Rajnish Tiwari
Stephan Buse *Editors*

RESEARCH

Managing Innovation in a Global and Digital World

Meeting Societal Challenges and Enhancing Competitiveness

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Rajnish Tiwari · Stephan Buse
Editors

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ISBN 978-3-658-27240-1 ISBN 978-3-658-27241-8 (eBook)
https://doi.org/10.1007/978-3-658-27241-8

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Festschrift in honor of
Cornelius Herstatt
on his 60th birthday

Prof. Dr. Cornelius Herstatt

(Bild: Goeldner/TUHH)

अद्भिर्गात्राणि शुद्धयन्ति, मनः सत्येन शुद्धयति।
विद्यातपोभ्याम् भूतात्मा, बुद्धिर्ज्ञानेन शुद्धयति॥

(*मनुस्मृति* ५ - १०९)

Body is purified by water;
Mind is purified by truth;
Soul is purified by learning and meditation;
Intelligence is purified by knowledge.

(*Ancient Sanskrit saying from India*)

Acknowledgments

We are indebted to a number of people for their invaluable contribution to the successful realization of this *festschrift* in honor of Prof. Dr. Cornelius Herstatt on the occasion of his sixtieth birthday. First and foremost, we would like to sincerely thank all authors who have kindly taken time off their busy schedules to share their insights on current developments in technology and innovation management in an increasingly global and digital world. We are delighted that we have been able to secure contributions from several internationally renowned thought-leaders and colleagues, who have vast academic and practical experience, and with whom Cornelius Herstatt has successfully collaborated for many years. This includes a number of his former doctoral students as well as former/current postdoctoral students, who have first-hand experience of a close research cooperation with Cornelius. All authors are united in their desire to express their special appreciation for Cornelius Herstatt.

We would like to express our gratefulness to Palgrave Macmillan UK for kindly allowing us a reprint of an article by Prof. Dr. Hugo Tschirky (Chapter 1), and to MIT Sloan Management Review for the friendly permission to reprint an article co-authored by Prof. Dr. Eric von Hippel (Chapter 8).

We thank Ms. Susanne Göbel from Springer Verlag for the smooth and productive collaboration in the production of this book. All colleagues at our institute have supported us whenever and wherever needed, e.g. in reviewing the manuscripts. Finally, special thanks are due to Dr. Thorsten Pieper for his very valuable, timely and highly appreciated support in the entire publication and coordination process.

Notwithstanding the fabulous support granted by such a great number of persons and institutions, any eventual errors and omissions in the editing of the book remain entirely ours.

Hamburg, Germany Rajnish Tiwari and Stephan Buse

Preface

This *festschrift* with the title "Managing Innovation in a Global and Digital World: Meeting Societal Challenges and Enhancing Competitiveness" is a commemorative volume, which is dedicated by its authors and editors to Prof. Dr. Cornelius Herstatt, who is celebrating his 60th birthday on June 17, 2019. It is intended as a gesture of recognition and appreciation for his lifetime achievements and for his outstanding contribution to the field of science, especially to the management of technology and innovation, over the past three decades.

Curriculum Vitae of Cornelius Herstatt

Cornelius Herstatt was born on June 17, 1959, in Cologne in then West Germany. As son of the banker Iwan D. Herstatt and his wife, Ilse Herstatt, Cornelius spent his school years in his hometown and subsequently completed a trainee program at Klöckner-Humboldt-Deutz AG in Cologne and London. Later, he studied Business Administration and Economics at the universities of Cologne, Zurich and Oxford. Between 1987 and 1991, he worked on his doctoral degree at the Institute for Business Research of the University of Zurich under the supervision of Prof. Dr. Edwin Rühli, which culminated in the award of a doctoral degree (Dr. oec. pub.) from the University of Zurich in 1991 for his research on the potential role of lead users as a source of innovations (dissertation title: "Anwender als Quellen für die Produktinnovation").

During this period, he also worked as a scientific assistant at the Business Administration Institute of the Swiss Federal Institute of Technology in Zurich under the direction of Prof. Hugo Tschirky for five years. His association with this institute, and especially the guidance of Prof. Tschirky, influenced his research significantly and has continued till today. In 1991, another deep-reaching influence took place in his academic life, as he went as a Visiting Scholar to Prof. Dr. Eric von Hippel at the Massachusetts Institute of Technology (MIT Boston). The fruitful collaboration with his academic mentor, Eric von Hippel, has culminated in many joint research projects and path-breaking publications as well as his engagement in the open and user innovation (OUI) community.

After his doctorate, Cornelius joined Arthur D. Little, a leading management consulting firm, where he worked till 1996 (last position Senior Manager). Later, he continued his management career as Vice President of Wärtsilä NSD AG in Winterthur in Switzerland. In 1998, Cornelius decided to pursue an academic career and joined the Hamburg University of Technology (TUHH), where he became the founding director of the Institute for Technology and Innovation Management (TIM). His engagement at TUHH continues to date and last year the TIM celebrated its 20th jubilee.

Cornelius lives with his wife Elke in Buchholz near Hamburg. Together they have three sons.

Academic Contributions & Achievements

Cornelius Herstatt has been a prolific scholar of business management and innovation-related issues for over thirty years. His impressive list of about 300 publications, of which more than 60 are in peer-reviewed journals, and the prizes and awards he has received illustrate why he has been one of the leading national and international scientists in his field, and why his works have been published and translated in several languages. A list of his publications can be found in Appendix-A.

Since the beginning of his research, Cornelius has focused on the phenomenon of "user innovation". With the advent of the Internet, his research has increasingly also included "Open Source Innovation" in (online) communities. Another core area of his longstanding research interest has been "Ageing Societies", which has led him to multiple research projects in Japan. More recently, he has been particularly interested in "frugal innovations" that are targeted at affordable excellence. This research has a strong focus on India, which has emerged as a lead market for frugal solutions: a development that Cornelius and his team were amongst the first to recognize. Further focal points of his research relate to globalization of innovation and ecological sustainability, especially circular economy and the "cradle-to-cradle" approach.

The high quality of research by Cornelius and his team has been honored by several "Best Paper Awards" at conferences and at journal level. The International Association for Management of Technology (IAMOT) included him in the "Top 50 list of researchers in technology and innovation management field" in 2009. This is an award "to recognize the contribution of the most active researchers" in this discipline.

Many of the research projects at his institute have been funded by grants from external funding institutions, such as the German Federal Ministry for Education and Research (BMBF), European Commission, German Research Council (DFG), Austrian Council for Research and Technology Development, and the International Red Cross Society. He is an alumnus of the Japan Society for the Promotion of Science (JSPS), the German Institute for Japanese Studies, the East-West Center (Hawaii), and Templeton College (Oxford). Due to the applied nature of his research, he has often successfully managed to acquire industrial funding for joint research and consulting/training leading to cross-fertilization of ideas that also has a positive effect on the quality of research.

As a leading scholar of his field, Cornelius has held several editorial positions in renowned publishing houses and has co-edited 14 contributed volumes, that have been very well-received in the scholarly community. In addition, he has held several visiting professorships, to cite a few examples, at Royal Melbourne Institute of Technology (Australia), Tokyo Institute of Technology (Japan), and Santa Clara University (USA).

The narration of his lifework and research would be incomplete without mentioning the nearly extraordinary contribution he has made in teaching and supervision. So far, he has mentored 39 of his students to a doctoral degree, while 12 others are currently pursuing one. Three of his students have completed a Habilitation (*venia legendi*), while three more are in this process. Eleven of his former students have, by now, their own chairs in innovation management-related fields and belong to leading academics in their own right. Similarly impressive is the number of thesis projects done at Bachelor and Master level: Cornelius has supervised about 500 such projects in the last 20 years.

Furthermore, he was instrumental in the creation of two international joint Master programs, i.e. the Erasmus-Mundus funded M.Sc. in Global Innovation Management (GIM), and its successor program M.Sc. in Global Technology and Innovation Management & Entrepreneurship (G-TIME). This contribution has been recognized by independent external bodies as well. For example, in 2004, the Hamburg-based Claussen-Simon Foundation awarded him the prize for best mentorship of Ph.D. candidates ("Doktorvater"), and in 2016, he won the "Hamburger Lehrpreis" for innovative teaching on recommendation of his students.

Finally, Cornelius' contributions are not limited to the academic world. He is a valued member of the civil society in Germany and abroad contributing to the betterment of the society. He is an Ambassador of *Steps for Children*, a non-governmental organization (NGO) that helps destitute children in Namibia and Zimbabwe. He has been awarded the medal "Honorary Cross" as well as the title of the "Honorary Knight" of the Order of St. John in recognition of his precious and valuable service to the society.

The sections above have demonstrated the outstanding position of Cornelius Herstatt in the international scientific community as well as in society. It has been a pleasure and an honor for both of us to initiate and realize the idea of this festschrift to mark the occasion of Cornelius' 60^{th} birthday. For us, Cornelius is a very special person both as an academic mentor and as a dear friend. We are delighted and grateful to have been a fellow traveler with him and we look forward to continue this rewarding journey with him in the diverse realms.

Rajnish Tiwari and Stephan Buse

Hamburg, June 2019

About the Editors and Authors

Editors

Dr. Rajnish Tiwari is Senior Research Fellow at the Institute for Technology and Innovation Management of Hamburg University of Technology, where he leads the research program "Global Innovation". Mobile Commerce, digital transformation and intercultural management are his other areas of interest. He is also a co-founder and member of the Board of Management of the Center for Frugal Innovation. Rajnish advised Germany's Federal Ministry for Education and Research (BMBF) concerning "new global innovation pathways". He has led projects to investigate potentials of "affordable excellence" in both emerging and industrialized economies, including India, Germany, Austria and Japan. Rajnish is an alumnus of the Japan Society for Promotion of Science and has been a visiting fellow at universities in Australia, India, Japan and the USA. Besides heading the Hamburg chapter of the German-Indian Round Table (GIRT) since 2010, he has also served on the advisory board of the German-Indian Society.

Dr. Stephan Buse is Deputy Director of the Institute for Technology and Innovation Management (TIM) at Hamburg University of Technology. Prior to that, he worked at the Chair of International Management at Hamburg University, which he provisionally headed between 2000 and 2005. At TIM, Dr. Buse co-leads the research programs "Global Innovation" and "Mobile Commerce". In addition, he has been the program-coordinator of the international Joint-Master Program "Global Technology and Innovation Management & Entrepreneurship (G-TIME)" which he also co-founded. His main research and teaching activities are in the fields of "Global Innovation Management" and "International Business Strategy", particularly questions regarding internationalization and the international division of labor. Furthermore, he is a co-founder and member of the management team of the Center for Frugal Innovation at TIM.

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Contents

Introduction

Key Issues in Managing Innovation in a Global and Digital World
An Introduction to the Festschrift in Honor of Cornelius Herstatt

Rajnish Tiwari and Stephan Buse

> "I think that you will all agree that we are living in most interesting times. (Hear, hear.) I never remember myself a time in which our history was so full, in which day by day brought us new objects of interest, and, let me say also, new objects for anxiety. (Hear, hear.)"

The quote above, attributed to a speech by British statesman Joseph Chamberlain delivered in 1898, seems to be as true today, more than 120 years after it was expressed, as probably at the turn of the 20th Century. The quote conveys "connotations of opportunity, excitement, anxiety, and danger" simultaneously (Chamberlain, 1898). These connotations are probably even more relevant today than they were back then, as discussed in the following.

Globalization of Technology and Innovation

The technological revolution of the previous 20-25 years, especially the one brought about by the Internet and other telecommunication technologies, has led to the creation of general purpose technologies (GPTs) that facilitate high quality, easy-to-use and cost-effective solutions (Teece, 2018). The ensuing "democratization of innovation" has led millions of individuals across the world to turn into innovators (von Hippel, 2005). The availability of vastly affordable communication at high bandwidth – in conjunction with globalization – has set free innovational and entrepreneurial spirit that was never possible before in the memory of the humanity. As a result, innumerable context-specific solutions are being developed in response to unmet needs of people leading to a host of new products, services, process technologies, and business models that can be offered via digital platforms to potential users and customers around the world (von Hippel, 2017; Teece, 2018). Large multi-national corporations (MNCs), small and medium-sized enterprises (SMEs), start-ups, academic and research institutions, governmental bodies, non-profit organizations, and individual innovators, around the globe can cooperate with each other, learn from each other, and co-develop solutions. Not surprisingly, the world, as we know it today, is a transformed place even in comparison to past 2 decades, and the transformation process is still underway.

The disruptive change brought about by the joint forces of technology and globalization have effected nothing less than an upheaval to the established economic order at micro and macro levels, affecting firms, industry sectors, and national economies alike. For example, five leading industrial economies (USA, Japan, Germany, Spain and France) had a cumulative share of nearly 60% in the global automotive production at the turn of the millennium in 2000, while the cumulative share of three leading emerging economies (Brazil, China and India) stood then at below 8%. By the end of 2018, the three emerging economies had clearly overtaken the group of industrial economies (see Figure 1 on next page).

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R. Tiwari and S. Buse (eds.), *Managing Innovation in a Global and Digital World*, https://doi.org/10.1007/978-3-658-27241-8_1

Moreover, the unsaturated markets in the developing and emerging market economies, including but certainly not limited to China and India, are turning into engines of growth and the relative share of the industrialized economies in the global economic output is continuously on the decrease (see, IMF, 2019). Apart from the increasing market attractiveness of the developing and emerging market economies, many countries of the Global South have accumulated significant technological capabilities necessary for innovation (Gerybadze and Merk, 2014). China, for example, has emerged as a very significant player in the field of research and development (R&D): in 2018, 21.8% of the global R&D spend was expected to take place in China, behind the USA (25.3%) and ahead of the cumulative share of 34 European countries (20.5%), as per R&D Global Funding Forecast for 2018 (R&D Magazine, 2018). India's share in global R&D expenditure was expected to stand at 3.8%, slowly inching closer to that of South Korea (4%) and Germany (5.3%), having overtaken all other industrial nations including France and the United Kingdom (R&D Magazine, 2018).

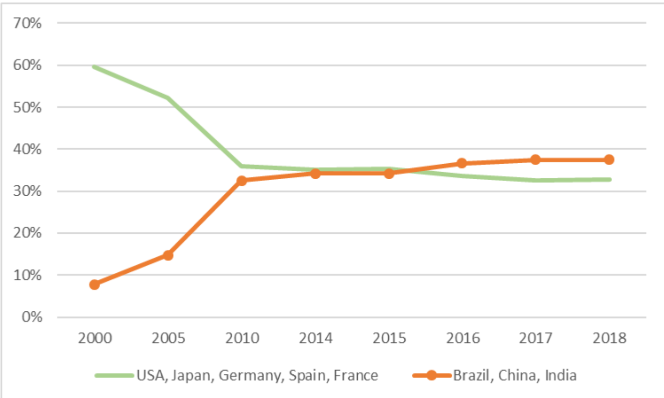

Figure 1: Share of selected countries in global automobile production, 2000-2018

Source: authors' illustration based on Statista (2019)

Establishment of production and R&D facilities as part of offshoring strategies by Western MNCs has also been as much a supporting factor for the advancement of technological capabilities in the emerging economies, as the global foreign direct investment inflows and outflows that have allowed the creation of open global innovation networks (Buse *et al*, 2010; Tiwari and Herstatt, 2012b). Global stock of inward FDI has increased five-times between 1998 and 2017, growing from $5.9 trillion to $31.5 trillion, as per data by the United Nations Conference on Trade and Development (UNCTAD, 2019). The data show that the growth in the inward FDI stock has been most prolific in the developing and transition economies, where the stock grew over nine-folds from $1.2 trillion to $11.2 trillion in this period, increasing the share of the developing and transition economies from 21% to 36% in the total stock.

Technological strength combined with market attractiveness has turned emerging economies like China and India into lead markets for certain products and technologies, even though merely 20 years ago, these nations would have hardly been considered as avant-garde of innovations (Gerybadze and Reger, 1999; Herstatt and Tiwari, 2017). Today, China is often seen as a lead market for products related to electronic mobility ("e-mobility"), the battery technology, and for solar energy, to cite but a few examples (EFI, 2012; Quitzow, 2015). India has emerged as a lead market for a broad category of frugal products and services that provide "affordable excellence", cutting across industries. Most notable examples include the small-car segment and healthcare (Tiwari and Herstatt, 2014; Ramdorai and Herstatt, 2015).

Catering to the needs of emerging markets often requires development of products and services that are responsive to the specific local needs rooted in socio-cultural, economic and geographic peculiarities. This often requires MNCs to engage in innovation activities in their target (lead) markets, giving rise to a host of organizational and mind-set issues. Furthermore, recent research has shown an emerging constituency for frugal products and services in the industrial economies (Radjou and Prabhu, 2015; Kroll *et al*, 2016; Tiwari *et al*, 2018). Factors driving this demand include the wish for voluntary simplicity and moderation in life, environmental concerns, ageing-related complications, and in some cases financial constraints. The demand for simpler and more affordable solutions in industrial economies is also giving rise to the phenomenon of "reverse innovation", which indicates that products and services developed in the Global South are being demanded in the economically developed Global North (Govindarajan and Trimble, 2012), which has traditionally been seen as the fountainhead of innovations (Vernon, 1966).

Globalization of innovation is giving rise to a host of new challenges: the question of ecological and societal sustainability being just one of them. Companies have to find mechanisms to operate in open global innovation networks to reduce market and technology uncertainty and create affordable excellence. The finite nature of natural resources, an increasing competition for skilled workers ("war for talent"), and the digital workplace are opening up new challenges for management of technology and innovation.

Chances and Challenges of Digital Transformation

The extent of the opportunities, challenges and disruption brought about by digitalization can seen in the fact that six of the world's largest companies by market value in 2018 represented the digital economy. Apple, Amazon.com, Alphabet (mother concern of Google), Microsoft, Facebook and Alibaba, together accounted for market value worth \$4.3 trillion (Statista, 2018), which was higher than the gross domestic product (GDP) of Europe's largest economy, Germany (\$4 trillion) or nearly comparable to the combined GDP of India (\$2.7 trillion) and Brazil (\$1.9 trillion) in 2018 (IMF, 2019). This feat is even more remarkable, when one considers that companies such as Google (founded 1998), Alibaba (founded 1999) or Facebook (founded 2004) are not even a quarter-century old and have overtaken many a large established company. Their disruptive business models often revolve around immaterial, non-physical goods and services offered to their customers practically free of charge or for a very little price.

Figure 2 shows some core drivers of digital transformation: The prevalence of mobile telecommunication technologies is unprecedented in the recent history. While in 1998, only 318 million mobile phone connections existed in the world, accounting theoretically for 5.3% of the world population at that time, this number has almost exploded: leading to more than 7.7

billion connections in 2017, theoretically accounting for 103.4% of the world population as per data by International Telecommunications Union.

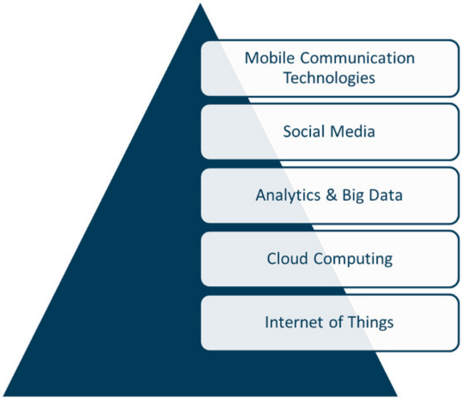

Figure 2: Drivers of digital transformation

Source: authors' illustration based on Chalons and Dufft (2017: 14 pp.)

The wide-spread usage of mobile telecommunication technologies has opened new possibilities for generation and monitoring of real-time data, especially at, but not limited to, social media platforms. Advancements in informatics allow analysis of large volumes of data, while cloud computing has reduced the need for physical infrastructure and opened new possibilities to share and secure data. Finally, Internet of Things (IoT) and Industry 4.0 are leading to process optimization, resource efficiency and cost-effective smart solutions.

As with globalization of technology and innovation, digital transformation also comes with its disruptive effects. Management of technology and innovation has to find new ways for dealing with issues related to business models based on "zero tariffs", private provisioning of quasi-public goods, revenues models, complementarity of assets, digital ecosystems, platform solutions and their relevance for competition and anti-trust regulations, as well as in terms of path dependencies to name but a few (Farrell *et al*, 2018; Haddud *et al*, 2018; Teece, 2018). Furthermore, issues related to cybersecurity and data protection and privacy are set to dominate research agenda cutting across disciplines, and necessitating transdisciplinary research involving engineering, social and behavioral sciences, law etc.

The sixtieth birthday of Prof. Dr. Cornelius Herstatt, a leading thought-leader in the field of technology and innovation management who has actively influenced and co-shaped the scholarly discourse for over two decades continuously, has offered us a welcome occasion and the perfect "excuse" to bring together some of the most extraordinary personalities and leading experts from our field to deliberate upon some of the key research issues identified above. It is with great pleasure and honor that we present the insights and research of 40 authors in 22 chapters within the framework of this contributed volume. An overview of the contributions is presented in the next section.

Overview of Contributions

The broad areas of contribution for this edited volume have emerged from the research interest and preoccupations of Prof. Cornelius Herstatt. Many of his works have focused upon management of technology and innovation. Especially the management of innovation process and its fuzzy front-end has attracted his attention (Herstatt and Verworn, 2004; Herstatt, Stockstrom, Verworn, *et al*, 2006; Herstatt and Verworn, 2007), where he has also concentrated on the use of innovative analogies in product development (Herstatt and Kalogerakis, 2005; Kalogerakis *et al*, 2010). Another core area of his research that has accompanied his research journey all along is the field of open and user innovation (Herstatt and von Hippel, 1992; Braun and Herstatt, 2007; Raasch *et al*, 2013). Since late 2005, the increasing trend of global innovation and technology convergence caught his attention and led to initiation of certain projects in the field of internationalization of R&D, lead markets and frugal innovation (Herstatt, Stockstrom, Tschirky, *et al*, 2006; Tiwari *et al*, 2008; Buse *et al*, 2010; Tiwari and Herstatt, 2012a). Increasingly, this stream has connected to topics of ecological sustainability and sustainable development goals that possess a global relevance (Drabe and Herstatt, 2016). Finally, he has been involved in research that can be broadly grouped as relating to innovation ecosystems, e.g. by including digital platforms and intellectual property right (IPR) regimes (Goeldner and Herstatt, 2016). These four broad groups of research streams have been consolidated in four parts for this contributed volumes, and altogether 22 chapters by renowned thought-leaders, colleagues and students having association with Cornelius Herstatt, showcase current developments in these areas, as described below:

Part I of the contributed volume deals with the "**Developments in Technology and Innovation Management**" and contains six chapters.

The first chapter of this contributed volume is titled "*Bringing technology to the boardroom: What does it mean?*" and is written by **Hugo Tschirky**. Arguing that management of technology is a task that warrants high priority attention of top management, he suggests that the "presence of technology in the boardroom" reflects a top management process and business decisions require an informed mindfulness of the fundamental opportunities and risks associated with technological change. Relevant questions concerning company policy, the technology competence within top management, the corporate culture etc. need to be raised and answered by top management. The contribution especially highlights the importance of "the inflow of relevant business (technology) information, the completeness of strategic business planning with respect to technology and innovation issues, and the implementation of management instruments which integrate the technology aspects of all major enterprise functions."

The second chapter of the contributed volume deals with the "*Challenges of maintaining innovativeness in organizations under business model transformation and digitalization*". Its author, **Tom Sommerlatte**, calls on companies and other societal stakeholders to respond more proactively to the big current transformation challenges such as, the shift to renewable energies, e-mobility, intelligent urban and organizational infrastructures, or smart homes. He argues that mastering the transformational challenges demands "significantly new and disruptive products and services that are based on out-of-the-box thinking about applications, new ways of value creation and market penetration, by using advanced technologies and knowledge for timely arousing and meeting latent demands". The contribution calls for a new leadership style and a new innovation culture to overcome the company-internal and external barriers to innovation and stem the transformations which society and business are set to undergo.

Chapter 3 concerns "*Digital technologies, competitiveness & policies: An integrative city-based policy roadmap for entrepreneurial ecosystems*" and is written by **Dilek Cetindamar, Thorsten Lammers** and **Nathalie Sick**. This paper offers a conceptual, city-based policy roadmap for policy makers for managing entrepreneurial ecosystems. The authors address the research gap of specific policies bringing together both technological developments and entrepreneurial activities at city level. The authors argue that policy makers should identify feasible frameworks to support a digitally competitive entrepreneurial ecosystem, given the wide opportunities arising from digital technologies.

The next contribution (Chapter 4) is about business model innovations and written in German (title: "*Entwicklung von Geschäftsmodell-Innovationen*". The author **Christian Müller-Roterberg** argues that the importance of business model innovations has become increasingly apparent in research and practice in recent years. He discusses whether the development of business model innovations follows the same established process as product innovations or whether a modified innovation process is required for business models. The paper aims to provide support for the practice to show promising steps and methods regarding the development of business model innovations.

In chapter 5, **Monika Petraite** investigates the theme of "*Developing Innovation Culture in the Baltics: Organizational Challenges in a Time of Transition*". An innovative corporate culture is seen as a critical success factor for the competitiveness of organizations. With an empirical research design, the author focuses on the understanding of innovation culture formation within business organizations in Lithuania and provides recommendations for action in designing innovative organizations and developing innovation cultures in transition economies in the Baltics.

