

There may also be benefits from adopting a variety of analytical tools according to the particular dimension and level of effectiveness to be evaluated. Besides panel data analytical methods, multi-level techniques can usefully take account of the different levels of variables. Evaluation at a macro ecosystem level may also need to adopt mixed method approaches that combine quantitative analysis with more qualitative approaches.

12.8 Concluding Comments

We hope that this volume will provide both a stimulus for future studies of science parks as well as future policy initiatives to stimulate their growth and efficiency. We have identified directions for the collection of data to enable such initiatives to be evaluated. With growing debate about the effectiveness of STPs and a fast moving landscape of technology-based ventures and their support mechanisms, such initiatives are assuming considerable urgency.

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