The sixth and final chapter of Part I is titled "*Caught in inaction?!? How do companies respond (or not) to the business implications of demographic change*", and is contributed by **Florian Kohlbacher**. The author argues that many companies currently fail to make the transition from recognition to exploitation of business opportunities arising from demographic change. He suggests that managers should pro-actively look for innovation opportunities enabled by demographic change.

Part II deals with the **"Developments in Open and User Innovation"** and contains six contributions.

This part begins with a contribution by **Christopher Lettl** (Chapter 7), who takes a closer look at "*Lead users and the organization*". Considering that lead user research has branched out into many different research streams, he takes an organizational view and differentiates three perspectives, i.e. lead users as external creators of ideas for focal firms, lead users as creators of organizations, and lead users as internal creators of ideas for focal firms. He elaborates on opportunities for further research in each of these perspectives.

"*When patients become innovators*" (Chapter 8) by **Harold Demonaco, Pedro Oliveira, Andrew Torrance, Christiana von Hippel**, and **Eric von Hippel** addresses the phenomenon of patients who "are increasingly able to conceive and develop sophisticated medical devices and services to meet their own needs - often without any help from companies that produce or sell medical products". The authors argue that patient innovation can also provide benefits to companies that produce and sell medical devices and services. They look at two examples of free innovation in the medical field - one for managing type 1 diabetes and the other for managing Crohn's disease. The cases are set within the context of the broader "free innovation movement".

Chapter 9 is concerned with "*Communities of practice as collective lead users*" and is authored by **Hans Koller, Benjamin Schulte, Florian Andresen**, and **André Kreutzmann**. Due to rapid technological changes and high-velocity of markets, many organizations face a challenge in creating "truly novel products and services that can secure sustainable competitive advantage". The authors argue that many organizations lack the ability to break from their own treaded pathways. Elaborating on the collective side of lead users, they propose "that intra-firm communities of practice as social entities can display similar lead user characteristics although no single individual member possess all criteria commonly associated with lead-userness". The conceptual deliberations in this paper are based on the conjunction of the concepts of lead users and communities of practice, which are supported by case studies in the context of the German Federal Armed Forces.

In chapter 10, **Christian Lüthje** investigates "*The role of retailers as generators and mediators of new product ideas*". He addresses the research gap on the role of retailers as a source of innovation in the scholarly discourse on open and user innovation. The author studies "the activities of retailer employees to develop own ideas for product innovations (retailer as innovator) and explores the retailers' efforts to obtain new product ideas from their customers (retailer as gatekeeper)". His empirical findings suggest that product manufacturers can benefit from cooperation with appropriate retailers in new product development.

Chapter 11 deals with the dilemmas faced by stakeholders of the sharing economy. In a contribution titled "*To share or not to share – Exploring how sharing behavior impacts user innovation*", **Frank Tietze, Thorsten Pieper**, and **Carsten Schultz** conceptually and empirically explore the impact of users' product sharing behavior on user innovation. They propose a new concept labelled "sharing experience" and how it can be operationalized based on the use experience construct. Furthermore, they offer a typology to categorize four user groups based on their sharing activity and conduct an empirical analysis to explore the impact of sharing experience on user innovativeness. Their "results indicate that users' sharing experience is positively associated with user innovativeness in certain situations and that users' technical expertise appears to positively moderate this relationship".

In the final chapter of Part II, **Tim Schweisfurth, Christoph Stockstrom**, and **Christina Raasch** investigate "*Individuals' knowledge and their explorative and exploitative behaviors*" (Chapter 12). They take a knowledge-based perspective to understand employees' explorative and exploitative behaviors and conceptualize knowledge-based precursors to these behaviors along two dimensions, level of existing knowledge vs. absorptive capacity, and need vs. solution knowledge. This focus helps them to address some significant gaps in the ambidexterity research. Supported by a quantitative study, they propose "that existing knowledge will relate positively to exploitative behavior, and that absorptive capacity for new knowledge from outside will relate positively to explorative behavior".

Part III deals with the **"Developments in Global and Sustainable Innovation Management"** and contains six chapters.

Alexander Gerybadze investigates "*Technology and innovation management in a global perspective*" in chapter 13. The author studies major trends and structural changes related to technology and innovation management (TIM) since the mid-1990s. He argues that TIM was traditionally characterized by an emphasis on R&D, technology-push, home-country bias as well as by a lead-countries bias, while technological parochialism dominated the thinking about global innovation. Until about 2005, innovation remained centered in large multinational corporations from a small group of advanced nations, and concentrated most of their R&D investments in a small group of target countries. This pattern has somewhat changed during the last fifteen years, and particularly during the last decade. The footprint of innovation activities has become much more global and diversified. An increasing number of countries have followed ambitious innovation strategies. He emphasizes that "our concepts of managing innovation had to be refined: towards more open, more user-oriented and more boundary-spanning concepts". Today there is a persistent increase in the globalization of the R&D function and a greater diversity of target countries for new R&D locations. Furthermore, he predicts that the globalization of R&D is likely to continue in the next decade predict future courses despite growing political instability. Prof. Gerybadze, a former member of the German Federal Government's Expert Commission for Research and Innovation, recommends that long-term megatrends like climate change, urbanization and new mobility be addressed from a global perspective, and the appropriate technological and social solutions be developed and implemented in many countries simultaneously. In this context, he underscores the growing relevance of the emerging market economies like China, India, Indonesia or Brazil as lead markets or innovation hubs. Adding a word of caution, he raises the question whether catch-up nations will be able to "grow beyond the so-called middle-income trap and whether these countries can implement a sustainable growth path".

Chapter 14 concerns "*Communication and Knowledge Flows in Transnational R&D Projects*" and is authored by **Maximilian Joachim von Zedtwitz**. He stresses that sharing knowledge efficiently can be difficult even in highly networked organizations because knowledge flows can be hindered by different factors such as, spatial distance, costs, and lack of trust. The author analyzes knowledge transfer, communication quality, and coordination in transnational R&D projects in industrial companies. Based on a cross-case comparison along these three dimensions, he proposes inter-, intra- and multi-local aspects of managing virtual R&D teams globally.

Chapter 15 is titled "*What enables frugal innovation? An examination of innovation pathways in India's auto component industry*". In this contribution, **Rajnish Tiwari** and **Katharina Kalogerakis** analyze if emerging economy firms can succeed with frugal products and services in the long run and what innovation pathways they take. They examine innovation capabilities in India's auto component sector, which has acted as a key enabler of frugal, extremely cost-effective solutions in the vehicle industry. Findings are that successful firms often engage in open innovation to reduce development costs. Leapfrogging to latest technologies allows them to engage in process innovations, leading to light-weighting of components and significant reduction in waste. The study proposes frugal innovation pathways that make use of collaborative development, avoid over-engineering and are often driven by economies of scale.

The next chapter continues the endeavor with frugal innovations by examining the determinants of consumer behavior in case of frugal solutions. **Fumikazu Morimura, Rajnish Tiwari** and **Stephan Buse** investigate the "*Potential role of frugal innovation for diffusing energy management systems in Japan*" in chapter 16. Increasing energy consumption is associated with major negative impacts on the climate. The Japanese government has sought to promote home energy management systems (HEMS) in private households as a measure to enhance energy security in the country. Reports suggest that while potential users appreciate the need for using HEMS, the actual adoption of HEMS in the country has remained low, indicating a gap in consumer intention and its actual implementation. High upfront investment, high switching/operating costs and the perceived technological complexity are reported as inhibiting the adoption of HEMS in Japan. This chapter investigates whether and in what respects frugal innovations might help in overcoming barriers for the adoption of HEMS. Frugal solutions may enhance the consumer perception of benefits of HEMS, while reducing negative perceptions regarding high technological complexity or expensiveness.

The question of consumer acceptance is also addressed by **Dominik Walcher** and **Christoph Ihl** in chapter 17, titled "*Determinants of willingness to pay when purchasing sustainable products: a study from the shoe industry*". Manufacturing and disposal of shoes is an often under-estimated environmental problem because a regular shoe usually consists of up to thirty parts of different materials, partly treated with hazardous chemicals. As the awareness grows, an increasing number of companies are starting to produce and sell eco-friendly shoes. This paper analyzes consumer behavior in the field of eco-friendly shoes. The results indicate that factors, such as social responsibility, perceived personal relevance, lack of trust, and lack of product benefit have an impact on the willingness to pay.

Chapter 18 is titled "*Green, social and profitable - the role of front end of innovation decision making in achieving more sustainable new products*" and is authored by **Katrin Eling**. She stresses that the competitive pressure on organizations to develop more sustainable new products is constantly on the rise due to globalization. Regulatory requirements and customer-induced demand are forcing companies to develop more sustainable products and services. The author argues that allowing employees to take action in this regard may increase their motivation and productivity and might attract high potentials to the organization. This chapter provides an overview of the opportunities available in the front-end of innovation.

Part IV of this contributed volume deals with the "**Developments in Innovation Ecosystems**" and contains four chapters.

This part begins with a contribution by **Elisabeth Eppinger** and **Daniel Ehls,** who propose "*A framework for analyzing technology ecosystems – adopting insight from biology*". The authors point out that "Technology Ecosystems perspective has become a preferred approach to analyze complex interactions and integrate several domains like Technology Management, Innovation Management and Strategy". At the same time, our understanding of ecosystems in management continues to remain limited. The authors adopt insights from biology where a far more detailed taxonomy for studying ecosystems can be found. The paper links the management ecosystem perspective and behavioral ecosystems with the purpose of disentangling "the relationships among different ecosystem layers, actors, and technologies". The authors develop "an instrument to advance management research and structure future research on sustainable technology adoption and diffusion". Furthermore, they "provide a taxonomy that differentiates dynamic, co-evolving technologies in co-evolving industry ecosystems".

In the next chapter of this part (Chapter 20), **Masaharu Tsujimoto** looks at "*Network externality vs. multi-layer platform link effect: A case analysis of 'FeliCa' based electric money platform ecosystems in Japan*". This paper focuses on FeliCa, an integrated circuit-based technology solution developed by Sony in 1996, and FeliCa-based Electric Money platform ecosystems. Previous research has emphasized the role of network externality as a critical success factor for platform ecosystems. Based on a multi-case analysis from Japan the author shows that successful platform leaders have not tried to expand the installed base of the new platform. They rather prefer to link the new platform solution with their existing platforms ensuring compatibility and offering virtual service programs. The author found that at the emerging stage of the platform ecosystem the effect of network externality is weaker than the link effect of multi-layer platforms.

Chapter 21 by **Frank Tietze** and **Ove Granstrand** is titled "*Enabling the digital economy - distributed ledger technologies for automating IP licensing payments*". The authors underscore that developing innovations for the digital economy, such as Internet of Things (IoT) devices and connected mobility solutions would probably require original equipment manufacturers (OEMs) to combine intellectual property (IP) from multiple sources (licensors). Due to the complexity involved, efficiently operating licensing payments to/from multiple licensors/licensees becomes increasingly mission-critical in the "pro-licensing era". The semi-manual processes, currently in use, are fraught with "information asymmetries, uncertainties, trust problems and transaction costs". The authors discuss the challenges faced by licensees and licensors and propose "a system based on distributed ledger technologies and smart contracts for automating trustworthy licensing payments that can substantially reduce currently existing challenges".

The final chapter of part IV and the contributed volume (Chapter 22) is authored by **Bharat Verma, Rita Snodgrass, Bill Henry, Buck Smith**, and **Tugrul Daim**. Their contribution with the title "*Smart cities - an analysis of smart transportation management*" contains a Social, Technological, Economic, Environmental and Political (STEEP) analysis of the benefits and risks of smart city innovations. The authors undertake an assessment of seven mid-sized US cities implementing different programs and compare the different approaches to implementation. The research indicates the role of governance structure as a critical success factor: "Cities with a strong mayor's office and a top-down governance found it more difficult to carry through with these programs, but cities run by strong city councils have a bottom up governance that is best suited for smart city innovations".

The festschrift concludes with a list of publications by Prof. Cornelius Herstatt.

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Part I

Developments in Technology and Innovation Management

Chapter 1

Bringing technology to the boardroom: What does it mean?

Hugo Tschirky

Abstract

The presence of technology in the boardroom reflects a top management process in which business decisions are taken with an awareness of the fundamental opportunities and risks associated with technological change. To comply with this responsibility, relevant questions need to be raised and answered within top management. These typically cover the quality of company policy, the availability of technology competence within top management, the nature of company culture, the inflow of relevant business (technology) information, the completeness of strategic business planning with respect to technology and innovation issues, and the implementation of management instruments that integrate the technology aspects of all major enterprise functions.

Keywords: Technology Management; Technological Change; Technology Competence; Strategic Business Planning; Integrated Technology Strategies

1 Understanding technology as an ordinary unit of general management

It is common to consider money as a basic unit of management. Cost, expenditure, assets, investments and finally bottom lines are expressed in Dollars, Pounds, Roubles and now in Euros. Time is another such unit. Working and operation times are measured in hours, project completion times are planned in months and sometimes strategic planning horizons are depicted in years. Technologies are de facto similarly manageable entities. Technology constitutes specific knowledge, abilities, methods and equipment, facilitating deployment of scientific and engineering knowledge.

In order to remain competitive, companies are mastering a countable number of technologies with four purposes: they enable researchers and engineers to develop new products and services, they allow products to perform specific functions, they serve manufacturing to produce products and finally they enable companies to operate their administrative processes and infrastructure. *Product technologies* on the one hand deploy scientific or engineering principles, e.g. from optics, electronics, nuclear physics, aerodynamics, etc. dealing with a specific effect and determine how an effect occurs. This effect allows the fulfillment of a specific product function, e.g. "detect fire" which - from the point of view of the market - is oriented towards expected customer needs, e.g. "protection from fire damage", as outlined in Figure 1. Product technologies that can fulfill this product function are for example light scattering, ionization or temperature technologies.

R&D faces the challenging task of making a reasoned choice between various technologies - both current and to be developed - representing variables in order to realize product functions.

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R. Tiwari and S. Buse (eds.), *Managing Innovation in a Global and Digital World*, https://doi.org/10.1007/978-3-658-27241-8_2

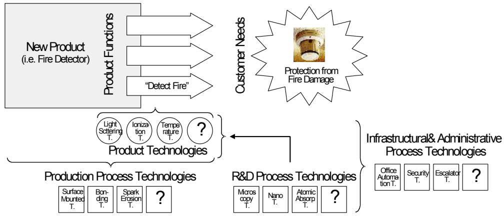


Figure 1: Product and process technologies constituting product creation
(Example: Development of fire detection sensor device) (Tschirky 1998: 228)

Process technologies on the other hand deploy the *effects* of an existing product technology. R&D process technologies are used for performing R&D activities and may include technologies such as microscopy, nano and atomic absorption technology. Typical production process technologies include casting, milling, galvanizing, soldering and surface mounted technology (SMT). They also consist of logistics and quality assurance technologies. Administrative process technologies usually comprise office automation technologies and, finally, infrastructural process technologies typically may comprise security, elevator, escalator and air conditioning technologies.

The above refers to an understanding of technology in the *limited domain* of product and market. As technological change permeates many social and economic domains, a further-reaching, *holistic* understanding of technology must also be developed. This extends beyond the domain of product and market and encompasses higher concepts of technology progress, quality of life and the social efficacy of technology.

2 How does technology management relate to general management?

With the vision that technology management should be part of general management, an immediate question comes up: what is an appropriate framework of general management to constitute a meaningful shell for technology management issues? When attempting to answer this question, it becomes obvious that the number of available frameworks is limited. Among them, the concepts of "Potential and Process Approach to the Enterprise" and "Integrated Management" appear to be best suited to the purposes:

With respect to concepts of *enterprise management* it is widely accepted that considering tasks on the *strategic* and subsequently on the *operational level* is indispensable to general management. For the management of the technology enterprise, however, a restriction to these two levels is not satisfactory since factors beyond strategy play an important role. Primary among these are company policy, company culture and original enterprise structures. This deficiency is taken into account in so-called "Integrated Management" concepts (Ulrich 1984, Bleicher 1991), in which the strategic and operational levels are grouped under a higher *policy level* of management[1] (Figure 2).

[1] In the original literature (Ulrich 1984, Bleicher 1991) this top level management is referred to in German "normative". A literal translation into English would lead to "normative". Since this translation may lead to confusion, the term "policy level" is used instead.

Firstly, on the *policy* level, primary decisions must be made according to the long-term goals of the enterprise. This requires the development of a consistent *company policy*. At the same time an awareness of the culture permeating the company is essential. Company culture includes the values held collectively by its employees, which is expressed, for example, in how employees identify with company goals and in the company´s behavior towards the environment, and manifest themselves in the company´s ability to change and innovate. On the normative level it is not only the *making* of long-term decisions which is vital for the company's future. Just as essential is *who makes these decisions*. This question involves the upper decision-making structures of the company. The far-reaching nature of technology decisions requires that technology expertise be applied to the decision-making process from the outset. The guiding principle for the normative level is the *principle of meaningfulness*.

Figure 2: Three levels constituting general management (Ulrich 1984: 329)

On the *strategic level* it is essential that company policy is transposed into comprehensible strategies. Strategies lay emphasis on the selection of those technologies necessary for the development and production of present and future products and services. In particular, decisions are made as to whether these technologies will be developed in-house or in conjunction with other firms, or whether they will be purchased completely from other companies. Relevant trends in strategic technology management indicate that strategic alliances, process management and innovative and innovation-boosting structures are taking on increasing significance, as is technology scanning and monitoring, i.e. the comprehensive and systematic collection and accumulation of information concerning existing and developing technologies. This "early warning function" is often referred to as *technology intelligence,* which is part of an overall business intelligence system. A further focus involves concepts of socio-technical systems design which postulate the quality of work-oriented deployment of technology *and* work. On the strategic level the *principle of efficacy* - meaning "doing the right things" - is prime.

Finally, on the *operational level* of management, responsibility is taken for transforming strategies into practice in the context of short-term goals. Operational management expresses itself, for example, in concrete R&D projects in which the necessary personnel, financial and instrumental resources are deployed according to a plan. Here the pointer is "doing things right", implying accordingly the *principle of efficiency*.

According to this view technology management can be conceived as an integrated function of general management which is focused on the design, direction and development of the technology and innovation potential and directed towards the policy, strategic and operational objectives of an enterprise.

This concept of technology and innovation management will be exemplified now in detail.

3 Technology and innovation management as an integrated part of general management - practical examples

3.1 Example 1: Expressing technology and innovation values in visions, policies and mission statements (policy level)

The longest-term decisions taken by company management are expressed in documents like *company vision, company policy, and mission statements*. As a rule, these kinds of statements are generalized which nevertheless aims at verbalizing the company's uniqueness. The content usually covers long-term objectives, main areas of activities, geographical dimensions of businesses, major resources and competencies, innovative ambitions, the desired relationship with customers, attitude towards societal and ecological expectations, the role and development of human capital and the values that determine communication and collaboration.

For companies relying on technology it is necessary to stress this dependence within such normative statements, because they represent strong signals inside and outside the company. In particular, in times of increasingly flattened hierarchies, such signals are gaining importance as guiding ties around decentralized responsibilities and competencies.

The following examples in Figure 3 illustrate normative statements that mirror the technology dependence of companies.

Compaq's Vision

Inspiration Technology
As an industry we talk a lot about speeds and feeds, and that's fine. Performance matters. But the real power of technology is not the machine; it's in the inspiration. The web was not a product of technology. It was one part technology and three part inspiration. The decoding of the human genome was less a technological achievement than a human inspired achievement, enabled by technology. At Compaq we look at it this way: People enabled by great technology can achieve great things.

Michael Capellas CEO, Compaq

President's Message

We are used to seeing technological development as a help to improve our standards of living.

Today, we are increasingly alert to their impact as to sustainability, efficient use of energy and environmental protection - for all our tomorrows.

We in ABB - as leaders in several key industrial areas - are at the very center of these challenges.

With our leadership role comes the responsibility to secure real and practical innovations.

Every year we invest a significant amount of our resources in research and development (R&D) in order to ensure that we remain a leader in our industry.

Our aim: to sustain growth and profitability through meaningful innovation.

That is the thought behind our ABB group slogan "Ingenuity at Work".

Göran Lindal
President and Chief Executive Officer, ABB

Figure 3: Examples of normative statements of technology-based companies

3.2 Example 2: Taking into account the vital link between technology & innovation strategy and company culture (policy level)

The uniqueness of each enterprise is primarily defined by its *organizational culture*. Understanding the organizational culture is an indispensable prerequisite for successful leadership of an enterprise under rapidly changing environmental conditions. Only cultural characteristics can ultimately explain why a new strategy has been implemented satisfactorily or not. In other words: Working on a new strategy must aim at reaching a “cultural fit“, i.e. correspondence has to exist between the behavioural pattern under which a strategy can be implemented effectively and the given culture determining current enterprise behaviour. Achieving such a cultural fit can mean intentionally changing the organizational culture as a proactive alternative to adapting a strategy to a given culture. This has been the case, for example, at ABB after the merger between BBC and ASEA (Figure 4):

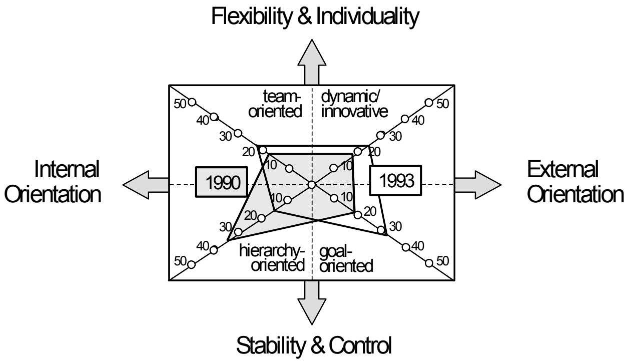


Figure 4: Examples of normative statements of technology-based companies (Meyer 1994: 47)

After the merger on 5th January 1988, ABB was challenged by enormous managerial problems. These included the organizational integration of companies in more than 50 countries, the creation of 3500 profit centers, the execution of programs to increase productivity, to realize numerous strategic alliances, and to maintain a high level of innovation capability despite cost reductions.

The main challenge consisted of implementing the new decentralization strategy "think global - act local". These fundamental changes were accompanied by investigations to determine the extent to which the company culture is responding to these changes. To this end a concept of company culture was developed as shown in Figure 4. Two main dimensions of cultural orientation were identified, which are internal orientation vs. external orientation and stability/control vs. flexibility/individuality. The results of the study are interesting: whereas in 1990 the company culture had a focus on internal orientation and stability/control, a distinct shift towards external orientation and flexibility/individuality could be observed in 1993.

3.3 Example 3: Equipping top management decision bodies with technology competence (policy level)

As a consequence of technology change and its inherent - often existential - opportunity and risk potential, a well balanced representation of technological and non-technological competences to make business decisions is required. In this context, the composition of the board of directors and the top management group is of primary importance. For example, this criterion is key to corporate governance at Intel (Figure 5 left).

A frequently chosen solution is to nominate a Chief Technology Officer (CTO) as a member of the top management group. According to a study completed by Roberts from MIT in 1999, this solution is realized in 95% of Japanese companies, the corresponding figures for Europe and the US are 32% and 8% respectively (Figure 5 right).

> INTEL CORPORATION BOARD OF DIRECTORS GUIDELINES ON SIGNIFICANT CORPORATE GOVERNANCE ISSUES
>
> 5. Board Membership Criteria
> The Nominating Committee is responsible for reviewing with the Board from time to time the appropriate skills and characteristics required of Board members in the context of the current make-up of the Board. This assessment should include issues of diversity, age, skills such as understanding of manufacturing, technology, finance and marketing, and international background - all in the context of an assessment of the perceived needs of the Board at that point in time. Board members are expected ...

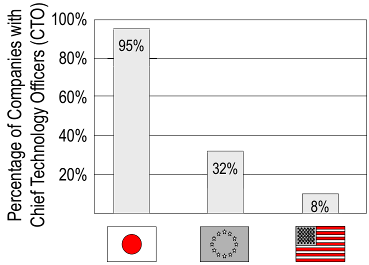


Figure 5: Competence structure of boards of directors and top management groups (Figure right: Roberts 1999: 5)

3.4 Example 4: Keeping the scope of technology strategic options wide open (strategic level)

Let's first ask the question: what are technology strategies? The answer often refers to leader or follower strategies. This may be correct but the useful content of strategies goes much further. In general, strategies are mid-term decisions on business activities and allocated or to be built-up resources. It can be useful to differentiate strategic statements from statements on "what will be reached?" (goal statements) and "how shall we reach the goals?" (path statements). This idea is expressed in Figure 6 left.

In terms of technology strategies this means that on the one side "goal statements" focus, for example, on decisions on core technologies, base technologies, support technologies and obsolete technologies. Often, decisions are taken on the level of strategic technology fields, which represent a grouping of structured technological knowledge around selected core technologies. On the other hand, "path statements" reflect decisions taken on being a leader or a follower in reaching the goals and on pursuing cooperation strategies, make or buy strategies or other selected strategies.

3.5 Example 5: Developing integrated technology strategies (strategic level)

The development of technology strategies is not an isolated activity but rather ought to occur within a joint and simultaneous collaboration between those responsible for functional and strategic business unit strategies (Figure 6 right).

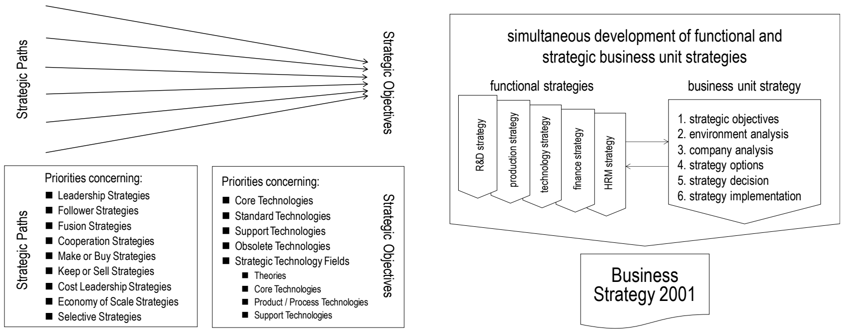


Figure 6: Content of technology strategies as a result of simultaneous development of functional and strategic business unit strategies (Tschirky 1998: 295)

The pattern of such a collaboration could, for example, consist of a stepwise and iterative integration of technology issues into the typical steps of strategic planning, such as setting strategic objectives, analyzing the environment, analyzing the company, elaborating strategic options, taking strategic decisions, implementing the strategy (Figure 7). This means, for example, when setting strategic business goals such as market shares and ROE-goals, matching strategic technology objectives such as innovation rate, quantitative quality goals (i.e. six sigma) and patent position are simultaneously set.

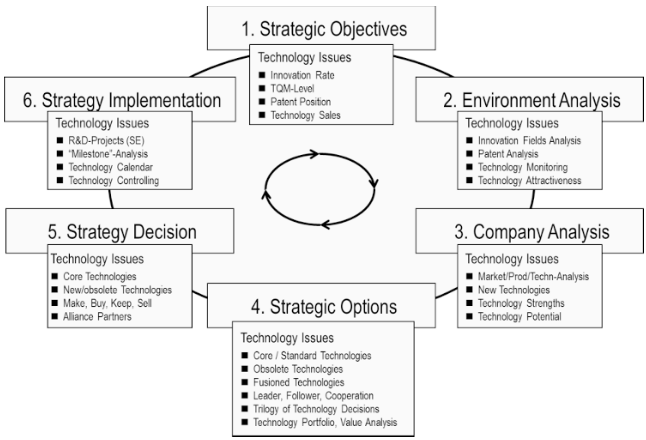


Figure 7: Integration of technology issues into strategic business planning (Tschirky 1998: 295)

In other words, pursuing such a procedure means closing “technology gaps” which are often observed in strategic business planning. These gaps are typically informational and are apparent in the following areas: technology objectives (see above), technology forecasting and assessment; technology networks relating technology and business units or relating product technologies to process technologies; market-product-technology analysis; defining technology potential; identifying the strategic technology position portfolio; specifying strategic technologies and, correspondingly technology strategies; defining technology projects consisting of R&D projects to develop product and process technologies; and, finally, the technology calendar, which represents a schedule for technology introduction.

3.6 Example 6: Analyzing carefully the current and prospective innovation rate (strategic level)

To be innovative is undisputedly a well justified recommendation for all business activities. Being innovative however is a quality which still characterizes a limited number of companies. Among them, 3M is certainly a good example. In the annual report for the year 2000, the new president W. James McNerney Jr. proudly reports that $5.6 billion or nearly 35 percent of total sales has been generated from products introduced during the past four years, with over $1.5 billion of sales coming from products introduced in 2000. A closer look at the company's management practice makes it easy to explain this impressive achievement, since above all, taking every measure to keep the company culture open and creative is obviously an outstanding leadership competence.

Becoming innovative may start with the analysis of the innovation rate, a recording of the amount of annual sales from new products. To this end, firstly, criteria for "new products" has to be established, which in the case of 3M, means market introduction over the past four years. Further steps focus on analyzing the innovation rate for the past few years and comparing the values with estimated values from competitors. Then, a decision has to be taken on how the innovation rate ought to develop in the years ahead.

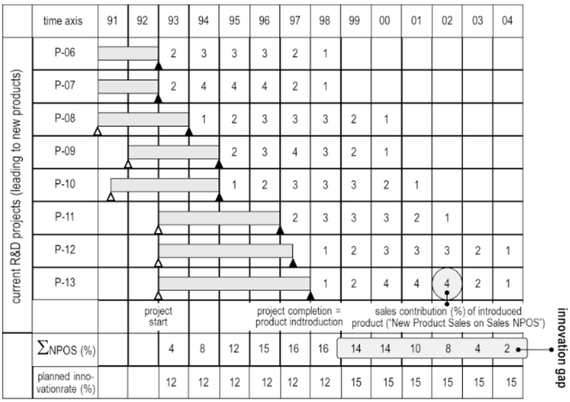


Figure 8: Analysis of the past and prospective innovation rate (Tschirky 1998: 342)

As a rule, it would be most unrealistic to assume that the long-range innovation rate will not rise. Whatever assumption is made, the natural question has to be how well the company is prepared to meet the prospective innovation requirements. It is in other words, the question on the appropriate content of the often cited "pipe line". The first answer to this question can be obtained relatively easily from the following analysis (see Figure 8):

First, using a suitable matrix, all ongoing R&D-projects are listed according to their starting and completion times. Then for all the projects, individually planned prospective sales contributions are "translated" into percentage values equaling "new product sales on sale" NPOS. Next, the NPOS values are calculated vertically for each year. Comparing these yearly values with the planned innovation rate allows a first estimate of how well the future innovation target will be met.

In the fictitious case, in (Figure 8), the company is facing a considerable innovation gap over the next few years, quantifiable in terms of percentage of sales. In this case the next steps are evident. They will have to focus on additional "innovation contributors", which may include increased buying-in of components and technologies, increasing market attractiveness of products in development, extending life cycle of existing products, setting-up research collaborations or planning additional R&D projects aimed at attractive new products.

3.7 Example 7: Optimizing technology knowledge resources: trilogy of technology decisions (strategic level)

Strategic technology planning as part of business strategy planning implies making three fundamentally different but mutually complementing decisions: The *first decision* ("Which Technologies?") originates from an extensive analysis of current and future products. In particular, key technologies that determine the product performance, and the process technologies required for product production and infrastructure. This analysis is based on so-called technology intelligence activities, which include cross-industry search of current technology, technology forecasting and technology assessment. Based on this analysis, a decision has to be made as to which of the available and yet-to-be developed technologies are required for the continuous development of the enterprise. The *second decision* ("Make or Buy?") is concerned with the question as to whether the required technologies are to be made available through acquisition, collaboration with other companies or through in-house development. The *third decision* ("Keep or Sell?") deals with whether available technologies are to be applied exclusively for company purposes or can - or even must - be made available to other companies.

These three decisions are tightly interdependent, and together, represent the "trilogy of strategic technology decisions" (see Figure 9). Having this trilogy in mind and working on the three decisions quasi-simultaneously offers various advantages. Above all, it allows productive use of information since all three decisions rely on mostly identical information concerning technology performance, technology application, technology forecasting, technology assessment, technology users, and technology providers. Then, an increased coherence of the three answers is to be expected, which certainly contributes to the quality of strategic technology planning. Finally, the trilogy concept leads to innovative structural solution. It consists of combining the buy- and sell-activities of technologies within an organizational element which can be called „Technology Intelligence Centre“. Its basic role is to improve the trilogy of strategic decisions, for example, with the establishment and operation of a company specific technology early warning system, with the actual execution of buy and sell negotiations of technologies and finally with the elaboration of proposals for technology strategy decisions. This concept, is in sharp contrast to classical company organization, where the procurement department and the marketing units are usually widely separated entities.

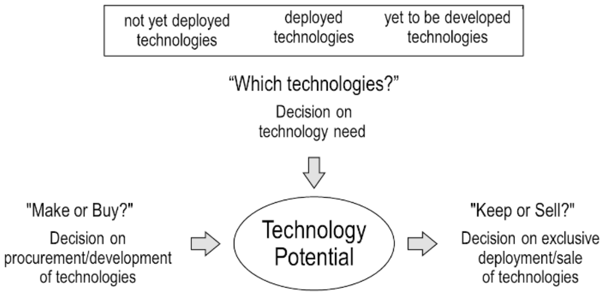


Figure 9: Trilogy of strategic technology decisions (Brodbeck et a. 1995: 108)

This so-called functional integration might manifest itself in practice as a central unit bringing together - partly temporarily and partly permanently - representatives from R&D, production, marketing and finance and carrying joint responsibility for periodic elaboration of strategic technology decisions.

Working on the trilogy concept leads to the hypothesis that, in the future, technology-intensive companies will need to position themselves in two quite different market domains: the traditional supplier-consumer market and the technology supplier-technology user market (Figure 10). This visionary concept of technology marketing has to be investigated further, under the assumption that its systematic implementation will contribute considerably to successful technology management.

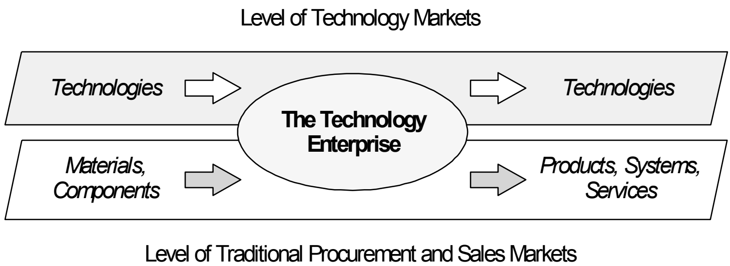


Figure 10: Prospective two-level market activities to be mastered by technology-based companies (Tschirky 1998: 302)

3.8 Example 8: Overviewing technology strategic positions completely (strategic level)

One instrument of Technology Management in particular has been seen to gain relatively wide acceptance early on: the Strategic Technology Position Portfolio (Figure 11, left).

It is a matrix tool that provides an easily interpreted and communicated overview of current and future technology positions. Its popularity is attributable to the fact that thinking in terms of portfolios is fundamental to strategic business planning, where strategic product and business positions are to be dealt with.

This portfolio rates and positions all major technologies according to their "Technology Attractiveness" with respect to their innovation and market potential, and their corresponding "Technology Strength", i.e. the resources currently available within the company.

This rating can be carried out in several ways. One, a theoretical approach, consists of making extensive assessments of the numerous factors which determine the two dimensions of the portfolio, such as market potential of new products, potential contribution to earnings and potential for multiple use (for technology attractiveness) and number of knowledge bearers, R&D expenditure and number of patents (for technology strength).

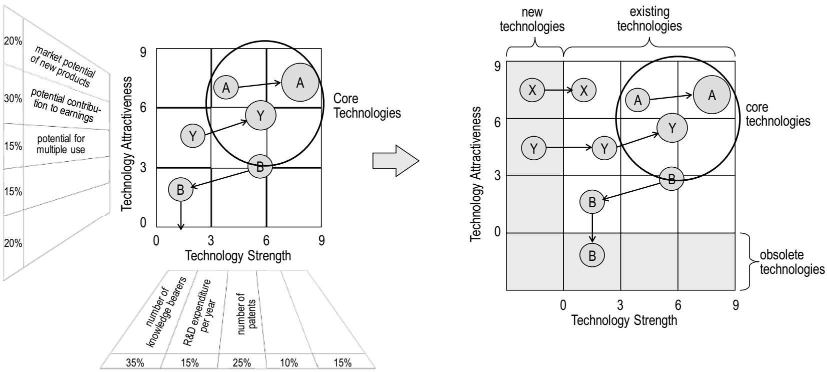


Figure 11: From the traditional to the dynamic technology portfolio (Tschirky 1998: 315)

Another, practice-oriented but nevertheless useful, consists of independently inviting experts from inside and possibly from outside the company to express their opinions on the attractiveness and competitive strength of various technologies. This procedure leads relatively quickly to the data required to draft the portfolio. This second approach has been successfully implemented recently by several Swiss companies from the mechanical, electrical and even the pharmaceutical industry.

Once the portfolio has been developed, its strategic evaluation can take place. This focuses on setting priorities as to the promotion or reduction of technology development resources or even the phasing-out of aging technologies. The latter decision usually follows intensive internal discussions. In particular, consensus has to be reached on core technologies. They constitute strategic knowledge assets of companies and are usually developed in-house with high priority (see next example).

The main merit of the technology portfolio lies in its high degree of condensation of strategic information and at the same in its ease in communicating strategic decisions. In addition, a successfully finalized technology portfolio reflects completion of a constructive collaboration between experts from R&D, production and marketing, which is a valuable goal on its own.

Despite the undisputed popularity of technology portfolios, they are still lacking essential strategic information. In its traditional form, the portfolio visualizes the positions of technologies which are currently being used by the enterprise and therefore their corresponding technology strength can be identified. It does not represent however, technologies which are attractive despite the lack of company resources. This information is significant, because the future promotion of new technologies will require company resources, in addition to that needed for the promotion of existing technologies. In order to include this information in the technology portfolio, the use of „Dynamic Technology Portfolio“ (Figure 11, right) is recommended instead; in addition to the traditional portfolio, it is extended by the column „New Technologies“ and at the same time by the line „Obsolete Technologies“. This allows the inclusion of information about technologies that had once been part of the company’s technology activities. Overall, this expands the time horizon of the portfolio.

3.9 Example 9: Core technologies as strategic backbone of technology and innovation management (strategic level)

In recent years, the notion of “core competencies” has become a widely accepted concept in general management. More precisely, it is a strategic concept which aims at explaining a company’s competitive strength. Earlier competitive positions were related to available resources, such as capital, human resources and logistics potential. In contrast to company resources which can be obtained or “bought”, core competencies describe capabilities that result from organizational learning over years. They are therefore more inherent, more genuine to the company and certainly less “purchasable” than resources. A typical core competence of Sony for example is miniaturization. Honda’s distinct core competence is mastering “high revolution engines”, which started in the early days when Honda produced high revolution scooters and mowing machines. This core competence enabled Honda to enter the Formula-1 competition successfully, at an amazingly early stage compared to its competitors.

Core technologies fall into the category of core competences. These are usually key technologies that give the company its unique competitive advantages. As mentioned, core technologies are preferably original technologies developed with priority funds within the company. Whereas companies depending on their size have to master hundreds or up to thousands of technologies, the number of core technologies is limited and may amount to a small proportion of all technologies. The ionization technology, described earlier, has been a core technology for Cerberus, a leading fire security company for over twenty years.

A final example refers to Advance Issue Sciences Inc. This company is renowned for its capability to produce human tissues. In essence, this capability is based on mastering two core technologies (Figure 12): cultivating human cells and building biodegradable scaffoldings. By combining these two core technologies the company is in the position to manufacture two- and three-dimensional tissues. The first batch of products, artificial skin in various configurations, is on sale. The next batch of products will consist of orthopedic cartilages and ears.

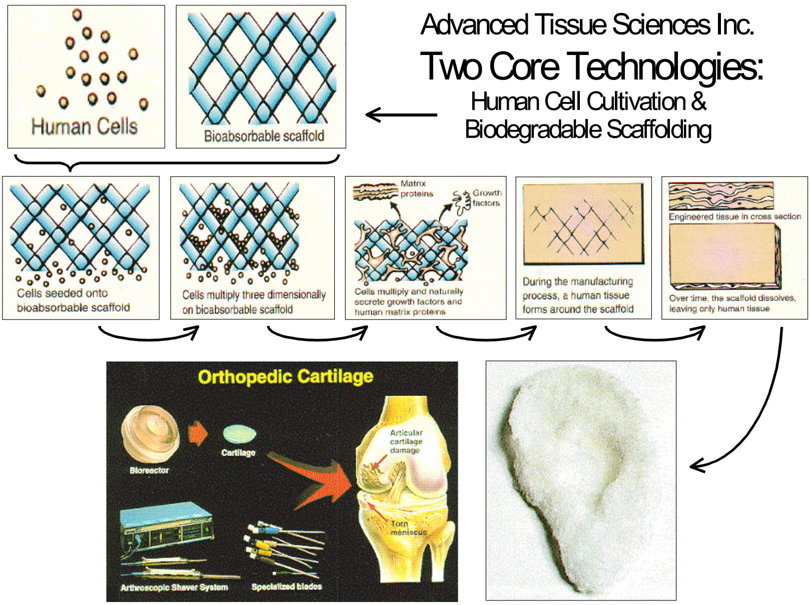


Figure 12: Example core technologies: Advances tissue sciences Inc. (2000)

Core technologies play a central role in strategic technology planning. Often they constitute the core of so-called strategic technology fields (STF), which as a structure can be used to reduce the complexity of the large number of technologies that usually need to be handled. STF's are the counterpart to Strategic Business Areas (SBA) which assemble knowledge on specific markets and their relevant customer needs/benefits, product functions, products and services.

Within STF's in addition to core technologies, relevant theories, product, process and support technologies are grouped which as a whole represent a strategic entity suitable for setting strategic priorities. Optimizing the technology potential, for example, means reducing the number of STF's to an economically and strategically justifiable minimum. At the same time, penetration of STF's throughout the SBA is aimed for (Figure 13).

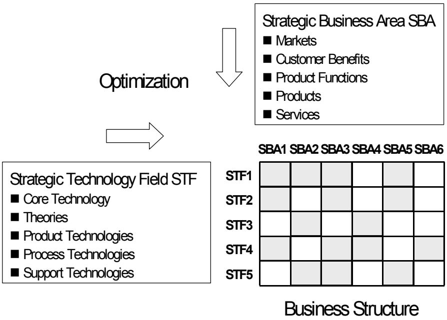


Figure 13: Optimizing core technology penetration in the strategic business areas SBA (Tschirky 1996: 80)

3.10 Example 10: Visualizing core technology forecasting effectively using technology roadmaps (strategic level)

Technology roadmaps are widely used strategic technology and business management tools which depict comprehensively the predicted development of essential technologies over time. They result from extensive research on available information on technology intelligence combined with concise company internal evaluation of technological in-house development. The following examples may illustrate this technique by illustrating the development of wafer and stepper technology predicted by Canon (Figure 14):

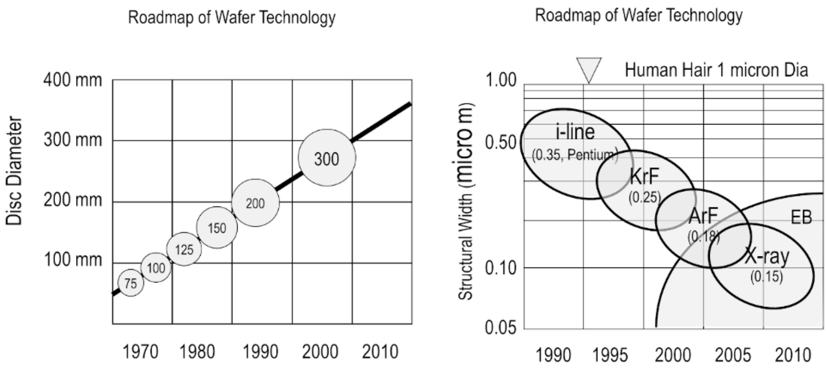


Figure 14: Technology roadmaps visualizing the predicted development of wafer (left) and stepper (right) technology (Canon, 2000)

3.11 Example 11: Relating the value of technology strategies directly to the company's value (strategic level)

A further strong link between technology issues and the general management perspective consists of evaluating technology strategies in such a way that allows for directly relating the value of technology strategies to the company's value. In the past, so-called investment and pay-back calculations have been applied in order to financially justify technology strategies or single R&D-projects. The decision to approve or reject project proposals was usually based on minimal rates of return (i.e. 15%) or maximum pay-back periods (i.e. 3 years).

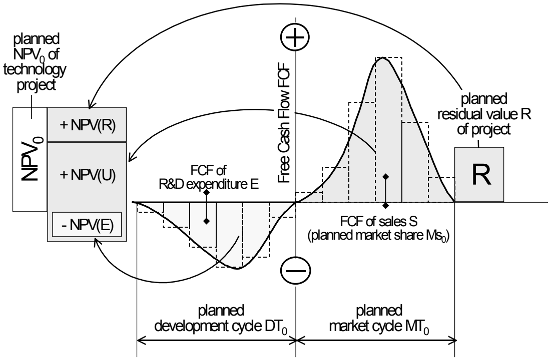


Figure 15: Establishing R&D projects net present values NPV (Tschirky 1998: 348)

Using the discounted free cash flow analysis, according to Rappaport (1986), it is possible to establish strategy and project values in terms of Net Present Values NPV (Figure 15), which represent numerical values referring to increases or decreases of the total company value. It is evident that, through this procedure, the interest of top management in technology strategies and R&D projects is much higher than in financial project data which only express a "local view" from the R&D department.

3.12 Example 12: Technology calendar: documenting interdisciplinary consensus (strategic level)

This technology management tool has a high integrative value. It provides an overview of all product and process technologies with respect to their timely introduction in existing and new products and in the production process respectively (Figure 16).

Technology (☐ Current Technologies, ☐ New Technologies)	Strategy	Products			
	Make or Buy? Keep or Sell?	Current Products		New Products	
		A	B	D	E
Product Technologies		98	98 03	97 00	00
Product Technology 1		03	00		
Product Technology 2	Make				
Product Technology 3	Sell		00		
Product Technology 4	Buy				
Process Technologies		98	98 03	97 00	00
Process Technology 1					
Process Technology 2	Sell				
Process Technology 3	Buy				
Process Technology 4	Make				

Figure 16: Technology calendar (Tschirky 1998: 320)

The elaboration of the technology calendar requires a high degree of interdisciplinary collaboration since it summarizes plans from marketing, R&D, production and financial points of view. Therefore, in addition to being a useful management tool it represents a documented evidence of above average level of internal communication quality.

3.13 Example 13: Gaining time to market using simultaneous engineering (operational level)

Given the accelerated pace of technological change, the main focus of R&D management has shifted from keeping project costs under control to timely introduction of new products. According to an often cited investigation by Siemens (Figure 17), a project cost overrun by 50% causes reduced earning in the order of 5%. However, if a five-year project is exceeded by only six months, the earnings are reduced by 30%.

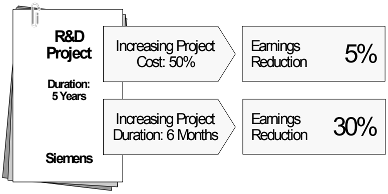


Figure 17: Project completion time: its leverage on earnings (Tschirky 1996: 95)

Project completion time can be reduced by what is commonly known as Simultaneous Engineering (SE; Figure 18, left):

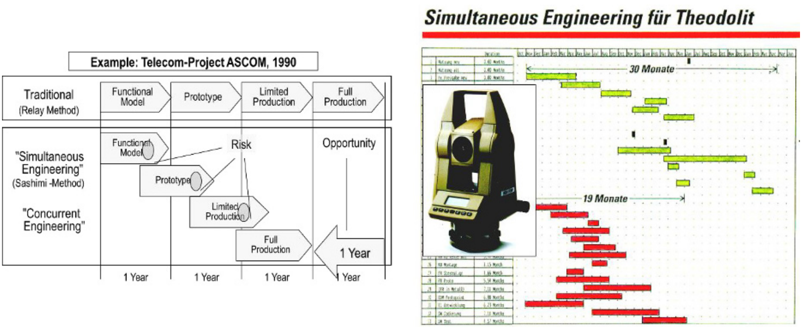


Figure 18: Project management by way of simultaneous engineering; case from practice (Development of Leica Theodolite) (Tschirky 1996: 101)

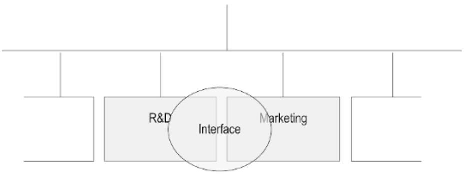
This project management concept converts the traditional procedure of completing the individual phases of product development (functional model, prototype, limited production, full production) in series to a procedure in which the phases are partly overlapping. This means on the one side to take risks, since essential project information may be uncertain during times of overlaps. On the other, however, valuable project time can be gained to the benefit of shortened R&D cycles and accelerated market entry. Concurrent Engineering is often used as synonym to SE.

In practical cases time reductions of 30% and more are not unrealistic. In the Leica case, a theodolite has been developed using simultaneous engineering, resulting in a shorter project time from 30 months to 19 months (Figure 18, right).

3.14 Example 14: Being aware of intracultural barriers and ways to overcome them (operational level)

Recently, one of the major players in the pharmaceutical industry expressed concern about the faltering collaboration between its R&D and marketing departments. Typical in this situation, was for example, the presence of prejudices between members of the two departments: marketing would consider R&D to be “narrow-minded, too specialized, not aware of ‘real-word’-problems, too slow, and not cost conscious." And R&D were of the opinion that marketing was "impatient, incapable of understanding technical problems, exclusively interested in short-term problems, unreliable with respect to confidential R&D-information."

Further investigations focused on the “interface” between marketing and R&D (Figure 19, right) and came to the conclusion that this situation was not the result of any “badwill” of the people concerned but rather the natural consequence of the fact that cultural determinants of the two groups were fundamentally different (Figure 19, right).



Cultural characteristics	R&D	Marketing
Time horizon	long-range	short-range
Feedback time	long	short
Reality	■ technological ■ “objective” ■ empirical ■ “factlogical”	■ economic ■ “intersubjective” ■ consens-oriented ■ “psychological”

Figure 19: The intracultural barrier between R&D and marketing (Wiebecke et al 1987: 5)

Therefore, subsequent research concentrated on the question of how to overcome such internal cultural barriers. The answer was threefold:

- building procedural bridges: joint planning of all aspects of R&D-programs: research, technology, product & process development, joint staffing of projects, pre- and post transfers, common proposals, including product specifications, jointly established criteria for project discontinuance, common base of information;building structural bridges: physical proximity, "organizational" proximity, integrators, process management, specialized transfer groups, internal multidisciplinary venture groups, simultaneous (concurrent) engineering project work;building human bridges: people movement, both upstream & downstream (most effective of all bridging approaches), improve: formal information & meetings, promote: informal contacts, rotation programs, “liaison” personnel, joint problem solving sessions, common training, create: interface awareness and atmosphere of mutual trust.

3.15 Example 15: “Gatekeepers”: usually anonymous carriers of informal communication (operational level)

One of the rare full-scale investigations in technology management, which got an extraordinarily wide acceptance, concerns the “Gatekeeper”-phenomenon. It was carried out by Tom Allen from MIT in the 1980’s and reveal a valuable insight into the dynamics of knowledge transfer in R&D organizations (Allen 1986). Main findings emphasize the dominance of communication and the key role which relatively few people play as carriers of communication processes.

Typical result of the investigations states that the frequency of internal and external and communications is a determining factor for project success (Figure 20).

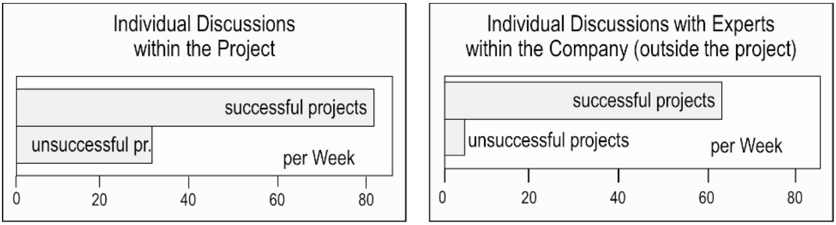


Figure 20: Internal and external communications of successful and unsuccessful R&D Projects (Allen 1986: 112, 114)

Not surprisingly, the contributions from the individual researchers and engineers to this frequency are unevenly distributed. In typical communication networks of R&D organizations which visualize the communication intensity during a given time period (i.e. one month) usually a small number of people attract attention as being "communication nodes" of the network (Figure 21, left). At first these people were called "communication stars". Since detailed analysis of their daily activities showed that in addition to being preferred discussion partners within the company they also were perceptibly above average in fostering external communication and literature study (Figure 1, right).

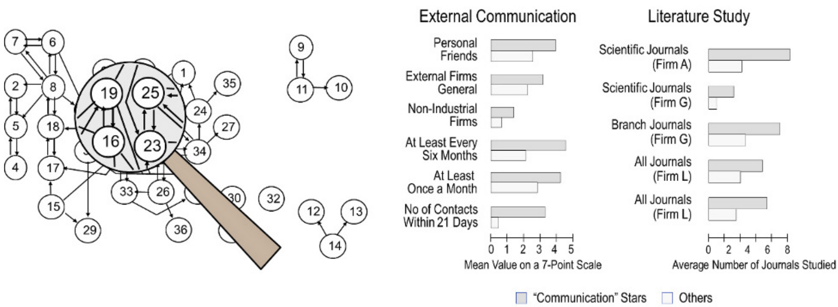


Figure 21: "Communication stars" (gatekeepers) within communication networks of R&D structures (Allen 1986: 146, 147)

Based on these findings the "communication stars" were baptized "Gatekeepers" since these people obviously functioned as gates for channeling external information and its internal distribution (Figure 22). In other words: information flow and thus knowledge transfer into companies occur at the first stage, mainly through the gatekeepers, who in the second stage are also responsible for the dissemination of the incoming knowledge.

The answer to the question "who are the gatekeepers?" revealed that they had above average competence in their professional field, they were members of lower management and their service in the company was neither the shortest nor the longest compared to their colleagues. And most surprisingly: the gatekeepers were unknown to the company management as carriers of roles crucial to the company's survival.

Sometimes when discussing the gatekeeper phenomenon in management seminars it is suggested to introduce something like a "gatekeeper management" in order obtain maximum results from the communication networks. This may not be a good idea. This is because informal communication processes, which constitute the underlying theme of the gatekeeper phenomenon, are not tightly manageable but need to be effectively supported, for example through generously supporting business travel and attending conferences.

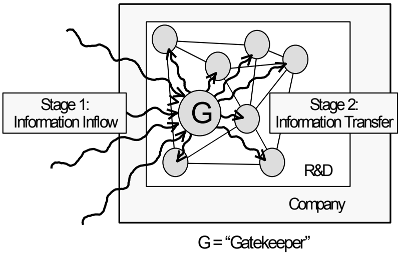


Figure 22: Dominant role of gatekeepers in the two-stage process of information in-flow (after Allen 1986: 162)

4 A model case of technology and innovation management

The following case example (Figure 23) of the Human Tissues Corporation Inc. (HTC) demonstrates the structures and tools of technology management which were chosen in order to build up a strong competitive market position.

The technology management of HTC contains a few centralized and a larger number of decentralized elements associated with the normative, strategic and operational level of management. The *first element* is the CTO-function established at the top management level. The *second element* is the vision "Technology for Quality of Life", which had been developed to express dominating values as a long-term orientation ("polar star"-function) of the enterprise. The *third element* is a technology policy, which had been elaborated in conjunction with an analysis of the enterprise culture in order to reach agreement between the long-term technology goals and the basic enterprise behavior. The analysis led to measures aimed at increasing the flexibility and external orientation of the enterprise.

The *fourth element* is the Technology Intelligence Center (TIC) reporting to the CTO. It represents the technology information pool of the enterprise. Its tasks comprise:

- the worldwide collection of technology-sensitive information,
- the establishment of relations to relevant technology users and suppliers inside and outside the medical branch,

- the preparation of make-or-buy and keep-or-sell decisions,
- the strategic evaluation of key and pacemaker technologies and negotiations on technology collaboration of any sort including the legal work.

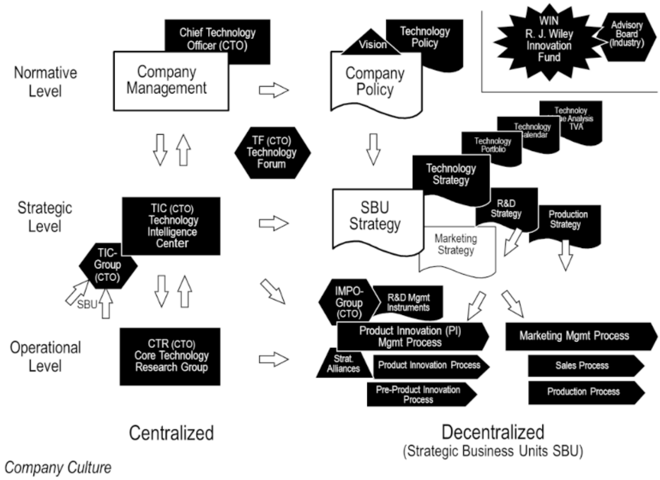


Figure 23: Elements of technology and innovation management of the Human Tissues Corporation Inc. (HTC) (Tschirky 1998: 370)

TIC is also in a position to perform patent analyses and to handle patent application procedures. In collaboration with the SBUs, the technology portfolio's are brought up-to-date periodically and support is provided to the SBUs for elaborating the technology calendars, which determine the sequence of introducing new and/or obsolete technologies. The TIC-tasks are handled by three people including one patent lawyer. The *fifth element* is the interdisciplinary TIC-Group consisting of SBU-representatives from R&D, marketing and production and the manager of the Core Technology Research Group (CTR). This group meets bimonthly under the guidance of the CTO. Main agenda items are news from technology intelligence, ongoing and future alliances, patent situation and licensing businesses.

The *sixth element* consists of the Core Technology Research Group also reporting to the CTO. It is focused on the evaluation and development of strategically significant technologies. It has close relations with universities and institutes of technology such as Caltech, Stanford and MIT. The *seventh element* represents the technology strategy which constitutes an integrated part of the SBU business strategies. Main planning instruments include technology portfolios, technology calendars and technology value analysis (TVA) which allows – as mentioned above - a way of relating the business value of a technology project to the enterprise value based on the free cash flow methodology by Rappaport. From the technology policy, SBU specific R&D and production strategies are derived. The *eighth element* reflects the process orientation and consists of three operational SBU processes, the product & process innovation (PPI) process, the pre-product & process innovation process and the production process. The

PPI process is focused on known technologies in order to keep the risk associated with development time low. The same is true for the production process, which is coupled with the sales process. New product and process technologies are evaluated within the Pre-PPI process. This task is closely related to CTR. The *ninth element* represents two management processes. The PPI management process takes responsibility for the PPI and Pre-PPI processes. This assignment is based on a close collaboration with TIC. The marketing management process is in charge of the sales and production processes.

The *tenth element* is the innovation management process owner group (IMPO). It brings together those responsible for the PPI management processes and enhances the exchange of experience, the coordination technology alliances and the development of suitable R&D management instruments (such as target costing, project management tools, etc.). The TIC and IMPO groups meet 3-4 times yearly in order to discuss basic questions of technology competitiveness. The *eleventh element* is the technology forum (TF). Under the leadership of the CTO, it takes place twice a year and is addressed primarily to the non-technical management those responsible of HTC. The main topics presented include the current technology situation of HTC, the progress of strategic technology projects and technology alliances, aimed at promoting the technology understanding across functional boundaries. The *twelfth element* finally is the J.R. Wiley Innovation fund (WIN). It had been established, by the enterprise founder, to increase the chances of acceptance of attractive innovation projects. This way, within HTC, two entirely separated routes exist to apply for innovation project funds, namely the ordinary procedure within the SBUs and the extraordinary path leading directly to WIN. The evaluation of WIN-proposals is done by an external committee consisting of representatives from industry and academia.

5 Does actively practicing technology management pay off?

As always, when attempting to relate business success to specific variables such as strategy, company culture, leadership or even entire management concepts, it is inherently difficult to come to unequivocal conclusions. A research study carried out at the Swiss Federal Institute of Technology on the "technology management intensity" of 60 SME's belonging to different industries of varying technology levels, identified a group of obviously innovative and financially successful enterprises which are practicing technology management proactively on all management levels, and another group of non-innovative and unsuccessful firms in which technology issues are at best marginally integrated into processes of general management (Kohler 1994).

In addition, an individual in-depth study of renowned technology enterprises as ABB, Siemens, 3M, Canon, NEC, Hewlett Packard, Honda, Hilti, Novartis, Monsanto, Roche and others revealed a high level of awareness of technology and innovation management issues in many forms. Of particular interest is the fact that these companies do not take a singular but rather an integrated approach to managing technology. They simultaneously manage on the normative level in terms of explicit technology policy and innovative organizational culture, on the strategic level in terms of a clear focus on core technologies and at the same time on a high intensity of strategic technology alliances, and finally on the operational level in terms of up-to-date management instruments such as target costing, concurrent engineering project management, process management and the promotion of informal communication.

No crystal ball is required to predict a significantly increasing need for management awareness of technology and its management, as we face the unprecedented challenges of the next millennium. There are "good" and "bad" ways to go about this, using the frameworks outlined above as well as others that follow in subsequent chapters.

Acknowledgements

This chapter was first published as Tschirky, H. (2004): “Bringing technology to the boardroom: What does it mean?” In: EITIM (Ed.), Bringing Technology and Innovation into the Boardroom: Strategy, Innovation and Competences for Business Value (pp. 19-46). Hampshire: Palgrave Macmillan UK. Republished with permission.

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Chapter 2

Challenges of maintaining innovativeness in organizations under business model transformation and digitalization

Tom Sommerlatte

Abstract

Even though "classical" innovation continues to be, for now, the essence of market and business dynamics, the world is moving towards significantly new and disruptive products and services that are, and increasingly will be, based on out-of-the-box thinking about applications, new ways of value creation and market penetration, by using advanced technologies and knowledge for timely arousing and meeting latent demands. At the same time, company-internal and external barriers continue to hamper the innovation performance, particularly when it comes to responding more proactively to the big current transformation challenges such as, the conversion to renewable energy, e-mobility, industry and services 4.0, to intelligent urban and organizational infrastructures, or to intelligent homes.The author, with his decades long experience as a "part of the game", proposes that it will require a new leadership style and a new innovation culture to stem the transformations which society and business are set to undergo.

Keywords: Digital Transformation; New Leadership; Innovation Culture; Business Transformation; Transformaton Challenges; Innovation Barriers

1 Changing role of innovation, innovation management and innovation research

Joseph Schumpeter's basic theory of innovation characterizes it as an entrepreneurially driven move to outcompete established combinations of capabilities and means of production, distribution and servicing by new combinations responding better to customer/user needs and/or circumstances (Schumpeter 1964). In view of current societal changes, ecological imperatives and intensifying global competition between areas with very different political and economic systems, the question arises, however, whether we have to take an innovative look at innovation and innovation management. "Classical" innovation continues, of course, to be, at least in the medium term, the essence of market and business dynamics, significantly new products and services based on out-of-the-box thinking about applications, new ways of value creation and penetrating markets, and using advanced technologies and knowledge for timely arousing and meeting latent demand. Having been in this game for decades but in the face of major disruptions recognizably ahead (Schnieder and Sommerlatte 2010, Guillebaud 2018), the author proposes to show that it will require a new leadership style and a new innovation culture to stem the transformations which society and business will have to undergo.

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R. Tiwari and S. Buse (eds.), *Managing Innovation in a Global and Digital World*, https://doi.org/10.1007/978-3-658-27241-8_3

A number of innovation adherents and proponents with a common breeding ground at Arthur D. Little and, thereafter, with successful careers in academia, business or consulting have, over the years, contributed important elements to innovation management (Little 1997). And many companies have by now adopted some or most of these elements for their innovation efforts. This applies to the inclusion of innovation in their corporate strategy (Roussel et al. 1991), to the professionalizing of their innovation processes (Little 1988), to methods of idea generation and cultivating the fuzzy front-end of innovation (Sommerlatte et al. 2006), to their knowledge management (Bellmann et al. 2002), to open source cooperation (Herstatt and Ehls 2015) as well as lead-user-interaction (Lüthje and Herstatt 2004). Major progress has also been made as to the understanding of innovation management in the international context, particularly for globally distributed competence centers of transnational corporations (Gerybadze and Reger 1998).

In spite of this progress and of ongoing research in these areas, there continue to be company-internal and external barriers to the innovation performance needed, particularly when it comes to responding more proactively to the big current transformation challenges such as, to name the most important ones, the conversion to renewable energy, to e-mobility, to industry and services 4.0, to intelligent urban and organizational infrastructures, or to intelligent homes.

Recent studies have shown that innovativeness depends to a substantial degree on the climate of trust within companies, the level of trust between companies, and the societal trust vis-à-vis change caused by digitalization (Scholl 2013). Transformation often undermines the trust basis and therefore can and often does negatively affect innovativeness (Sommerlatte and Fallou 2012). Trust research as initiated by Niklas Luhmann and other researchers (Luhmann 1989, Willkes 1999) has therefore increasingly been directed to the effects of trust in organizations under transformation. While the role of trust has been recognized by a number of authors as a key element of innovation culture, there is little knowledge which trust-building and trust-degrading aspects shape the innovation culture and therefore affect the inherent innovativeness of organizations.

In the following, a model of the ramifications of trust in business organizations is described which the Trust Management Institute, drawing on work of a number of researchers, has developed and applied to helping companies maintain their innovativeness while undergoing business model transformation.

2 A model of trust ramifications in business organizations

Trust has been investigated at the level of interpersonal relationships (Sommerlatte 2016) and at the level of organizational systems. The model of Trust Management Institute is based on the interdependence of the individual trust profile of leaders, its effect on the psychological contract in business organizations and, resulting from this, the climate of trust.

2.1 The trust profile of leaders and innovation

While the discussion of leadership profiles has mainly dealt with the use of power and authority versus more cooperative and emphatical forms of exerting influence (Davis et al. 2000), trust research has shown that the ability and willingness of a leader to build relationships of trust, i.e. trusting others and being trusted by others, is a more telling assessment of his leadership quality and, in particular, his capability to stimulate and manage innovation (Klotz 2016).

A number of descriptors have been advanced to characterize the trust profile of a leader and to explain why and how he/she is likely to lead the innovation process successfully (Sommerlatte and Fallou 2012). In this context, innovation process is not meant to be the formal organizational process from idea generation through the stages of innovation projects up to successful market introduction. Rather the issue is the ability to coordinate a variety of people with specialized knowledge, to stimulate learning, probing and selectivity and to maintain commitment and cooperation. This is what requires trusting others and demonstrating understanding and support to be trustworthy in their eyes.

The Trust Management Institute has experimented with various analytical models which have been proposed for establishing the trust profile of leaders. In our practical work with clients, we arrived at an inquiry structure allowing to obtain a fairly comprehensive assessment of the trust profile from which clear operational conclusions and recommendations can be derived. Leaders with a strong trust profile are good at coordinating the inputs of a wide range of people and knowledge, at dealing skillfully with differences and conflicts and at arriving at shared and motivating decisions. This kind of leader is very different from the classical hierarchical leader imposing himself/herself and using the formal authority of his/her position to pursue own views, preferences or interests.

Organizations under business model transformation and digitalization need trust-based leadership because in such an environment leaders depend increasingly on a range of highly specialized and rapidly evolving knowledge of experts, and their role must be based on integrity, social influence, transparent judgment and fairness to win followers (Keuper and Sommerlatte 2016). This implies that in spite of transformation, the relationship between company management and employees has to remain a reliable agreement on give and take and that a psychological contract that cannot be changed one-sidedly.

2.2 Implications of the psychological contract for innovativeness

Transformation, in order to be accepted and supported by the members of an organization, has to take into account that over time a tacit agreement has come about on what the give and take of the organization is in return for the engagement and loyalty of its people (Raeder and Grote 2012). As long as this tacit agreement holds, a climate of trust can prevail. If, however, transformation - initiated by the leaders or forced upon a company by external imperatives - changes the give and take unilaterally, then the psychological contract is broken and the trust climate deteriorates. Typically, this leads to a deterioration of the engagement and loyalty of the people and hence to a decline of innovativeness.

The experience of Trust Management Institute has shown that in many companies successive waves of restructuring, process reengineering and rationalization, more or less imposed by top management, have invalidated the formerly established psychological contract without replacing it by a new one that rebalances fairly the give and take. This is, in a number of cases we encountered the main obstacle to innovative drive and cannot be overcome by further organizational and procedural measures.

The Trust Management Institute holds that it has therefore become a basic condition for innovation management to be aware of the current status of the psychological contract in comparison to the motivation profile of the employees of the company. This analysis has, in our experience, to address the questions (Sommerlatte and Fallou 2012):

- What leeway do people have in exercising their role in the company?
- What sense of belonging does the company provide?
- How do people view the stability of the company in the future?
- What flexibility does the company show in responding to market and competitive challenges?
- Is there a higher cause making people proud to be a member of this company?
- To what extent and how does the company award the commitment of its people?
- What is the image that the company projects to the public?

Deficiencies in these areas of the psychological contract can be traced back to weaknesses of the trust profile of the leaders of the company and cause shortcomings of the climate of trust. To recognize and overcome these weaknesses and shortcomings is the key challenge of companies wishing to secure the innovativeness needed for successful business model transformation and digitalization.

2.3 Innovation in a climate of trust

Given the crucial importance of a company's climate of trust for its innovativeness, it is astonishing how little attention is being paid to it by most innovation managers. Building a climate of trust has been a subject mainly of authors in the area of organizational psychology. Arnie Dahlke concludes from 25 years of organizational research that the functioning of an organization rests predominantly on building relationships and that trust is the essential building block of a strong relationship. He postulates that widespread performance in an organization is based on a foundation of trusting relationships and that employees can have all of the best equipment, all of the latest technology and the most effective business processes but will not perform at their best if they don't trust their managers (Dahlke 2019).

Mayer et. al. correlate trustworthiness to goodwill, integrity and competence of the leaders and developed an integrative model of organizational trust (Mayer et al. 1995). Several authors studied the role of trust during organizational change and showed how change affects the climate of trust if it is not consciously protected (Kimberley and Härtel 2007, Dillingham 2019). In Germany, publications on organizational trust have mainly addressed its role for social cohesion (Hartmann and Offe 20019), for achieving satisfaction and self-fulfillment at work (Müller 1999) as well as for successful leadership, concluding that "leading is the art of building a climate of trust" (Posé 1984).

The impact of variables of company culture on innovativeness has been studied by Wolfgang Scholl in the context of research on the conditions for the success of innovation projects. He shows that several of the variables of company culture are themselves strongly correlated to trust (Scholl 2014). The Trust Management Institute has, after experimentation with combinations of variables for assessing the climate of trust and in cooperation with top managers and its scientific advisory board, zeroed in on a model of climate of trust based on

- The quality of communication in the company,
- The reliability of the functioning of the organization,

- The future perspectives seen for the company,
- The identification of the people with the company
- The appreciation of the people by the leaders of the company,
- The sense of community of the people in the company.

The overall assessment of the climate of trust is deduced from a rating from “I completely disagree” to “I completely agree” that a sample of people from all levels and functional departments of a company give to a battery of statements such as:

- *My company's top management communicates in a clear and comprehensible fashion.*
- *The company's top management makes credible statements.*
- *My supervisor makes credible statements.*
- *At my company, people stick to their commitments.*
- *I know what to expect from my company's top management.*
- *The management team is open to my ideas and opinions.*
- *I believe in the longevity of my company.*
- *I have a long-term perspective at my company.*
- *My company has done well so far, even when times were difficult.*
- *My company has a clear code of conduct and values.*
- *The leaders and all employees stick to the code of conduct and the company's values.*
- *The company gives its employees enough leeway for new initiatives.*
- *There is an open dialog between top management and employee representation.*
- *My company is highly regarded among customers and other stakeholders.*
- *I feel part of the company.*
- *I believe that my company has important tasks and responsibilities on its agenda.*

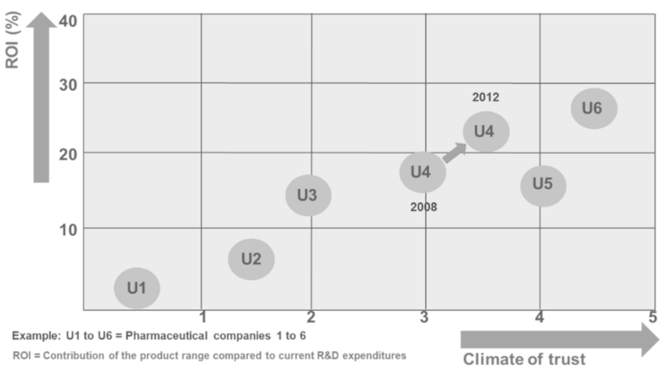

Figure 1: The return on innovation (ROI) of companies in the same industry differs depending on their climate of trust

In order to be able to equate the quality of the climate of trust to the level of innovativeness of a company, we use the concept of "Return on Innovation" (ROI) which is not applied to individual innovation projects but to the overall innovation performance of a company over a number of years. For this, we determine the overall profit contribution of the full product/service range during the time span considered and compare it to the cost of product/service development during that same period. This approach permits to compare the innovation performance among several companies of an industry as well as the evolution of the innovation performance of a given company over time (see Figure 1).

3 Maintaining high innovation performance in times of transformation and digitalization

Society and economy have increasingly reached a situation in which the transformation of business models as well as paradigm changes through digitalization are not only brought about by entrepreneurial drive and competitive dynamics but are required and often imposed by fundamental societal changes, ecological imperatives and rivalry between different political and economic systems, with other words through other forces than the classical innovation dynamics. These on-going changes, imperatives and rivalries are bluntly obvious and have been debated in numerous publications. They are endangering the climate of trust not only in individual companies but in entire industry sectors and in society as a whole because - as urgent as they may be - a lot of uncertainty transpires from which direction they will take, how quickly they will come about and what effects they will have on the fate of many companies and people.

So, while the rapid shift to renewable energy and to electrical vehicles is of high societal interest and politically wanted, while the so-called fourth industrial revolution based on artificial intelligence and integrated automation is expected to sweep the world and lead to a jump in productivity and customer responsiveness, or while intelligent and interactive infrastructure systems are said to be able to do away with congestion and offer comfort and convenience, the massive potential consequences, both good and bad, are jeopardizing the climate of trust and thus possibly misleading behavior and decisions on the way. Since all these developments and others need effective innovation management and since we have learnt how a positive climate of trust arises, even in situations of choice, or can be destabilized and therefore help or hinder innovativeness, this paper is a call for an enriched approach to innovation management in order to make it trust-based and able to better deal with more than customer demand, namely societal safeguard.

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Chapter 3

Digital technologies, competitiveness & policies: An integrative city-based policy roadmap for entrepreneurial ecosystems

Dilek Cetindamar, Thorsten Lammers and Nathalie Sick

Abstract

This paper offers a conceptual city-based policy roadmap for policy makers who are interested in managing their entrepreneurial ecosystems. The literature lacks specific policies bringing together both technological developments and entrepreneurial activities at city level, even though recent studies point out the role of policies for entrepreneurial ecosystems in order to build entrepreneurial economies. Given the wide opportunities arising from digital technologies for economic growth, policy makers need to identify feasible frameworks to support a digitally competitive entrepreneurial ecosystem. By combining the previous literature on entrepreneurship and digital technologies within a particular urban context, this paper describes a conceptual roadmap as a tool that might help policy makers to plan the future competitiveness of their cities.

Keywords: digital technologies, entrepreneurial ecosystem, city, policy framework

1 Introduction

The recent entrepreneurial literature provides several dynamic factors affecting the success of an entrepreneurial ecosystem (Stam, 2015). However, researchers point out the role of local conditions and bottom-up processes and they advise customization of policies rather than copying successful policies applied in other regions such as in Silicon Valley (Alvedalen & Boschma, 2017; Isenberg, 2011). More importantly, they call policy makers for creating policies for entrepreneurial regional economy rather than for entrepreneurship alone (Thurik et al., 2013). In fact, Stam (2018) specifically calls for policies for an entrepreneurial economy by understanding local knowledge through the lens of an ecosystem and involvement of the relevant stakeholders. Agreeing with such a policy approach, this paper emphasizes the need for a city-based tool that integrates both entrepreneurship and technology policies to flourish and generate innovations for the overall performance of the ecosystem.

Due to rapid urbanization, cities have become a major site of competitiveness (Roger et al., 2015). As a United Nations (2017) report summarizes, cities account for 70% of global gross domestic product in 2016. Thus, cities are becoming key platforms for policy makers. In parallel to increased economic importance of cities, policy makers are also expected to face new challenges arising from the radical transformation of cities into "smart cities" due to recent technological changes.

Digital technologies such as big data analytics and 3-D printing are attracting attention from entrepreneurs and policy makers for different purposes. These technologies could help policy

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R. Tiwari and S. Buse (eds.), *Managing Innovation in a Global and Digital World*, https://doi.org/10.1007/978-3-658-27241-8_4

makers effectively and efficiently manage their cities in addition to being a source of economic and social growth. The literature presents a number of studies on digital technologies and entrepreneurial policies carried out independently by disciplines ranging from operations management to entrepreneurship. Thus, this paper offers a short literature review and then proposes a conceptual roadmap tool customized for the use of digital entrepreneurial ecosystem at city level. Roadmaps are widely known for being a strategic decision process framework that supports enterprise innovation activities. They have attracted the interest of an increasing number of academics and practitioners, and have been applied in many different industrial sectors and organizations (Lee et al., 2007; Amer and Daim, 2010). For example, Lee et al. (2013) developed an integrated roadmapping process for services, devices and technologies capable of implementing a smart city development R&D project in Korea. Similar to their work, this paper targets to develop an integrative policy roadmap as an effort to both develop and commercialize digital technologies at city level and benefit from these technologies locally.

The paper has four sections. After this short introduction, section 2 presents theoretical discussions on digital entrepreneurial ecosystems. It starts with the introduction of entrepreneurial system and digital technologies, and then moves into the arguments showing the need for policies to establish and develop entrepreneurial ecosystems. Section 3 lays the ground for the conceptual roadmap model. The last section summarizes the paper and ends with suggestions for future research.

2 Background on digital entrepreneurial ecosystems

2.1 Entrepreneurial ecosystems

Entrepreneurship is the process by which individuals exploit opportunities for innovation (Schumpeter, 1934), while ecosystem refers to the interconnectedness of organizations that are mutually dependent on each other's inputs and outputs (Stam, 2015). The entrepreneurial ecosystem concept emphasizes that entrepreneurship takes place in a community of interdependent actors. Even though there are discussions around the use of entrepreneurial ecosystems (Alvedalen and Boschma, 2017), this paper will use it in a pragmatic manner to refer the interlinkages of complex and dynamic actors (Oh et al., 2016). Considering that entrepreneurship is an important source of innovation, productivity growth and employment (WEF, 2013), many countries are searching ways of creating an amiable environment for entrepreneurship to flourish in a competitive world (Autio et al., 2018).

Seemingly paradoxical, there is a revival of emphasis on regions and on the importance of geography in economics in the 21st century despite the extent to which globalisation has turned our world into a "global village" (Henderson, 1995). In this context, the entrepreneurial ecosystem approach has commonalities with other established concepts, in particular regional innovation systems (Cooke, 1992) and regional innovation management (Kriz et al., 2016; Autio et al., 2018). Similar approaches highlighting the importance of the regional environment as a driver of innovation are industrial districts, industrial clusters, and innovative milieus (Asheim et al., 2011). These concepts are grounded in Marshall's work (1898) on industrial districts where economic value results from the interplay of institutions, agglomeration economics and cooperation of firms. The original definition of industrial district is the spatial concentration of firms operating in one particular industry in a town or a few neighbouring small towns where especially small firms cooperate with each other and are embedded in the local community (Richardson, 1995).

The attractiveness of a region is a function not only of geographical and socio-economic factors taken in isolation, but also of a complex interplay of external economies characteristic of a prior industrial agglomeration (Richardson, 2015). For example, the sources of agglomeration economies arise from local concentration of customers, which reduce overhead and infrastructure costs; economies of scale in production or distribution; sufficient demand to warrant the provision of specialized infrastructure; and deep and diversified pool of workers sufficient to realize a more specialized local division of labour. In the same way, these economies are product of the use of specialized equipment and services; opportunities for bulk purchasing; joint research; organized markets for finished products; reduced cost of negotiating and monitoring contracts; and existence of specialized brokers or specialized machinery producers (Henderson, 1995; Marshall, 1898).

Agglomeration economies refers to the unit cost reductions of a firm arising from internal and external economies when it is located together with relatively dense clusters of other firms or specialized resources rather than located elsewhere. These economies fall into one of the following three groups (Hoover, 1975). The first one, internal economies, is related to the idea of economies of scale and caused by the increase of the firm scale of production at one point. The second one, localization economies, is externalities associated with the presence of many other producers in the same industry or sector. The last one, urbanization economies, is externalities associated with the co-presence of firms from diverse industries. In other words, urbanization economies are applicable to all firms in all industries, arising from the enlargement of the total economic size of that location for all industries taken together. Over time, agglomeration economies have become the crucial element for regional and economic policies (Hoover, 1975). Along these lines, Leydesdorff and Deakin (2011) pointed out that cities are “key components of innovation systems” because of their dense networks between academia, industry and government. Cities thus provide exceptional circumstances for collaborations across the triple helix as an essential prerequisite for regional development (Katz and Wagner, 2014).

Cities / metropolitan areas are not only be the base for the accumulation of ubiquitous assets, economic, physical, as well as networking (Newman, 2017), but they are the implementation arena for many digital technologies. In the past, there have been studies on the economic development around technologies developed and utilized at cities that forms the base of a rich literature on Technopolis (Phillips, 2006). It seems history repeats itself with new digital technologies. The goal for policy makers could be to find ways to identify the potential industrial clusters in their cities and then to support entrepreneurship ecosystems around them in order to efficiently utilize digital technologies.

This new type of ecosystems inspired academics to bring forward a new concept: digital entrepreneurial ecosystems, defined as “entrepreneurial activities that optimize the utilization and reconfiguration of digital infrastructure in the form of new systems, new platforms, and new networks.” (Susan and Acz, 2017). The study of Du et al. (2018) clearly shows that studies on digital entrepreneurship have mainly focused on firm-level characteristics and largely overlooked the external environment, i.e., the digital entrepreneurial ecosystem. That is why academics have recently started to point out new policy and strategy related issues arising from digital ecosystems (Weill and Woerner, 2018).

2.2 Digital technologies

Digital technologies are general-purpose technologies and have the potential to change all aspects of production, consumption, and government services in our daily life. They will have a massive impact on entrepreneurial ecosystems not only by providing new capabilities and business models but also by affecting their environment and its surrounding regulating frameworks (see Figure 1). Current trends in digital technology development include the Internet of Things (IoT), enhanced data analytics, artificial intelligence (AI) and virtual reality. Companies increasingly realize that digital transformation will become an imperative in today's competitive market (Newman, 2017). Currently, the pace of change provoked by digital technologies is not only accelerating, but also widening. For example, it will not only enable people to increase their capabilities but also increase organizational innovation as well as integrate whole ecosystems and supply chains (Groopman et al., 2017). These macro trends will bring with them massive regulatory challenges to provide stability on topics such as AI and cyber security (Dia, 2016; Hellwig, 2017). Research goes as far as claiming that advances in digital technology could automate half of today's work by 2055 (Manyika et al., 2017).

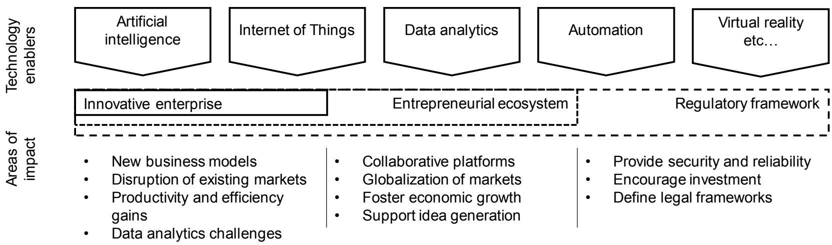

Figure 1: Dimensions of digital technology impact; Source: authors

Originally created in the context of manufacturing in Germany, the term Industry 4.0 describes a new trend of automation and data exchange enabled through the IoT, cyber-physical systems and cloud-computing (Jasperneite, 2012). This technological shift will have a significant impact on global competitive frameworks, as companies change to become integrated networks with high automation levels and real-time data access (Brettel et al., 2014). Increasing technologically enabled customer demands put further pressure on organisations' competitiveness (Kumar, 2017). The impacts of this shift go beyond manufacturing. It will provide business opportunities and challenges in areas such as logistics, smart services IT infrastructures, and workforce management (Schlaepger et al., 2014). Thus, policy makers should consider the ways of integrating digital technologies into their ecosystem plans.

For this purpose, the smart city approach provides a valid starting point to design digital entrepreneurial ecosystems. The concept of smart cities arose from smart specialisation strategies for regions, where 1) the competitive advantages of the region is identified, 2) R&D and innovation efforts are targeted in these areas, and 3) based on that, a vision for regional innovation is developed (OECD, 2013). Smart cities apply these principles on a city (metropolitan) level, mostly with a focus on IT as an enabler (Caragliu et al., 2011). Having just emerged with the rise of IT, there is no coherent definition of a smart city yet, but rather common elements of existing smart city concepts (Albino et al., 2015). However, key elements consist of a technology-based infrastructure, a closely connected network of partners, a creative class, and an urban development plan for economic and social sustainability (Hollands, 2008).

2.3 Policies for entrepreneurial ecosystems

The last decade has witnessed the rise of technology-based entrepreneurs who managed to build companies based on the use of emerging digital technologies. However, the pure availability of digital technologies in a particular country does not guarantee to establish successful companies and economic growth. This is why academics and policy makers who are concerned with market failures of new technologies are increasingly calling for policy interventions (Rodrik, 2008). In fact, studies focusing on digital platform ecosystems have recently raised the market failure concerns not for policy makers but also for leaders in digital platform ecosystems (Helfat and Raubitschek, 2018). Digital technologies supply a platform where companies such as Apple build many products and services through partners, eventually building an ecosystem of companies raising against other ecosystems (Teece, 2018). However, leading and managing such a platform is not easy for companies, since they need to design, manage, and alter ecosystems as conditions change in dynamic environment. As the work of Helfat and Raubitschek (2018, p. 1342) describes “platform leaders operate in a world of market failure characterized by imperfect information about relevant choices and the outcomes of making them, in a setting that calls for highly interdependent decisions due to the frequent presence of cross-side (or indirect) network effects.” In order to overcome this market failure, Helfat and Raubitschek suggest platform leaders to develop innovation capabilities, environmental scanning and sensing capabilities, and integrative capabilities for ecosystem orchestration. It seems similar capabilities are relevant for policy makers that try to establish a technology-based platform for all stakeholders to benefit.

Further, Stam (2018) makes a convincing argument that policies work if they focus on building entrepreneurial ecosystems for creative destruction. In other words, these policies will enable the creation of innovative start-up that help economies to diversify their productive structures in order to sustain economic growth. Structural change helps economic development by transferring the economy’s limited resources from low-productivity activities to high productivity activities (Rodrik, 2008). That is why Stam (2018) argue that supporting new innovative start-ups can overcome two key government failures used against policy making: (1) the most efficient and effective allocation of (public) resources in the future and (2) the government’s liability to rent seeking by vested interests (Mueller, 2003).

For a successful policy, besides the focus on start-ups, Stam (2018) argues that two types of input are needed: (1) data on the nature of the innovative start-ups themselves and their context and (2) consultation of and collaboration with public and private stakeholders. Only then, policy makers might develop direct levers for policy intervention and their implementation through the help of stakeholders.

Regarding the first input, companies are located in certain regional or urban environments with varying contextual factors. Big cities around the world are trying to leverage on their advantages and overcome their city-specific challenges to attract start-ups and provide an optimal breeding ground for digital entrepreneurship. The use of digital technologies to generate competitive advantage is, among others, a critical factor affecting the success of an entrepreneurial ecosystem. However, researchers point out the role of local conditions and bottom-up processes and they suggest customization of policies for the respective entrepreneurial regional economy (Stam, 2015). Thus, a comprehensive policy should integrate both entrepreneurship and technology policies in order to flourish and generate innovations for the overall performance of the ecosystem.

The second input requires democratic integration of all stakeholders. A recent report (Rissola and Sörvik, 2018) highlights how EU policy makers establish ecosystem orchestration mechanisms to generate interactions among stakeholders and improve their digital capabilities. In 2016, the EU launched Digital Innovation Hubs at regional level because on average in the EU, only about 1 out of 5 companies has highly digitised while there are still large disparities between regions in the take-up of information and communication technologies (ICTs) by small and medium sized companies. Hubs target these firms embedded in different regional contexts and try to orchestrate ecosystems by helping these firms to understand and utilize digital opportunities. As the report confirms, this initiative of establishing hubs is in line with the EU "smart specialization strategy" (3S) that aims to create specialization of regions. In other words, each region will build strengths on certain industrial innovation and technological activities through local stakeholder engagements as promoted by the EU and OECD (2012). The study of Radosevic and Stancova (2018) calls this 3S the largest innovation policy experiment in the world. Such approaches help identifying areas of discovery and mobilising stakeholders to know where the greater potential for regional growth is in a collaborative manner. Even EU policies force the integration of research and innovation strategies to comply with smart specialisation strategies by making this a prerequisite in order to receive funding from the European Regional Development Fund.

The geographical unit for ecosystems could be city, region, nation, or even a group of countries such as the European Union. This paper chooses the city as a feasible unit of analysis. However, it is necessary to note that city does refer to the metropolitan area in the geographical sense. There are three main reasons for choosing the city level as the scope of investigation for policy makers. First, due to the trend of rapid urbanization, there are abundant entrepreneurial opportunities. The United Nations (2017) project the number of people living in cities to reach to more than six billion people. City population represents not only customers but also workforce, innovators, and entrepreneurs. Second, digital technologies are diffusing rapidly at cities as previous technologies have done (Phillips, 2006). Cities have also become the major unit of competitiveness and therefore policy makers at cities race with each other to build smart cities to gain competitive advantage (Cetindamar and Gunsel, 2012; Roger et al., 2015). Third, city level analysis helps to consider a well-defined unit of location for understanding social, historical, and political fabric, which creates the base for an entrepreneurial ecosystem (Thurik et al., 2013).

3 A conceptual policy roadmap tool for managing digital entrepreneurial ecosystems in cities

3.1 Roadmaps

Galvin (1998) defines "roadmap" as "an extended look at the future of a chosen field of inquiry composed from the collective knowledge and imagination of the brightest drivers of change in that field" (p. 803). The roadmapping approach has become one of the most extensively used techniques for supporting strategic planning and innovation; it has also been widely used in public domains, in order to influence policy, research funding, and standards

(Phaal and Muller, 2009). This is due to its ability to provide a coherent, holistic, and high-level integrated view of complex systems, while displaying the interactions between various innovation activities over time (Groenveld, 2007; Kostoff and Schaller, 2001; Popper, 2008). Such a systems-based approach of strategic roadmapping is also potentially useful in managing and developing strategies for standardization activities in support of innovation, as a practical and operational tool for observing how standardization and other innovation activities influence each other with a more careful level of analysis.

This paper proposes an approach to build an integrative city-based policy for digital entrepreneurial ecosystems. The roadmap framework as a strategic tool might help policy makers to align the capacity of a city in digital technologies with the capacity residing in its entrepreneurship ecosystem (Cetindamar and Gunsel, 2012). This could increase utilization of technologies and bring together a number of benefits as discussed in the following paragraphs (Cetindamar et al., 2018).

First, local governments develop economic and technology policies for future economic development. Understanding the impact of digital technologies on city competitiveness requires an understanding of decisions made by numerous stakeholders at city level. Governments, managers and researchers regularly make decisions independent of each other. Bringing them together will profoundly influence each city's future development, economic fabric and national competitiveness. As Best (2015, p.4) argues for the industrial ecosystem in Boston: "The population of enterprises is embedded in a regional industrial ecosystem that facilitates ongoing reshuffling of the region's expertise, technology capabilities and financial resources for not only a single company but for a cluster of companies to grow fast." Managers are making critical decisions about what technologies to invest in; researchers consider what scientific areas to conduct their research; policy makers search support schemes for future and invest in infrastructure and research projects. These decisions call for sound empirical research that takes into account changing contexts, technologies and stakeholders. The proposed roadmap tool contributes to the evidence base to inform decisions in this complex and changing landscape.

Second, the integrative framework will provide data in two direct ways. Firstly, the roadmap will contribute to integrative policy discussion by bringing the complementary needs of education, entrepreneurship, industrial, innovation and technological policies. Secondly, the systematic investigation will improve the systemic use of digital technologies for increasing competitiveness of companies and entrepreneurs at city level. The commercialization of science has been a national priority in many countries. The potential changes in industry and technology programs could contribute to competitiveness capacity of cities that will capture technological opportunities, thus enabling the long-term success for city's economy and welfare.

Third, the roadmap might deliver data in indirect ways. For example, city level data on ecosystem could help to supply input for addressing complementary fields such as education. In particular, the observation of future might be instrumental in planning educational programs to align with future expectations at industrial sectors. This could be helpful in generating inclusive cities by dropping the digital divide in skills. Similarly, the integrated policy could help efficient use of resources at cities, improving the sustainability of cities. Moreover, adoption of digital technologies by companies will generate many spill over effects such as development of digital capabilities that might be transferrable to other sectors in city environment.

3.2 Designing a policy integrated roadmap

A generalized strategy process model comprises the following steps (Phaal et. al, 2010):

1. Vision and goals: to establish a sense of direction, in terms of a future vision and goals.

2. Appraisal of current position: to collate and assess information currently available, together with a review of current and historical strategies, activities, and performance.

3a. Assessment of external environments: to collect and assess information relating to external factors, issues, and drivers to identify opportunities and threats.

3b. Assessment of internal environments: to collect and assess information relating to internal resources, capabilities, and constraints, to identify strengths and weaknesses.

4. Generation and assessment of strategic options: to generate strategic options, identify gaps, and assess and select the options to derive strategic plans.

5. Implementation: to put the strategic plan into action.

6. Evaluation and learning: to review outcomes and disseminate results.

This general framework targets companies but its adopted versions include national level assessments such as the standardization roadmaps for ICT system standards (Ho, 2014) or the smart city development research & development project (Lee et al., 2013). In this paper, we customize it for the city level. The success of an entrepreneurial ecosystem relies on local conditions and bottom-up processes, thus policies for entrepreneurial regional economy call for customization (Stam, 2018). A comprehensive policy might integrate both entrepreneurial and technology policies in order to flourish and generate innovations for the overall performance of the ecosystem. The proposed framework/approach is not a product or technology roadmap but a policy roadmap. Roadmapping is a powerful technique that has become integral to creating and delivering strategy and innovation in many organisations. A recent work uses it to have multi-dimensional science and technology planning (Huang et al., 2014). The graphical and collaborative nature of roadmaps supports strategic alignment and dialogue between functions in the firm or organization and even between organizations. Since entrepreneurial ecosystems are embedded within the local context, the roadmapping technique gives flexibility to policy makers by allowing the alignment of specific needs at all levels, including functional, organisation-wide and even collaboration between organisations. Additionally, roadmapping draws on collaborative strategy making. Decision-making is consensus-based and transparent, facilitating key stakeholders to take roadmaps forward and apply according to their need.

This paper aims to expand the generic roadmap in such a way that it will satisfy two policy rules for entrepreneurial ecosystems offered by Stam (2018): (1) the roadmap should deliver data about the nature of the innovative start-ups themselves and their context and (2) the roadmap will rely on consultation of and collaboration with public and private stakeholders. Thus, this paper proposes small modifications to the 6-step generic roadmapping process (Phaal et al., 2010) to comply with these two rules. The layers of the city-based policy roadmap consist of policy, industry and technology. In the proposed model, Step 1, 5 and 6 are same as originally designed, while the remaining steps are modified as shown in Figure 1.

Inspired by Ho (2014), we call three steps in the middle (Steps 2, 3 and 4) as the "input and analysis stage" of the road-mapping process. Activities in these steps bring together the analysis and assessment of policy goals and capacities of a city in the form of industrial and technological capacities, with an emphasis on start-ups. This could fulfil the first policy rule mentioned above. During the input and analysis stage, we particularly suggest an in-depth roadmap exercise for each particular technology field. This is because, even though technologies such as artificial intelligence and block-chain are under the title of digital technologies, each of them are different in terms of the involved technologies, products and services. This necessitates a separate roadmapping exercise for each technology field. This detailed roadmapping approach is also in line with the EU's strategic call for building smart specializations. In other words, we argue that each urban region has a few core capabilities as targeted in EU's smart specialization strategies. That is why it is critical to determine key strategic orientations for the city to enhance its competitiveness along its capabilities.

The second policy rule could be fulfilled by the inclusion of macro-micro analysis at each investigation level, industrial, policy and technological. While macro-level analysis refers to the assessment of technological and entrepreneurial capacities of a city at the aggregate level, the micro-level covers the assessment of capacities of individual stakeholders/organizations (i.e. entrepreneurs, firms, innovators). This stakeholder approach could facilitate the communication among entrepreneurial ecosystem actors (industry bodies, suppliers, researchers, innovators, investors, entrepreneurs, and governments). Hence, their policy decisions and technology strategies might contribute to a healthy collaborative endeavour for creating future (Tan et al., 2015).

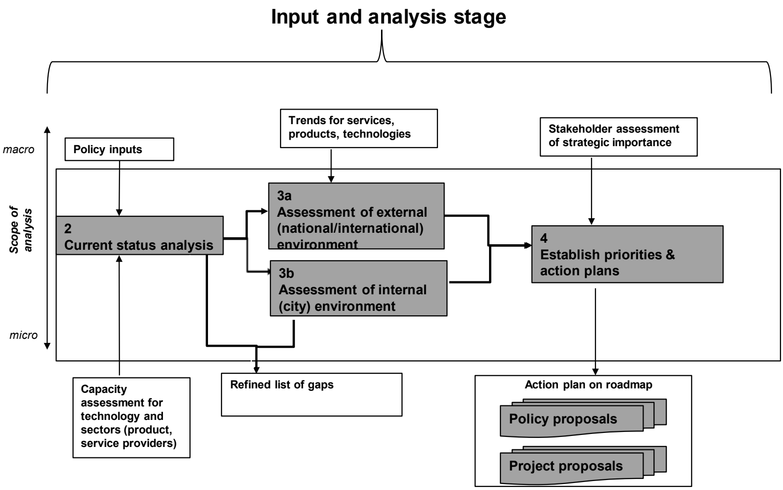

Figure 2: Policy roadmap for an entrepreneurial ecosystem; Source: Authors, based on Phaal et al. (2010)

In our model, the micro-macro analysis requires gathering data for current city levels of industry and technology capacities as well as potential trends at the national/international level. The inclusion of trend analysis on international level is particularly important to position city's ecosystem in global networks. As Radosevic and Stancova (2018) criticize, EU's smart specialization strategies ignore the need to couple with international knowledge and production networks and thus limit the effectiveness of R&D-based growth. In other words, Step 2 and 3 together focus on the analysis of indicators for the specific technology field such as AI, including: patents, scientific publications, infrastructure (incubators, technoparks, etc.), creative local labour, graduates in digital fields, research & development (R&D), and start-ups.

Besides capacities, a long-term trend analysis could bring wide range of data about technologies, industries, and policies. Thus, trend analysis again requires the consideration of micro-macro analysis. That means, the trend data should come not only from city level resources but also from national and international studies. Policies at city level need to pull together data from different policy documents. Each city or nation might have different policies and call them differently, but roadmapping activity should analyse all existing policies ranging from industry, education, technology, competitiveness, innovation, entrepreneurship, start-up, to smart city policies. The goal in aligning different policies is to find out policy goals and specific programs designed for the particular technology at hand. Similarly, the industrial base of a city might help to bring rich data on finding opportunities for integrating technology and industrial capacities at the local level. For example, AI is expected to influence medical sector, so roadmap activity could focus one technology and one industry. This might allow the selection of lists of services and products produced in the city by those particular industry actors. Then, there is need to collect national and/or international trend analyses for industries, technologies and policies. These trend analyses might rely on secondary resources such as forecast studies as well as customized data collection efforts such as a Delphi survey with specific technical experts from industrial, academic, R&D backgrounds.

4 Concluding remarks

This paper has outlined some of the recent studies regarding entrepreneurial ecosystems and digital technologies. To create a competitive environment for flourishing digital entrepreneurial ecosystems, there is an urgent need to align cities' entrepreneurial and technology policies. Since this area is still largely unexplored, this paper focuses on finding a possible mechanism in aligning policy agendas around digital technologies and entrepreneurial ecosystems. Then, drawing on literature, we propose a conceptual tool for policy makers: an integrated city-based policy roadmap to manage city based policies in order to support the creation and commercialization of digital technologies at the city level.

A systemic perspective of an integrated city-based policy roadmap could be instrumental in finding ways of how best to align digital technologies with entrepreneurial capabilities at local ecosystems. This local data could prevent to pursue unrealistic trends set by global hype on some digital technologies in general. Thus, we believe that a closely connected analysis of individual digital technologies could be of high significance in two ways. First, both managers and entrepreneurs might improve their utilization of digital technologies by understanding the complex relationships between digital technologies and entrepreneurs. For example, the commercialization of science has been a national priority in many countries like Australia (e.g. the Australian Government's Science and Research Priorities). The effective adoption of digital technologies by companies, particularly start-ups, could result not only in immediate economic benefits, but it could also generate many spill over effects. One such spill over effect is the transfer of digital capabilities to other sectors in city environment, contributing to the economic and social growth of cities. Another one is the increased collaboration among business and researchers in innovation ecosystems at cities.

The conceptual framework presented here needs to be further developed and tested, e.g. using case studies. Future studies should help to develop policy agenda in a number of ways. They might develop metrics to assess strategic fit between ideal city policies and their realization at city level. They could raise the issue of the alignment of capacities at digital technology and entrepreneurship for a healthy economic growth at cities. They might also conduct empirical studies to collect data and search for ways of streamlining and enriching the proposed framework. In particular, comparative studies might enrich the framework and increase the generalizability of the findings driven from the studies of individual cities.

Acknowledgements

We are grateful to the attendees of PICMET 2018 who have given comments on the early version of this paper.

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Chapter 4

Entwicklung von Geschäftsmodell-Innovationen

Christian Müller-Roterberg

Abstract

In den vergangenen Jahren hat sich in Forschung und Praxis zunehmend die Bedeutung von Geschäftsmodell-Innovationen herausgestellt. Vor diesem Hintergrund stellt sich die Frage, ob die Entwicklung von Geschäftsmodell-Innovationen nach dem gleichen etablierten Prozess abläuft wie bei Produkt-Innovationen oder ob es bei Geschäftsmodellen eines modifizierten Innovationsprozesses bedarf. Nach einer kurzen Darstellung des Prozesses bei Produkt-Innovationen, einer Definition von Geschäftsmodell-Innovationen und deren Bedeutung sowie einem merkmalsgestützten Vergleich zwischen Produkt- und Geschäftsmodell-Innovationen soll auf der Grundlage von existierenden Konzepten in diesem Artikel ein Innovationsprozess für Geschäftsmodelle vorgestellt werden. Dieser soll Unterstützung für die Praxis liefern, dabei aufzuzeigen welche Schritte und Methoden zielführend bei der Entwicklung von Geschäftsmodell-Innovationen sind.

Keywords: Geschäftsmodell-Innovationen; Innovationsprozess; Produkt-Innovation

1 Prozessmodelle bei Produkt-Innovationen

Die erfolgreiche Ausgestaltung des Entwicklungsprozesses von Produkt- und Dienstleistungsinnovationen ist bereits Gegenstand von zahlreichen Studien gewesen. Als ein wesentlicher Erfolgsfaktor hat sich dabei gezeigt, dass dieser Prozess in einer systematischen und strukturierten Art ablaufen sollte. Aus der Innovationsforschung entstammen daher zahlreiche Phasenmodelle, die sich u. a. in ihrer Detaillierung unterscheiden (vgl. Derenthal 2009: 44ff., Herstatt/Verworn 2007, Vahs/Brem 2015).

Ein in der Praxis weitverbreiteter Ansatz ist der Stage-Gate-Prozess nach Cooper (2011). Hierbei wird der Innovationsprozess in Stages und Gates unterteilt. Zwischen jedem Schritt („Stage“) folgt eine Überprüfung der Idee bzw. des Vorhabens („Gate“), bei der entschieden wird, ob die Idee/Vorhaben weiterverfolgt oder fallengelassen wird, bevor es zum nächsten Schritt im Prozess kommt. Die inhärente Komplexität und Unsicherheit von Innovationsvorhaben wird dadurch sukzessive abgebaut. Zudem lassen sich mit diesem strukturierten Entscheidungsverfahren die Projekt- bzw. Produkt-Flopraten senken und die begrenzten Unternehmensressourcen effektiv und effizient nutzen. Gleichwohl wird am Stag-Gate-Prozess und auch grundsätzlich an den Phasenmodellen der stark sequentielle Charakter und damit fehlende iterative Ablauf kritisiert. Durch den Einbau von Feedback-Schleifen kann dieser Kritik begegnet werden (s. Müller-Roterberg 2018a).

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R. Tiwari and S. Buse (eds.), *Managing Innovation in a Global and Digital World*, https://doi.org/10.1007/978-3-658-27241-8_5

2 Geschäftsmodell-Innovationen

Geschäftsmodell-Innovationen sind bewusste Veränderungen von bestehenden oder Schaffung neuer Geschäftsmodelle. Dabei geht es um die Erlangung eines Wettbewerbsvorteils durch Differenzierung gegenüber Konkurrenten. Unter Geschäftsmodell (engl. Business Model) soll hier die modellhafte Beschreibung der Art und Weise verstanden werden, wie ein Unternehmen für bestimmte Kunden einen Wert schafft, diesen erstellt und liefert sowie davon nachhaltig wachsende Erlöse erwirtschaftet (vgl. Osterwalder/Pigneur 2010: 14). Das Geschäftsmodell ist damit die Umsetzung und Konkretisierung einer Strategie und stellt das Bindeglied von Strategie zu den einzelnen Geschäftsprozessen dar (vgl. Osterwalder/Pigneur 2010: 2, Bieger/Reinhold 2014: 25). Geschäftsmodell-Innovationen sind tiefgreifende, strategische Innovationen, da sie die grundlegende Struktur eines Geschäftes verändern.

In Ergänzung sind auch die Begriffe Geschäftsidee, Geschäftsmodell-Innovationen sowie Geschäftsplan wie folgt im Sinne einer praxisorientierten Definition zu verstehen: Die Geschäftsidee betrifft nur einen Teil des Geschäftsmodells (wie z. B. eine Idee für eine Produkt- oder Dienstleistungsinnovation) und kann zugleich Anstoß für eine Geschäftsmodell-Innovation darstellen (s. u.). Eine Geschäftsmodell-Innovation soll hier in Abgrenzung zu Produkt-, Dienstleistungs-, Verfahrens- und Sozial-Innovationen gleichzeitig immer Änderungen von mehreren Elementen eines Geschäftsmodells umfassen (vgl. Gassmann et al. 2017: 7, Labbé/Mazet 2005: 897f. sowie Lindgardt et al. 2009: 2), und zwar mit einem gewissen Neuigkeitsgrad – entweder in seinen einzelnen Elementen oder als Ganzes gesehen (vgl. Björkdahl/Holmén 2013). Der Geschäftsplan (Businessplan/Business Case) schließlich ist das schriftlich dokumentierte Konzept eines Geschäftsmodells und beschreibt auch die Schritte für dessen Umsetzung und Finanzierung.

3 Bedeutung von Geschäftsmodell-Innovationen

Die Bedeutung von Geschäftsmodell-Innovationen für die unternehmerische Praxis ist in der Forschung weit anerkannt (vgl. Amit/Zott 2001, Chesbrough 2006). Erste Studien geben Hinweise, dass es einen positiven Zusammenhang zwischen Geschäftsmodell-Innovationen und Wachstum bzw. Erfolg eines Unternehmens gibt (vgl. Massa/Tucci 2014, Reinhold et al. 2011, Amit/Zott 2007, Stähler 2002). Die Boston Consulting Group postuliert in einer Studie, dass Innovationen bei Geschäftsmodellen vierfach erfolgreicher seien als Produkt-/Dienstleistungsinnovationen (Lindgardt et al. 2009). Eine Studie von IBM spricht in ähnlicher Weise bei Geschäftsmodell-Innovationen von einem jährlichen Gewinnmargenwachstum von mehr als 5 Prozent - ebenfalls das Fünffache mehr als bei Produkt-/Dienstleistungsinnovationen (IBM 2006). Johnson/Christensen (2008) identifizierten, dass 40 Prozent der Unternehmen, die in den letzten 25 Jahren in die Liste der weltweit 500 umsatzstärksten Unternehmen (Fortune Global 500-Unternehmen) aufgenommen worden sind, dieses durch Innovation ihres Geschäftsmodells erreicht hätten.

Vor diesem Hintergrund setzen sich zahlreiche Unternehmen das Ziel, ihre Innovationsanstrengungen bei der Entwicklung von Geschäftsmodellen zu steigern (vgl. Johnson 2010, IBM Corporation 2006, Höhmann 2014). Heutzutage ist die alleinige Fokussierung auf Produkt- und Prozess-Innovationen nicht ausreichend. Aus einer Branchenperspektive kann daher vermutet werden, dass entsprechend des etablierten Modells von Abernathy/Utterback (vgl. Abernathy/Utterback 1978, Utterback 1994) die Innovationsrate im Zeitverlauf durch die Entwicklung von neuen Geschäftsmodellen gesteigert werden muss (s. auch Müller-Roterberg 2018a). In der nachfolgenden Abbildung ist daher das Branchenentwicklungsmodell nach Abernathy/Utterback ergänzt in Anlehnung an Massa/Tucci (2014: 436) mit einer Kurve für Geschäftsmodell-Innovationen ergänzt.

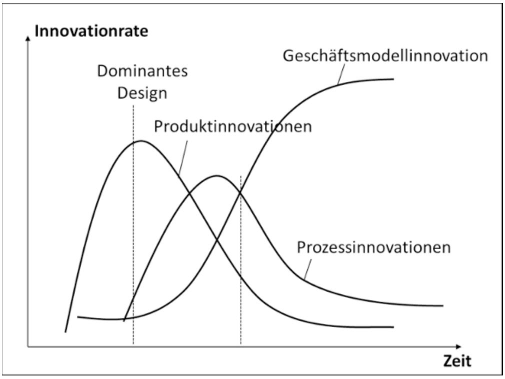


Abbildung 1: Branchenentwicklungsmodell nach Abernathy/Utterback (1978) ergänzt um Geschäftsmodell-Innovationen

Produkt-Innovationen und in der Folge Prozess-Innovationen können nur temporär die Innovationsrate und damit auch die Wettbewerbsfähigkeit steigern. Die Innovationsrate wird hier als das Verhältnis des Umsatzes der in den letzten Jahren neu eingeführten Innovationen zum Gesamtumsatz in einem bestimmten Jahr verstanden. Im Zeitverlauf ist es aus Branchensicht daher zwingend erforderlich, die Anstrengungen für Innovationen beim Geschäftsmodell zu erhöhen.

Allerdings wird nach Gassmann et al. (2017) nur 10 Prozent des Innovationsbudgets tatsächlich für die Entwicklung von Geschäftsmodell-Innovationen verausgabt (vgl. Gassmann et al. 2017, s. auch Johnson 2010). In der Unternehmenspraxis wird darüber hinaus ein Mangel an effektiven Methoden und Instrumenten für die Entwicklung von neuen Geschäftsmodellen (Höhmann 2014) konstatiert.

4 Vergleich der Merkmale von Produkt- vs. Geschäftsmodell-Innovationen

Aufgrund der oben genannten grundsätzlichen Bedeutung von Geschäftsmodell-Innovationen lässt sich eine hohe strategische Bedeutung für das Unternehmen feststellen, die sogar den Wert von Produkt-/Dienstleistungsinnovationen übersteigen kann (IBM 2006, Lindgardt et al. 2009).

Bei der Anzahl der gleichzeitig verfolgten Innovationsvorhaben ist ein weiterer Unterschied zwischen Geschäftsmodell- und Produkt-Innovationen festzustellen. Bereits für Startup-Unternehmen ist es zielführend, aufgrund der inhärenten Unsicherheit bei Produktentwicklungen mehrere Innovationsvorhaben zu initiieren. Größere Unternehmen haben häufig mehrere Dutzend Innovationsprojekte gleichzeitig entlang der einzelnen Phasen eines Innovationsprozesses laufen. Da ein Geschäftsmodell per Definition immer komplett ein Unternehmen oder zumindest einen ganzen Geschäftsbereich umfasst, wäre die Implementierung von mehreren komplett verschiedenen Geschäftsmodellen eine komplizierte und komplexe Aufgabe. Nur ein Geschäftsmodell pro Geschäftsbereich bzw. Unternehmen ist daher zu empfehlen (vgl. Johnson 2010: 167). Casadesus-Masanell/Tarzijan (2012) sehen in der simultanen Implementierung von mehreren Geschäftsmodellen sogar die Hauptursache für strategisches Versagen. Gleichwohl können in einzelnen Elementen und Gestaltungsoptionen je nach Gegenstand der Innovation und je nach Kundensegment unterschiedliche Ausprägungen sinnvoll sein. So können für das gleiche Produkt bei unterschiedlichen Zielgruppen völlig andere Arten der Kundenbeziehung bzw. der Vertriebs- und Kommunikationskanäle notwendig sein.

Bei neuen Produktentwicklungen lassen sich inkrementelle bis hin zu radikalen Innovationen feststellen. Da radikale bzw. disruptive Innovationen häufig ein neues Geschäftsmodell erfordern, sind diese (häufig aber nicht immer!) zugleich auch Geschäftsmodell-Innovationen. Daraus kann abgeleitet werden, dass innovative Geschäftsmodelle häufig einen disruptiven Charakter haben (vgl. Christensen 1997 und 2003).

Diese Geschäftsmodell-Innovationen tangieren häufig sämtliche Bereiche der unternehmerischen Geschäftstätigkeit (Köster 2003: 51), sodass alle Unternehmensbereiche im Prozess beteiligt sind. Bei Produkt-Innovationen wird zwar ebenfalls die Implementierung von abteilungsübergreifenden Teams als ein wesentlicher Erfolgsfaktor gesehen, dennoch überwiegen hier als Treiber der Entwicklung die Funktionsbereiche Forschung und Entwicklung bzw. Marketing. Der Prozess zur Entwicklung von Geschäftsmodell-Innovationen ist demgegenüber zwingend unternehmensweit anzulegen.

Des Weiteren ist bei Produkt-Innovationen – vor allem im Hightech-Bereich – ein starker Technologiebezug und damit einhergehend eine hohe Intensität der Aufwendungen für Forschung und Entwicklung festzustellen. Demgegenüber zielen Geschäftsmodell-Innovationen z. B. auf neuartige Erlösmodelle, Wertschöpfungsarchitekturen, Kostenstrukturen oder einem besonderen Kundennutzen (value proposition) ab, der wiederum nicht unbedingt technologischen Charakter aufweisen muss. Insofern sind bei Geschäftsmodell-Innovationen der Technologiebezug und die Intensität von Forschung und Entwicklung (FuE) eher gering.

Der Anstoß bzw. die Quelle von Produkt-Innovationen erfordert auf Seiten der Innovatoren häufig ein vertieftes Mthodik- und Fachwissen der Problemstellung („Technology-push Ansatz“) und/oder eine Offenheit bzw. Sensibilität gegenüber den Kundenbedürfnissen („Market-pull Ansatz“). Insofern lässt sich bei der Prozessausrichtung von Produktenwicklungen ein Bottom-up-Prozess beobachten, der bei den direkt am Innovationsgeschehen aktiv Beteiligten beginnt. Eine frühzeitige Unterstützung des Top-Managements wird gleichwohl für den Erfolg hierbei als hilfreich angesehen. Aufgrund ihrer strategischen Bedeutung und ihres unternehmensweiten Charakters ist bei der Entwicklung von Geschäftsmodell-Innovationen in existierenden Unternehmen die Unterstützung des Top-Managements zwingend erforderlich.

Der Prozess kann zwar auch Bottom-up initiiert werden, dennoch ist insgesamt der Prozess Top-down auszurichten.

In der nachfolgenden Tabelle sind diese einzelnen Unterschiede zwischen Produkt- und Geschäftsmodell-Innovationen zusammengefasst. Vor dem Hintergrund dieser Differenzen stellt sich die Frage, inwieweit dies zu einer anderen Ausgestaltung des Innovationsprozesses führen muss.

Tabelle 1: Vergleich Produkt- vs. Geschäftsmodell-Innovationen

Merkmal	Produkt-Innovationen	Geschäftsmodell-Innovationen
Innovationsgrad	Inkrementell bis radikal	Disruptiv
Technologie-Bezug	Hoch	Gering
FuE-Intensität	Hoch	Gering
Strategische Bedeutung	Gering bis hoch	Sehr hoch
Prozessbeteiligte	Funktions- bis abteilungsübergreifend	unternehmensweit
Prozessausrichtung	Zumeist Bottom-up	Zumeist Top-down

5 Prozessabläufe für Geschäftsmodell-Innovationen

Aufgrund der Bedeutung des Geschäftsmodells für ein Unternehmen sollte der Prozess für Geschäftsmodell-Innovationen immer systematisch, strukturiert und methodengestützt ablaufen. Damit wird u. a. sichergestellt, dass bei so einem komplexen und unternehmensweiten Prozess die Verantwortlichkeiten geklärt sind, Aufgaben nicht vergessen werden und grundsätzlich der Ablauf effektiv sowie effizient durchgeführt wird. Dies stellt bei Geschäftsmodell-Innovationen – wie auch bei Produkt-Innovationen – einen wesentlichen Erfolgsfaktor dar (Jonda 2004).

Im Gegensatz zu Produkt-Innovationen haben sich bei Geschäftsmodell-Innovationen in Forschung und Praxis noch Fumikazuetabliert (Schallmo 2013/2014/2015a/b, Weiner et al. 2010). Dennoch gibt es bereits einige Ansätze von Prozessmodellen (Bucherer 2010, Köster 2013, Schallmo 2013, Wirtz/Thomas 2014), die allerdings – im Vergleich zu den weit entwickelten Prozessmodellen bei Produkt-Innovationen – erheblich voneinander divergieren. Köster (2013) spricht hier von einer stark fragmentierten Forschungslandschaft. In der nachfolgenden Abbildung sind einige dieser Prozessmodelle exemplarisch und stellvertretend für den Stand der Forschung dargestellt. Sie unterscheiden sich nicht nur in ihrer Detaillierung und den verwendeten Begrifflichkeiten, sondern lassen sich auch anhand der einzelnen Aufgaben, unterstützenden Methodiken und der Phasen-Reihenfolge differenzieren. Vor allem in der frühen Innovationsphase, dem sog. „Fuzzy Front End“, sind größere Unterschiede in den Konzepten erkennbar, da der Anstoß bzw. die Quelle von Geschäftsmodell-Innovationen je nach Autor unterschiedlich gesehen wird. Zudem geben nur sehr wenige Autoren dezidierte Hinweise für die Praxis, welche methodischen Vorgehensweisen entlang der einzelnen Phasen zu empfehlen sind (Köster 2013, Wirtz/Thomas 2014).

6 Prozessmodell für Geschäftsmodell-Innovationen

Da – wie oben erwähnt – die bestehenden Prozessmodelle zu Geschäftsmodell-Innovationen die frühe Innovationsphase vernachlässigen bzw. wenige praxisrelevante Hinweise für die methodische Vorgehensweise geben, soll zur Schließung dieser Lücke im Folgenden ein Prozessmodell vorgestellt werden. In Anlehnung an das etablierte Stage-Gate-Modell von Cooper (2011) sowie dem Prozessmodell von Wirtz (2010: 216) werden hierzu verschiedene Phasen spezifiziert, die an bestimmten Stellen im Prozess Entscheidungspunkte haben, die sog. „Gates", um das Vorhaben fortzusetzen, zu modifizieren oder fallenzulassen. Um die berechtigte Kritik des zu starken sequentiellen Charakters am Stage-Gate-Prozessmodell (s. Müller-Roterberg 2018a) zu vermeiden, wird hier vorgeschlagen, dass der Prozess in einer Prototyping-Phase mit einem sog. Hypothesize-Design-Test-Learn-Zyklus entsprechend des Lean-Startup-Konzeptes (Ries 2012) auszuführen ist. In ähnlicher Weise sind auch Design-Thinking-Prozesse ausgestaltet (s. hierzu Müller-Roterberg 2018c). Das heißt, über die konkrete Ausgestaltung der Geschäftsmodell-Innovation sind Annahmen zu formulieren, die getestet werden, um daraus zu lernen. Zum Beispiel bietet es sich an, die Annahmen („Hypothesen") über die Wünsche, Bedürfnisse und Probleme der Kunden frühzeitig in Form von Experimenten zu testen, um daraus für die weitere Entwicklung zu lernen. Weiterhin lassen sich die Aufgaben in den einzelnen Prozessschritten in Form von Projekten bearbeiten, die sich wiederum nach den Prinzipien des agilen Projektmanagements durchführen lassen (s. zum agilen Projektmanagement s. Müller-Roterberg 2018a). Damit wird der Prozess iterativ und agil umgesetzt.

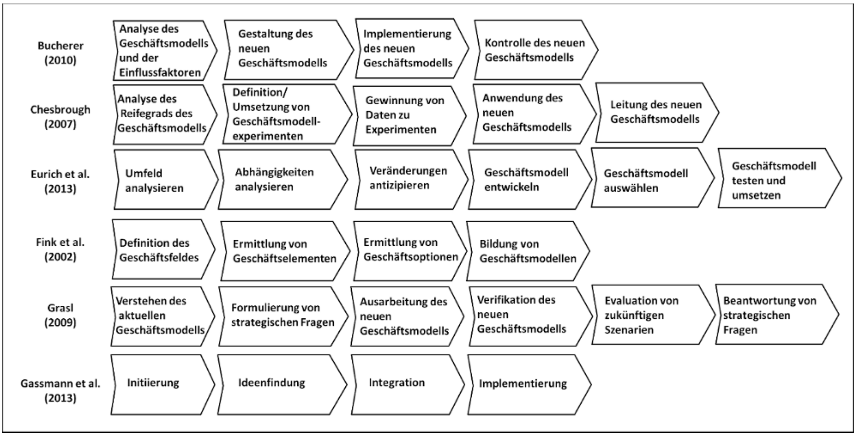


Abbildung 2: Prozessabläufe von Geschäftsmodell-Innovationen (I)

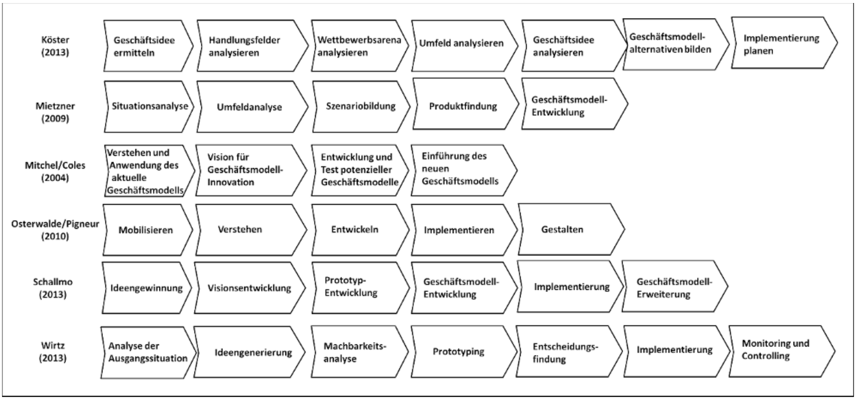


Abbildung 3: Prozessabläufe von Geschäftsmodell-Innovationen (II)

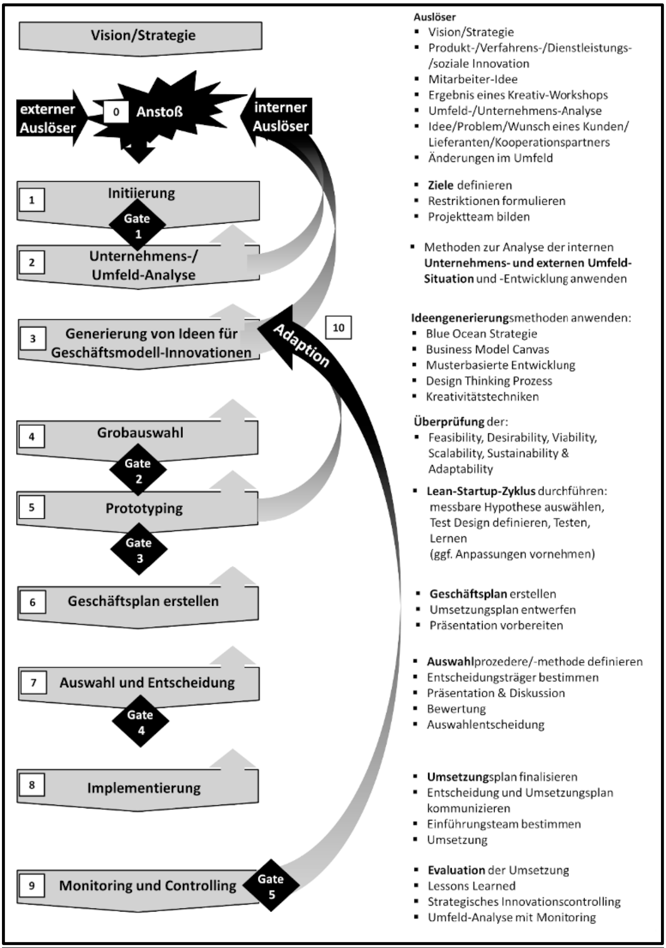
Nachfolgend sind die Schritte für dieses iterative und agile Prozessmodell zur Entwicklung von Geschäftsmodell-Innovationen kurz zusammengefasst (Abbildung 4). Eine ausführliche Darstellung dieses Prozessmodells findet sich in Müller-Roterberg (2019).

6.1 Anstoß und Initiierung [0/1]

Der Anstoß für die Entwicklung einer Geschäftsmodell-Innovation kann sehr vielfältig sein und soll hier in interne und externe Auslöser unterteilt werden:

Der Abgleich des bestehenden Geschäftsmodells mit der (Unternehmens-)Vision bzw. Strategie kann als interner Auslöser zur Einsicht führen, dass es einen akuten Handlungsbedarf zur Überarbeitung des Geschäftsmodells gibt. Zudem können die gerade initiierten oder laufenden Innovationsvorhaben, die zu neuen Produkten, Verfahren, Dienstleistungen oder zur Restrukturierung von administrativen Aspekten führen, ein neues Geschäftsmodell notwendig werden lassen. Wie oben bereits erwähnt, ist dies häufig bei radikalen oder disruptiven Innovationen der Fall. Das Erkennen von offensichtlichen Schwächen des Unternehmens bzw. die tiefergehende Analyse der aktuellen und zukünftigen Unternehmens- und Umwelt-Situation können des Weiteren Anlässe darstellen, dass Geschäftsmodell komplett zu überarbeiten und nicht nur inkrementelle Verbesserungen vorzunehmen (zu Methoden für die Unternehmens- und Umweltanalyse s. Müller-Roterberg 2018b). Strategisch denkende Mitarbeiter sind ebenfalls eine fruchtbare interne Quelle für Anstöße, die vielleicht zunächst scheinbar nur einen unbedeutenden Teil des Geschäftsmodells betreffen, dann aber die Notwendigkeit einer Geschäftsmodell-Innovation aufzeigen.

Externe Auslöser für Geschäftsmodell-Innovationen können ebenso aus sehr unterschiedlichen Quellen stammen: Kunden, Lieferanten, Händler, Forschungsinstitute, Hochschulen, Berater/Dienstleister können mit ihren Ideen, Problemen, Bedürfnissen, Wünschen oder Aufgaben die Initiierung eines Entwicklungsprozesses für ein neues Geschäftsmodell bewirken. In der Praxis häufig anzutreffen, ist die Initiierung eines solchen Innovationsvorhabens als Reaktion einer Veränderung in der Wettbewerbsstruktur bzw. bei dem größten Mitkonkurrenten. Ebenso können (abrupte) technologische, politisch-rechtliche, sozial-gesellschaftliche Einflüsse oder auch Natur-Ereignisse der Anlass sein. Ein Unternehmen sollte diese Anstöße nicht nur reaktiv auf sich zukommen lassen, sondern sollte mit den Methoden der Unternehmens- und Umfeldanalyse (s. Müller-Roterberg 2018b) sowie den Methoden zur Kundenorientierung (s. Müller-Roterberg 2018a) bzw. durch den hier dargestellten Innovationsprozess sein Geschäftsmodell permanent kritisch reflektieren und Verbesserungen bzw. substanzielle Änderungen anstreben.



Abbidlung 4: Prozessmodell zur Entwicklung von Geschäftsmodell-Innovationen

Nachdem der Anstoß für die Überarbeitung bzw. Neuentwicklung des bestehenden Geschäftsmodells gegeben wurde, sollte im Sinne einer systematischen (Top-down; s.o.) Vorgehensweise ein internes Projekt hierfür vom Top-Management initiiert werden. Hiermit beginnt offiziell der eigentliche Innovationsprozess. Idealerweise sollte die Initiierung des Projektes eine Veränderungsbereitschaft im Unternehmen erzeugen.

Als Erstes sind dabei die Ziele dieses Projektes zu definieren. Mit Geschäftsmodell-Innovationen lassen sich die strategischen Innovationsziele eines Unternehmens umsetzen. Im Einzelnen sind z. B. aus Kunden-/Wettbewerbs- und Unternehmenssicht folgende Ziel zu nennen (in Anlehnung an Schallmo 2013: 33f.): Einen neuen bzw. gesteigerten Kundenwert stiften und damit Kundenbindung erhöhen bzw. neue Kundensegmente ansprechen, Wettbewerbsvorteile schaffen bzw. verbessern, sich gegenüber der Konkurrenz klarer differenzieren und die Imitierbarkeit erschweren sowie neue Erlösquelle erschließen und verbesserte Kostenstruktur erzielen. Im Sinne einer klaren Zielbildung sind hier auch mögliche Vorgaben zu definieren. Dazu gehört auch präzise zu benennen, welche Restriktionen zu beachten sind. Dies kann die Eingrenzung des Suchfeldes oder Festlegungen bedeuten, welche Elemente des Geschäftsmodells (s. Osterwalder/Pigneur 2010) nicht oder nur in einem gewissen Rahmen verändert werden dürfen. Obwohl diese Vorgaben die Kreativität stark beschneiden können, wird damit die Strategie-Konformität und Umsetzbarkeit sichergestellt. Gleichwohl sollten solche Vorgaben gut begründet sein und kritisch hinterfragt werden. Gerade im Durchbrechen von Konventionen kann viel Kreativitätspotenzial stecken.

Sobald die Ziele grob definiert sind, sollte ein interdisziplinäres Projektteam zusammengesetzt werden. Da Geschäftsmodell-Innovationen alle Funktionen betreffen, sind hier leitende Personen aus der Forschung, Entwicklung, Produktion, Marketing, Vertrieb, Controlling und anderen Service-Einheiten (z. B. Rechts-/Patentabteilung, Qualitätsmanagement etc.) einzubinden. Das Kernteam sollte nicht mehr als fünf bis neun Personen umfassen. Schließlich ist das Zeit- und Kostenbudget für dieses Projekt sowie die Berichts- und Kommunikationswege abzuklären. Die grundsätzliche Durchführung dieses Projektes sollte sich nach den Prinzipien des agilen Projektmanagements (s. Müller-Roterberg 2018a) richten.

Zum Abschluss der Initiierungsphase sollte im Sinne eines „Gates“ die Entscheidung über die nachfolgende Frage fallen:

Gate 1

„Sind alle Voraussetzungen und Anforderungen an dem Projekt geklärt, dass sich zum Ziel setzt, eine Geschäftsmodell-Innovation zu entwickeln?“

6.2 Unternehmens-/Umfeldanalyse [2]

Im nächsten Schritt kann eine tiefergehende Analyse über die Ist-Situation und die zukünftigen Entwicklungen und Trends sowohl unternehmensintern als auch im Umfeld des Unternehmens durchgeführt werden. Hierfür bieten sich zahlreiche Methode der Unternehmens- und Umfeldanalyse an, die in Müller-Roterberg (2018a) ausführlich erläutert und in der nachfolgenden Tabelle zusammengefasst sind. Die Ergebnisse der Umfeld- und Unternehmensanalysen können Methoden wie z. B. die Portfolio-Technik und SWOT-Analyse ganzheitlich bewertet werden.

Tabelle 2: Methoden der Umfeld- und Unternehmensanalyse

Umfeldanalyse	Unternehmensanalyse
▪ Trendanalyse	▪ GAP-Analyse
▪ PESTEL-Analyse	▪ Stärken-Schwächen-Analyse
▪ Trend-Impact-Analyse	▪ Risikoanalyse
▪ Technologie-/Industrie-Entwicklungsmodelle	▪ Wertketten- und Prozess-Analysen
▪ Delphi-Methode	▪ Benchmarking
▪ Szenario-Technik	▪ Analyse der Dienstleistungsqualität
▪ Road-Mapping	▪ Kernkompetenzen-Methode (VRIO)
▪ Stakeholder-Analyse	**Ganzheitliche Methoden**
▪ Branchenstruktur-Analyse	▪ Portfolio-Analyse
▪ Konkurrenten-Analyse	▪ SWOT-Analyse
▪ Anforderungsanalyse	

6.3 Generierung und Auswahl von Ideen [3/4]

Sofern – wie bei jedem existierenden Unternehmen – ein aktuelles Geschäftsmodell vorliegt, sollte dieses durch die oben genannte Unternehmensanalyse bewertet werden. Bei der Betrachtung des Geschäftsmodells ist es wichtig, die richtige Flughöhe für die Analyse und Entwicklung zu finden („Nicht Bodenhöhe, sondern 10 000 Meter Flughöhe wird angestrebt" (Gassmann et al. 2017: 29)).

Eine einfache Möglichkeit die wesentlichen Elemente eines Geschäftsmodells mit der richtigen Flughöhe zu beschreiben, ist das Business-Modell-Canvas-Konzept von Osterwalder/Pigneur (2010). Dieser Ansatz ist auch dazu geeignet, Ideen für neue Geschäftsmodelle zu entwickeln. Hierbei wird das Geschäftsmodell in die einzelnen Elemente eines Geschäftsmodells zerlegt und für jedes Element die Gestaltungsmöglichkeiten bzw. -optionen betrachtet. Damit lassen sich neue Gestaltungsoptionen entwickeln bzw. im Ganzen neu kombinieren.

Unterstützend kann man dabei Kreativitätstechniken bzw. Methoden der Kundenorientierung (wie z. B. die Customer Journey) einsetzen. Nachfolgend ist eine Zusammenstellung von Kreativitätstechniken aufgeführt, die in Müller-Roterberg (2018c) ausführlich beschrieben werden und sich in intuitiv-kreative und systematisch-analytische Methoden einteilen lassen.

Eine weitere Möglichkeit zur Generierung von Geschäftsmodell-Innovationen ist der musterbasierte Ansatz (vgl. Gassmann 2017, Müller-Roterberg 2019), bei dem man Anregungen aus anderen Bereichen durch die Konfrontation bzw. Adaption von erfolgreichen Geschäftsmodellen bzw. Teilen davon bekommt.

Ergänzend sollte man für eine wettbewerbsorientierte Vorgehensweise bei der Ideengenerierung auch die Blue-Ocean-Strategie (vgl. Kim/Mauborgne 2005) verwenden. Damit ist es möglich, die dominante Branchenlogik zu erkennen und gezielt Konventionen zu durchbrechen. Hierbei sollte man aber immer antizipieren, dass der Wettbewerber darauf reagieren wird. Geschäftsmodelle, die neue Markteintrittsbarrieren schaffen, sind hier vorteilhaft.

Tabelle 3: Kreativitätstechniken

Intuitive-kreative Techniken	Systematisch-analytische Techniken
▪ Brainstorming	▪ Osborn-Checkliste (SCAMMPER)
▪ 635-Methode (Brainwriting)	▪ Mind-Mapping
▪ Reizworttechnik	▪ SIL-Methode
▪ Semantische Intuition/The perfect prefix	▪ Synektik/Bionik
▪ ABC-Wortliste	▪ Progressive Abstraktion
▪ Forced Relationship	▪ TILMAG
▪ Provokationstechnik	▪ Morphologischer Kasten/ Sequentielle Morphologie / Attribute Listing
▪ Walt-Disney-Methode	▪ HIT
▪ 6-Hüte Methode	▪ Lotusblüten-Technik
▪ Zukunftswerkstatt	▪ TRIZ
▪ Delphi-Methode	▪ SIT

Nach der Generierung von verschiedenen Ideen für Geschäftsmodell-Innovationen können in Anlehnung an Day (2007) in einer ersten qualitativen, checklistenartigen Bewertung die aussichtsreichsten Ideen nach den Kriterien Desirabilty, Feasibility, Viability, Sustainability/Scalability und Adaptability ausgewählt werden. Im Sinne einer Checkliste können mit diesen Kriterien folgende Fragen adressiert werden:

Ist die Geschäftsmodell-Idee wünschenswert/nützlich aus Kundensicht? („**Desirability**“/ „**Utility**“)

- Sind Kunden für das Geschäftsmodell identifizierbar?
- Kann man mit dem Geschäftsmodell einen Kundennutzen schaffen? Werden damit (unentdeckte) Wünsche des Kunden befriedigt?
- Passt das Geschäftsmodell zur Innovationsstrategie und kann es einen bedeutenden Beitrag zur Strategie leisten? Wird das Geschäftsmodell vom Top-Management gewünscht?
- Wird das Geschäftsmodell im Unternehmen akzeptiert? Passt es zur Kultur?
- Gibt es Synergien zu anderen Geschäftsbereichen bzw. Kompetenzen des Unternehmens?
- Lassen sich aus dem Geschäftsmodell Lerneffekte für das Unternehmen erzielen?
- Ist das Geschäftsmodell ethisch wünschenswert?

Ist die Geschäftsmodell-Idee machbar? („**Feasibility**“)

- Ist das Geschäftsmodell klar/verständlich/nachvollziehbar?
- Ist das Geschäftsmodell leicht nachzuahmen?
- Sind zur Umsetzung Lizenzen/Know-how von anderen notwendig?
- Ist es technisch umsetzbar?
- Sind hohe Investitionen für Entwicklung, Produktion und/oder Markteinführung/Vertrieb notwendig?
- Besitzt das Unternehmen die notwendigen Ressourcen/Kompetenzen zur Umsetzung? Wenn nicht, sind diese leicht/schnell beschaffbar?
- Sind Partnerschaften mit anderen (Unternehmen/Forschungseinrichtungen) nötig bzw. möglich? Sind diese schnell umzusetzen?

- Gibt es hohe Markteintrittsbarrieren?

Ist die Geschäftsmodell-Idee wirtschaftlich? („**Business Viability**“)

- Gibt es eine große Kaufkraft und -bereitschaft beim Kunden?
- Ist der Markt attraktiv und wächst dieser (dynamisch und langfristig)?
- Ist die zu erwartende Rendite attraktiv?
- Sind die Risiken für die Umsetzung des Geschäftsmodells bestimmbar/quantifizierbar/akzeptabel?

Ist die Geschäftsmodell-Idee langfristig bzw. nachhaltig tragbar? („**Sustainability/Scalability**“)

- Gibt es Vorteile gegenüber existierenden (bzw. möglichen neuen) Geschäftsmodellen der Konkurrenz?
- Sind die potenziellen Kunden auch langfristig bereit, dafür zu bezahlen?
- Ist das Geschäftsmodell skalierbar?
- Besitzt das Geschäftsmodell ökologische/gesellschaftliche Vorteile?

Ist die Geschäftsmodell-Idee passfähig zum dynamischen Umfeld? („**Adaptability**“)

- Ist das Geschäftsmodell passfähig bzw. anpassungsfähig an die dynamisch ändernde Umfeldsituation?
- Ist das Geschäftsmodell passfähig zu den politischen, gesellschaftlichen, wirtschaftlichen, rechtlichen/regulativen Rahmenbedingungen?
- Können weitere Geschäftsmodelle (-alternativen) für sich ändernde Situationen daraus entstehen?
- Ist der Zeitpunkt bei der Markteinführung des Geschäftsmodells ideal?

Auf Basis dieser (ersten) Bewertung ist am Entscheidungspunkt Gate 2 letztlich folgende Frage zu beantworten:

Gate 2

„Ist das Geschäftsmodell wünschenswert aus Sicht des Kunden, machbar, wirtschaftlich, nachhaltig, skalierbar und anpassungsfähig?“

6.4 Protoytyping [5]

Im Rahmen der Entwicklung eines Geschäftsmodells sollte jede Änderung eines Elementes oder die Wahl einer neuen Gestaltungsoption (s. Business Model Canvas von Osterwalder/Pigneur 2010) getestet werden. Es ist hierzu zu empfehlen, im Sinne des Lean-Startup-Ansatzes nach Ries (2012) eine Annahme (Hypothese) über die gewünschte Wirkung dieser Änderung bzw. Gestaltungsoption zu formulieren, ein geeignetes Testdesign auszuwählen, einen Test mit der relevanten Zielgruppe durchzuführen und aus den Ergebnissen zu lernen, um ggf. umzusteuern. Da die zu testenden Hypothesen möglichst in einer visualisierten, im weitesten Sinne greifbaren funktionsfähigen Art und Weise vorliegen sollten, spricht man hier auch von Prototyping (vgl. Müller-Roterberg 2018c). Idealerweise sind hier mehrere Alternativen gleichzeitig und vergleichend zu testen. Plakativ spricht Schrage (2014) von der 5 x 5 x 5 x 5 x 5–Formel: Fünf Teams von je fünf Personen machen je fünf Tests in fünf Wochen für maximal je 5.000 Euro.

Tabelle 4: Prototyping-Techniken im Rahmen der Geschäftsmodell-Entwicklung

Prototyping-Methoden	
▪ Vor-Ort Interviews	▪ Interviews auf neutralen Platz
▪ Telefon-Interviews	▪ Video-Chats
▪ Instant Messaging	▪ E-Mails
▪ Online-Befragungen	▪ Fokus-Gruppen
▪ Kundenbeobachtungen ▪ Tagebuch des Kunden ▪ Cultural Probes ▪ Experience Sampling	▪ Kundenkliniken
▪ Usability-Tests/Live Testing	▪ Zeichnungen
▪ Modellkonstruktionen	▪ Storyboarding ▪ Storytelling
▪ Comics	▪ Rollenspiele ▪ Bodystorming ▪ Lego Serious Games
▪ Wireframes/Mockups	▪ Websites/Landing Pages
▪ Videos	▪ Concierge-Minimum Viable Prototypes
▪ Wizard-of-Oz-Minimum Viable Prototypes	▪ Open-Source-Prototypen
▪ 3D-Rapid-Prototyping	▪ Crowdfunding
▪ Business Model Canvas	

Die Tests für die Ausgestaltung der Geschäftsmodell-Elemente Schlüsselpartner, Ressourcen und Schlüsselaktivitäten (s. Business Model Canvas von Osterwalder/Pigneur 2010) lassen sich „Backstage“ handhaben, denn hier kann auf die Expertise der eigenen Mitarbeiter bzw. Kooperationspartner zurückgegriffen werden. Die Tests über die Geschäftsmodell-Elemente Nutzenversprechen, Kundensegmente, Beziehungen, Kanäle und Erlösmodelle sind wiederum „Frontstage“ durchzuführen, da hier ein Kundenfeedback eingeholt werden muss. Um diese Test durchzuführen und die Annahmen bzw. die Ausgestaltungsoptionen für den Kunden anschaulich und greifbar werden zu lassen, bieten sich die in der nachfolgenden Tabelle zusammengefassten Prototypen-Techniken an. Eine ausführliche Beschreibung dieser Prototyping-Techniken findet sich in Müller-Roterberg (2018c).

Ausführliche Empfehlungen zur Durchführung des Lean-Startup-Ansatzes, der entgegen des Namens auch bzw. gerade für bestehende Unternehmen geeignet ist, finden sich bei Ries (2012) bzw. in Müller-Roterberg (2018a). Diese iterative Durchführung von Tests mit der gezielten Weiterentwicklung des Geschäftsmodells auf Basis eines frühzeitigen Kundenfeedbacks ist gerade bei der komplexen und unsicheren Entwicklung von Geschäftsmodell-Innovationen ein zielführendes Konzept.

Am Entscheidungspunkt Gate 3 ist somit folgende Frage zu beantworten:

Gate 3

„Welche Gestaltungsoptionen des Geschäftsmodells können verwendet, welche müssen geändert/verworfen werden?“

6.5 Geschäftsplan erstellen [6]

Sofern die Annahmen zum Geschäftsmodell durch das Kundenfeedback ihre Bestätigung bekommen haben, kann auf dieser Basis ein Geschäftsplan entwickelt werden. Wenn es sich um das Geschäftsmodell des kompletten Unternehmens handelt, spricht man von einem Businessplan ansonsten auf Projektebene von einem Business Case. Eine detaillierte Anleitung zur Entwicklung eines Businessplans/Business Cases findet sich ausführlich in Müller-Roterberg (2019).

Bei bestehenden Unternehmen ist so ein Geschäftsplan für die Entscheidungsfindung notwendig, da es sich hier um eine strategisch wichtige Entscheidung handelt. Bei Unternehmensgründungen oder Startup-Unternehmen fordern die externen Investoren häufig derartige Geschäftspläne an. Ist dies allerdings nicht notwendig und wird auf eine schnelle flexible Entscheidung z. B. aus Wettbewerbsgründen mehr Wert gelegt, kann auch ein ausführlicher Business Model Canvas (vgl. Osterwalder/Pigneur 2010) als Entscheidungsgrundlage dienen.

Der Geschäftsplan sollte auch einen ersten Entwurf des Umsetzungsplans umfassen. Damit lassen sich die Umsetzungsgeschwindigkeiten/-risiken und Aufwände abschätzen.

Abschließend sollte das Geschäftsmodell nochmals auf Konsistenz der einzelnen Elemente überprüft werden und ggf. optimiert werden. Die Positionierung im Sinne eines Alleinstellungsmerkmals (Unique Selling Proposition; USP) gegenüber anderen sollte zudem klar erkennbar sein.

6.6 Auswahl und Entscheidung

Die Auswahl eines Geschäftsmodells und die Entscheidung über dessen Umsetzung ist eine weitreichende strategische Entscheidung, die in der Verantwortung des Top-Managements liegt. Am besten ist schon im Rahmen der oben genannten Initiierung zu klären, wer zu den Entscheidungsträgern gehört, welche Entscheidungskriterien mit welchen Bewertungsmethoden angewendet werden und welche Informationen mit welchem Detaillierungsgrad hierfür vorliegen müssen. Nur wenn dies vorab definiert ist und allen Beteiligten kommuniziert wurde (insbesondere dem Projektteam zur Erarbeitung eines Geschäftsmodells), kann effektiv und effizient der Auswahl- und Entscheidungsprozess durchgeführt werden.

Neben den oben bereits genannten qualitativen Kriterien Desirabilty, Feasibility, Viability, Sustainability/Scalability und Adaptability zur checklistenartigen Bewertung stehen zahlreiche weitere Methoden zur Verfügung, die von rein qualitativen bis hin zu quantitativen Methoden aus dem Bereich der Wirtschaftlichkeitsrechnung reichen. Eine Übersicht von potenziellen Bewertungstechniken findet sich in der nachfolgenden Tabelle, wobei in dieser noch frühen Phase der Geschäftsmodellentwicklung die qualitativen Techniken zielführender sind. Vor allem das Scoring-Verfahren zum Vergleich verschiedener Geschäftsmodellalternativen unter Berücksichtigung von qualitativen und quantitativen Kriterien ist hier für die unternehmerische Praxis zu nennen.

Neben der Entscheidung über ein Geschäftsmodell sollte auch über den Umsetzungsplan formal entschieden werden. Dieser Plan umfasst die im nächsten Abschnitt genannten Aspekte.

Am Entscheidungspunkt Gate 4 ist somit folgende Frage zu beantworten:

Gate 4

„Welches Geschäftsmodell wird wie und wann umgesetzt?“

Table 5: Bewertungstechniken für Geschäftsmodell-Ideen

Bewertungstechniken	Erläuterung bzw. Literaturangabe für ausführliche Beschreibung
Checklisten mit Ja/Nein-Abfragen	s.o. mit den Kriterien Desirabilty, Feasibility, Viability, Sustainability/Scalability und Adaptability.
Advocatus Diaboli vs. Advocatus Angeli	Je eine Person schlüpft in die Rolle des Kritikers (Advocatus Diaboli) und/oder des Verteidigers (Advocatus Angeli) der betrachteten Geschäftsmodell-Alternative.
Pro-/Kontra-Bilanz	Argumente Pro und Contra zu den Geschäftsmodell-Alternativen werden gegenüber gestellt.
Rosinenpicken	Jeder Teilnehmer wählt seinen Favoriten und begründet dies kurz.
Kartenreihung	Karten mit Vorschlägen zu Geschäftsmodellen werden in eine Reihung gebracht.
Dot-Voting (Dotcrazation)	Abstimmung über die Geschäftsmodell-Alternativen mit Klebepunkten, die jeder Teilnehmer in einer bestimmten Anzahl bekommt und frei verteilen darf.
COCD-Box	Ideen für neue Geschäftsmodelle werden anhand der beiden Dimensionen Originalität und Schwierigkeitsgrad der Umsetzung in drei Felder einsortiert: Now: Geschäftsmodell, das man sofort umsetzen kann. Wow: Geschäftsmodell, das sehr originell und umsetzbar ist. How: Geschäftsmodell, das sehr originell, aber schwer umsetzbar ist. Mit unterschiedlich farbigen Punkten kann jeder Bewertungsteilnehmer die Geschäftsmodelle klassifizieren.
Ich mag, ich wünschte, wie wäre es, wenn	Jeder Bewerter soll bei den entwickelten Geschäftsmodellen beschreiben, was er daran mag, wie er sich dieses Geschäftsmodell als Lösung wünschen würde und wie aus seiner Sicht das ideale Geschäftsmodell sein könnte, wenn irgendetwas möglich wäre.
Opus-Methode	Die unten stehenden Statements zu den entwickelten Geschäftsmodellen werden auf Karten geschrieben und die Bewerter sortieren diese Karten in Schachteln, die mit „Ich stimme zu“, „Ich stimme teilweise zu“, „Ich stimme nicht zu“, „Ich habe keine Meinung“. Statements zu den Geschäftsmodellen können z. B. sein: „Kunden werden das Geschäftsmodell mögen, weil …“ „Der Nutzen des Geschäftsmodells ist …“ „Das Geschäftsmodell ist der Konkurrenz überlegen, weil….“ „Die Umsetzung des Geschäftsmodells wird funktionieren, wie …“ „Die Finanzierung des Geschäftsmodells wird funktionieren, weil …“ (In Anlehnung an Michalko 2006 bzw. Aerssen van/Bucholz 2018: 354).
PPCO-Methode	s. Management-Handbuch Innovation von Müller-Roterberg (2018a)
6-Hüte-Methode/Walt-Disney-Methode	
Portfolio-Technik	s. Praxishandbuch Innovationscontrolling von Müller-Roterberg (2018b)
Entscheidungsbaum	
SWOT-Analyse	
Scoring-Verfahren	
Präferenzmatrix (Paarvergleich)	
Net Present Value	
Real-Options-Verfahren	
Interner Zinsfuß	
Return-on-Investment (RoI)	
Amortisationsdauer („Payback“-Periode)	

6.7 Implementierung und Steuerung

Der Umsetzungsplan sollte folgende Aspekte umfassen (vgl. Wirtz 2010: 260f.): Realisierungspläne mit Fristen/Termine und insbesondere den Meilensteinen, Budgetierung der Implementierung (Schulungskosten, Aufbau einer neuen Infrastruktur etc.), Auswahl geeigneter (fachlich als auch sozial/kommunikativ) Teammitglieder für die Einführung, Teamausstattung, Festlegung von Maßnahmen zur Umsetzung einschließlich der begleitenden Kommunikationsmaßnahmen sowie Festlegung der Verantwortlichkeiten und Aufgaben bei der Implementierung.

Die oben in der Phase 2 erläuterte Unternehmens- und Umfeldanalyse sollte als ein permanent durchzuführender Prozessschritt verstanden werden. Auf dieser Basis sollten mit einem Monitoring über einen längeren Abschnitt die Trends und Entwicklungen im Umfeld des Unternehmens beobachtet werden. Die zugrundeliegenden Annahmen des Geschäftsmodells sind wiederum im Sinne eines Prämissen-Controllings regelmäßig zu hinterfragen. Der oben erwähnte Lean-Startup-Ansatz (Ries 2012) ist hierfür auch während der Umsetzung einzusetzen, um durch frühzeitiges Feedback einen Änderungsbedarf zu erkennen. Wie der Erfolg, Hindernisse und Risiken bei der Umsetzung des Geschäftsmodells frühzeitig identifiziert werden können, ist ebenso vorab zu klären. Methoden aus dem Innovationscontrolling, wie z. B. das Erheben und Analysieren von geeigneten Kennzahlen sowie Methoden des Risikomanagements (vgl. Müller-Roterberg 2018b) können hier hilfreich sein.

Am Entscheidungspunkt Gate 5 ist somit folgende Frage zu beantworten:

„Muss das Geschäftsmodell angepasst werden?“

Schließlich ist das Geschäftsmodell regelmäßig auf Basis der Informationen des Monitorings und Controllings an das dynamisch verändernde Umfeld anzupassen.

Die oben aufgeführten Schritte vom Anstoß bis zur Adaption des Geschäftsmodells sind hier zur besseren Übersichtlichkeit sequenziell dargestellt, gleichwohl umfasst dieser Prozess – wie bereits eingangs erwähnt – in jeder Phase Rückkoppelungen, wie es in der Abbildung 4 angedeutet ist. Je nach Unternehmenssituation (großes, bestehendes Unternehmen vs. kleines, neu gegründetes Unternehmen) werden nicht alle Schritte in dieser Ausführlichkeit durchgeführt. Dennoch umfasst der hier vorgestellte Prozess eine Ausführlichkeit, die der Bedeutung des richtigen Geschäftsmodells für ein Unternehmen angemessen ist.

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Chapter 5

Developing Innovation Culture in the Baltics: Organizational Challenges in a Time of Transition

Monika Petraite

Abstract

The development of innovative culture within an organization is listed among the core factors for innovation sustainability and continued success within organizations. However, neither the phenomena of innovative culture was studied in depth at the micro level, nor the organisational factors, influencing the formation of certain innovation culture profiles within an organisation were analysed, nor especially, their underpinnings tested at the empirical level. The paper focuses on the understanding of innovation culture formation within business organizations, in depth analysis of the core organizational factors, influencing this formation and finally, also defining the diversity of innovation culture profiles in business organizations. The analysis of those factors contributes to the understanding of the phenomenon of innovation culture in business organisations from the empirical perspective, but also provides the ground and implications for action in designing innovative organisations and developing innovation cultures in catching up countries, as the paper is based on empirical findings from Lithuania.

Keywords: Innovation culture profiles, business organizations; organizational design

1 Introduction

Since the final decades of the 20th century, a great deal of interest has been shown in the concept of innovation and the effects of innovation culture on organizational performance (Anderson, 1998; Dobni,2008). OECD (2012) pointed out that it is increasingly recognized that innovation is influenced by certain social and cultural values, norms, attitudes and behaviors, which may be described as innovation culture. Research demonstrates that organizational innovation culture exerts a strong influence on innovation performance. For example, Hurley (1995) shows that the characteristics of organizational innovation culture (such as power-sharing, support and cooperation, career development and participation in decision making) demonstrate a significant impact on an organization's innovation rate. Claver et al. (1998) conclude that organizational innovation culture is the premise of technological innovation and innovation performance. Similarly, Deshpandé et al. (1993) and Kleinschmidt et al. (2007) indicate that an innovation-oriented firm's culture provides a competitive advantage by increasing the emphasis on innovation and fostering receptiveness to new ideas. Stock et al. (2013) show that a company's innovation-oriented culture positively affects business performance by increasing product program innovation.

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R. Tiwari and S. Buse (eds.), *Managing Innovation in a Global and Digital World*, https://doi.org/10.1007/978-3-658-27241-8_6

However, the analysis of organizational innovation culture faces methodological challenges, associated with the conceptual perspectives it takes. Following *emic* approach, the organisational innovation culture can be seen as a set of unique and not replicable values and norms that enable innovative activity (Pike, 1967, Jucevcius 2007). Alternately, following *etic* approach (Pike, 1967), organizational innovation culture can be defined by means of theoretical analysis and common factors, characterising successful innovation culture, that are shared by all successful organizations and can be revealed by application of empirical and statistical analysis methods. Therefore, in the analysis of organizational innovation culture, it is important to acknowledge the uniqueness of local cultural and business values (that potentially might affect innovation activity) with the universal features of innovation culture. This supports the idea of potential coexistence of common (or universal) innovation culture characteristics and contextual innovation culture characteristics, namely which are of interest in our study. However, empirical value based sociological investigation constructs have limitations, as they might reveal a wishful thinking rather than the actual state of the art. However, organizational norms, and values can be studied via the organizational behaviours and practices which are easier to monitor and through which innovation culture manifests. This approach allows to study organizational innovation culture constituents that are developed and shaped by organizational design characteristics. In sum, organizational designs, processes, routines and metrics define the framework for innovation culture development and manifestation.

Studies of organizational innovation culture and behaviours has been studied in various national and industrial contexts, including Herstatt et al. study on Innovation cultures in Germany, Japan and also industrial studies by Jucevcius and Stanevice in Lithuania. With this study we aim to look at the specific context of innovation culture development in businesses of a transition economy. The typical challenges the firms face during the transition is the need to combine benefits of cost efficiency and productivity increase with the more sophisticated innovation oriented activities in order to ensure the smooth transition towards an innovation driven economy and knowledge based sources of competitiveness. This causes a specific combination of organizational routines and practices, that might deviate from the "golden standard" set by firms in the well-developed robust innovative economies. The countries in rapid transition face socio – cultural change as well, and a specific challenge of shifting productivity and "zero mistake" tolerance cultures in business towards learning, creativity and innovation oriented cultures with high tolerance for uncertainty. The selected cases of our study are Baltic economies and their firms that exactly are in the moment of transition from productivity driven growth to the innovation driven growth (WEF, 2017) and are facing both, managerial and organizational shifts with an aim to develop more innovation supportive cultures. This requires the Baltic countries, including Lithuania (our in depth case study), to search for context specific innovation culture development approaches along with unique innovation activity coordination mechanisms. The manifestation of contextual and universal innovation culture characteristics varies depending on the sectorial and organizational demographics, whereas the organizations on top of universal innovation culture characteristics also manifest sector specific features and organizational innovation culture profiles.

The research design aims at revealing specific characteristics that would allow to define innovation culture profiles across sectors and organizational demographics, while studying systemic underpinnings of so called "soft" and "hard" organizational characteristics within the certain innovation culture profiles. The entire approach is based on the idea of Ba by Nonaka (1998), where particular attention is given to knowledge creation contexts and environments.

The approach is complemented with organizational design approach, which provides a systemic view on the organizational innovation culture constituents manifesting through organizational practices, orientations, processes and supporting structures (Stanford, 2007). Entire practices vary significantly across sectors and organization demographics, which implies the studies of universal innovation culture characteristics to be insufficient in order to explain and support the development of innovation culture within business sectors. In order to understand the formation of organizational innovation culture, we need to focus on the understanding of sectorial and organizational contexts and their effects on the phenomena studied.

Based on this problem formulation, the chapter aims at providing organizational innovation culture profiles in business organizations in Lithuania, as based on the empirically tested characteristics and their manifestations. Although this paper does not provide a prescriptive method for business organisations to follow in order to become innovative, it does identify what organizational factors and their configurations are important in shaping an organisation's innovative culture. We also were able to extract universal and distinct features of organizational culture manifestations within the sample organizations, which have allowed to form a distinct innovation culture profiles. The analysis and discussion is based on the original Innovation Culture Survey in Business (Janiunaite, Petraite and Jucevicius, 2011) results from the selected sample of Lithuanian innovative organizations from various industry sectors, (total sample reached 300 innovative organisations) .

The first chapter, provides the theoretical perspective in innovation culture manifestation and analytical approaches in business. Secondly, we look at the empirical data analysis along the organizational design constituents from the perspective of innovation culture manifestation, and extract universal innovation culture parameters, valid for Lithuanian organizations. Third, we look at the distinct features of innovative behaviours and form innovation culture profiles along sectors and organization sizes. Finally, the look on the overall innovation culture development in Baltic business organizations is provided, with further research implications following.

2 Frameworks for innovation culture analysis and profile identification in business organizations

Innovation culture, which emphasizes a behavioural pattern, in which all members of the organization mobilize positive factors to innovate and collaborate, is a new type of culture which emerged together with the boom of innovation in business. An innovation culture can make it easy for senior management to implement innovation strategies and plans (Ahmed, 1988, Tellis et al., 2009; Xie et al., 2014). The definition of innovation culture (very much as any other culture related definition) is facing the methodological “black box”, i.e. authors demonstrate the tendency to define by the term almost everything that is associated with complex innovation activities in an organization.

As Buckler (1997) suggests, innovation culture is an environment and an almost spiritual force that exists within a company and drives value creation. Heindenreich (2001) defines innovation culture as ‘a relatively stable way of reflection, behaviour and social organization taking place on the basis of corporate values’. Sutton (2001) suggests that organizations’ innovative culture manifests when organizations’ employees are encouraged to experiment and to implement innovations together with organizations’ managers, who support the ideas and incentives. Thornherry (2003) proposes that organizational innovation culture is a synthesis of values, attitudes, beliefs and ideas within the company which aim to reward innovation, encourage risk-taking and engage flexibly with a complex environment. Wieland (2006) defines 'innovation culture as made up from technological visions, research traditions, value systems, etc., shared by those who take part in the innovation process. Jucevicius (2007) defines 'innovation culture' as the entirety of unique culture values, which are characteristic to every society and organization as well as enable formation of innovative activity specific for that social formation. Dobni (2008) argues that innovation culture in an organization can be broadly defined as ranging from the intention to be innovative, to the capacity to introduce some new prod-ucts, services, or ideas, through the introduction of processes and systems which can enhance performance. According to Xuemei (2016), the core concept of innovation culture can be summarized as the intention of excitation, encouraging innovation and improving performance of organization. The brief presentation of definitions above implies that the concept of innovation culture is complex and embraces a large variety of approaches. The innovation culture has been studied from both, the innovation management perspective, which mainly focused on its contents (Tidd, Bessant and Pavitt, 2005), and the organizational studies per-spective, which put the emphasis on the organizational design as a basis for innovation culture. Thus, the definitions of organizational innovation culture represent the underpinning of both research traditions. The given spectrum of innovation culture definitions allows us to define an organization's innovation culture as the manifestation of the entirety of innovation friendly characteristics of organizational practices, processes, supporting structures, designs and capabilities that enable its innovation, creativity and productive innova-tive outputs. Given this definition, we need to look at the organizational processes, structures and behaviours and study them from the innovation promotion perspective. Here, again, we have numerous studies to exam-ine the characteristics or dimensions of an organizational innovation culture (Ceylan, 2013; Christensen and Raynor, 2003; Hammer, 2004; Govindarajan and Trimble, 2005). Culture in organizations as the deep-seated values and beliefs are shared by employees at all levels (Schein, 1984). Accordingly, an organizational inno-vation culture epitomizes the expressive character of employees and is communicated and reinforced through symbolism, feelings, relationships, language, behavior, physical settings and artifacts (Schein, 1984). Lemon and Sahota (2004) developed a set of conceptual models of organizational culture, including the firm's environment, values, technology, knowledge structures, organizational structure, individuals and the collective and organizational memory. In addition, Dobni (2008) argues that an innovation culture can be defined as a multi-dimensional context including the intention to be innovative, the infrastructure to support innovation, the operational-level behaviors necessary to influence a market and value orientation and the environment required to implement innovation.

The developed framework for analysis (Petraite, 2012) integrates the most important dimensions of organizational design, that could be assigned to the „hard" organizational dimensions, such as organizational structure and infrastructure and regarded as the key defining constituents for organizational processes; strategy (including vision, mission) and related performance measurement and monitoring systems, but also „soft" organizational factors, such as leadership and management practices, including support for innovation activity, organizational processes, organizational learning, communication and networking for innovation, which together constituted large blocks of empirical research characteristics.

Innovation strategy and related organizational design characteristics, such as its structure and infrastructure alignment with the innovation activity purposes, managerial practices (innovation activity organization and monitoring) form an explicit and relatively simple framework to diagnose organizational preconditions for innovation culture. Consequently, they also form the group of powerful tools for innovation culture development and change in an organization, as they build organizational platform for innovation activities and define preconditions for organizational processes, which are directly reflected in innovation culture dimensions. Qualitative features such as leadership and management communication processes are directly shaping organizational culture, innovation support practices and organizational learning for innovation, which leads to distinct innovation performance. Thus, actual innovation performance is defined by both „hard“ and „soft“ organizational characteristics. Innovation culture profile results as a complex and specific combination of above listed characteristics, that form unique organizational clima („ba“) for innovation within an enterprise and entire business sectors.

3 Empirical data collection and analysis methodology

The organizational innovation culture determinants were linked to the innovation culture characteristics and transferred into the diagnostic tool (Janiunaite, Petraite and Jucevicius, 2011) that was applied for empirical investigation.

In order to achieve the research goal the large scale survey was applied. The research questionnaire was designed by referring to the above distinguished characteristics of organizational innovation culture. Nine large building blocks were constructed, reflecting the organizational design characteristics impacting innovation culture, namely, organizational innovation strategy, organizational structure, organizational infrastructure, organization and monitoring of innovation activities, organizational culture in relation to innovation, organizational communication, knowledge and learning processes for innovation, support for innovation and management profile for innovation.

The case study country was Lithuania and the survey was executed in Lithuanian language. The method of mixed sample formation was chosen, where the sectoral characteristics were combined with demographic characteristics. First, business organizations were identified according to their activity sector and size. In the next step the auxiliary criteria were added, namely the organizations had to demonstrate innovative activity in terms of products, processes or both. In these organizations the respondents were selected by expert selection method. The criteria that determined the expert selection were: 1) a respondent works for this organization, 2) the respondent‘s work profile is that he/she has the expertise on innovative activity in the organization. In total 290 respondents, representing individual organizations, participated in the survey. The geography of the survey was limited to Lithuania (a Baltic country) and embraced different industries. The collected data was coded into SPSS. The logic of empirical data analysis and application of analytical tool sequences was determined by the goal of our research – identification of the diversity of innovation culture profiles in business organizations along industry and organization size. The second determinant was the research instrument that constituted of large sets of organizational dimensions and characteristics, as retrieved form the literature analysis. And last but not least, another determinant was the logic of empirical data collection that was based on the sample of innovative organizations from the NACE rev. 2 business related sectors (i.e. C to N). Based on these determinants, the data analysis followed three steps: first, data condensation via factor analysis, second, search for statistically important differences between various groups of respondents (grouped along NACE rev. 2 classes and business organization size) via single-factor dispersion analyses (ANOVA and DUNCAN tests), and third, comparison of the dispersed data groups via descriptive statistics, which allowed to distinguish innovation culture profiles across business sector related organizations.

Research instrument constituted of 9 large organizational dimensions research blocs, the number of characteristics measured within each block varied from 13 to 44. Likert scale was chosen for the evaluation of each factor (1 –strongly disagree, 3 – no opinion, 5 – strongly agree), which was transferred into SPSS data sets.

In the first step of data condensation via factor analysis, the factor wage limitation $p > 0.5$ was introduced. KMO of each factor block varied from 0.902 to 0.770. 33 significant factors were condensed from the factor analysis, which allowed linking of tested and internally correlating organizational characteristics to the meaningful factors. As a result, factor analysis provided theoretical framework of organizational culture dimensions with qualitative meanings that are presented in the Table 1.

Table 1: Universal organizational innovation culture factors in business organizations.

	Factor title	*Number of statements*	*KMO*	*Factor loadings (max-min)*
Organisational innovation strategy	Explicit innovation strategy	6	0,770	0,758-0,58
	Adequate resources for innovation	3		0,818-0,718
Organizational structure	Flexible and initiative supporting organizational procedures	6	0,771	0,793-0,637
	Distributed decision making rights	3		0,771-0,586
	Clear allocation of innovation tasks	5		0,807-0,58
	Strictly regulated organisational structure	2		0,796-0,718
	Competence and project based dynamic organizational structure	2		0,688-0,519
Profile or organizational infrastructure	Participation (of users and employees) facilitating IT platform	3	0,774	0,802-0,587
	Effective and flexible information and innovation experience management system (Explicit knowledge for innovation management system)	4		0,819-0,617
	Creativity and cooperation facilitating physical organizational infrastructure (Facilitating tacit knowledge management for innovation)	4		0,815-0,633
	Innovation partnership supporting IT and physical infrastructure (Networked knowledge management infrastructure	3		0,854-0,62
Organization and monitoring of innovation activities	Effective management of innovation processes	9	0,838	0,743-0,51
	Effective system of innovation activity monitoring and results measurement	6		0,762-0,568
	Effective and precise innovation management decision making	2		0,764-0,611
Organizational culture in relation to innovation	Organisational climate supporting diversity of ideas and opinions	7	0,896	0,822-0,55
	Value based orientation towards innovation	8		0,743-0,55
	High tolerance of innovation risks	2		0,801-0,657
Organizational communication	Effective system of innovation activity communication	15	0,902	0,845-0,526

Knowledge and learning processes for innovation	R&D knowledge development for innovation	6	0,782	0,888-0,788
	Individual and group based innovation competence development	5		0,763-0,56
	Learning for innovation supporting organizational systems	4		0,766-0,566
	Absorption of internal and external innovation experiences	5		0,75-0,51
	Enabling learning results for innovation	2		0,756-0,718
	Development of strategic innovation competencies internally	3		0,774-0,511
	External sourcing for innovation ideas	3		0,85-0,565
	Support for creativity for innovation	3		0,687-0,487
	Internal experience based learning for innovation	2		0,819-0,758
	Routine based and customer oriented organizational learning	2		0,717-0,606
Support for innovation	Concentration and direction of human resources towards innovation activity	7	0,793	0,763-0,544
	Innovation supporting motivation and career system	5		0,818-0,583
Management profile for innovation	Distinction of innovation as a management field	6	0,826	0,802-0,547
	Competence based dynamic management	2		0,861-0,763
	Formal fixed management	2		0,814-0,812
	Professional management of innovation	2		0,761-0,564

The universal organizational characteristics constituting innovation culture in Lithuanian organizations were empirically retrieved. These will be tested across sectors and organization sizes with the next step in search for diversities within each factor.

Important common innovation culture characteristics in Lithuanian business organizations are as follows:

- *Innovation strategy:* explicit, with adequate resource acquisition and allocation at the strategic planning level;
- *Organizational structure related determinants*: flexible and initiative supporting organizational procedures; distributed decision making rights; clear allocation of innovation tasks; competence and project based dynamic organizational structure as an opposite to strictly regulated and inflexible organizational structure;
- *Organizational infrastructure related determinants:* participation (of users and employees); innovation facilitating IT platform; effective and flexible information and innovation experience management systems; creativity and cooperation facilitating physical organizational infrastructure; Innovation partnership supporting IT and physical infrastructures;
- *Organization and monitoring of innovation activities:* Effective management of innovation processes, effective system of innovation activity monitoring and results measurement, effective and precise innovation decision making;
- *Organizational culture in relation to innovation:* organizational climate supporting diversity of ideas and opinions, value based orientation towards innovation, high tolerance of innovation risks;
- *Organizational communication:* effective system of innovation activity communication;
- *Knowledge and learning processes for innovation:* R&D knowledge development for innovation, individual and group based innovation competence development, learning for innovation supporting organizational systems, absorption of internal and external

innovation experiences, enabling learning results for innovation, development of strategic innovation competencies internally, external sourcing for innovation ideas, support to creativity for innovation, internal experience based learning for innovation, routine based and customer oriented organizational learning;

- *Organizational support for innovation:* concentration and direction of human resources towards innovation activity, innovation supporting motivation and career system;
- *Management profile for innovation:* distinction of innovation as a management field, competence based dynamic management as an opposite to formal fixed management, professional management of innovation.

The second step of empirical data analysis aimed at search of statistically important differences between various factors across respondent groups, based on business sector (NACE rev. 2, C to N) variable in order to distinguish sector specific innovation culture characteristics. Single factor dispersion analysis (ANOVA) and DUNCAN test allowed revealing sector specific organizational innovation culture dimensions, complementing universal innovation culture characteristics (see Table 1). This method allowed distinguishing the only factors, which were statistically different across sectors. In this step the statistically important difference was assigned when $p<0,05$. From 33 factors, retrieved in the first step of data analysis, seven factors were further condensed, which were especially important in search for varieties of innovation culture profiles across business sectors. The third step of data analysis was focused on the 7 retrieved factors with an aim to reveal specific organizational innovation culture features as related to business sector, that differentiate from the overall innovation culture profile as retrieved in the first step.

The step four repeated the logic of step 2 and 3 and focused on search of statistically important differences between various factors across respondent groups, based on enterprise size (small, (1-49 employees), medium (50-249 employees), large (250+ employees)) variable. Single factor dispersion analysis (ANOVA) and DUNCAN test allowed revealing enterprise size specific organizational innovation culture characteristics, complementing universal innovation culture characteristics. This method allowed distinguishing the only factors, which were statistically different across enterprise size. In this step the statistically important difference was assigned when $p<0,05$. From 33 factors, retrieved in the first step of data analysis, nine factors were further condensed, which were especially important in search for varieties of innovation culture profiles across different sizes of organizations. The next step of data analysis was focused on the nine retrieved factors with an aim to reveal specific organizational innovation culture features as related to business organization size, that differentiate from the overall innovation culture profile as retrieved in the first step (see Table 3).

Research limitations derive from the single country based sample (Lithuania) and the single data collection method applied, that does not allow triangulation, which might be important in revealing specific innovation culture development determinants.

4 Diversity of innovation culture profiles in business organizations: industry and size related determinants

4.1 Factors, determining innovation culture profiles along industry sectors

Factors, implying differences in innovation culture profiles across business sectors were extracted based on ANOVA and DUNCAN tests. Organizations in different sectors demonstrated significantly different behaviours as related to the ways of *resource allocation for innovation*, *organizational structure flexibility*, *partnership facilitating infrastructure*s, *innovation activity monitoring systems and measurement of innovation results*, *innovation communication* systems, *learning for innovation* and recognition *of innovation as an important management function* (see Table 2).

Features of industry related innovation culture profiles where distinguished, indicating sector and industry specific differentiation from the general innovation culture manifestation (see section 3) in business sector, while analysing the single industry along significantly differentiating factors as provided above.

Below or at average performing innovation culture profiles were demonstrated by *manufacturing* (C), *transportation and storage* (H), *information and communication* (J) and *wholesale and retail trade* (G) sectors.

Manufacturing (C) organizations did not differ from the general sample in all innovation culture defining factors but featured strongly inflexible organizational structure as compared to other industries, which partially led to average innovation culture levels. Very much alike, *transportation and storage* (H) sectors were demonstrating strongly inflexible organizational structure as compared to other industries and also moderate ability to attract and allocate resources for innovation, moderate effectiveness of innovation communication system and consequently, also moderate ability of learning for innovation from internal experiences, while performance in other factors remained at the average level. *Information and communication* (J) sector, compared to others demonstrated moderate performance in establishing innovation partnership facilitating infrastructure and effective system of innovation communication, but kept at the average level in terms of other factors. *Wholesale and retail trade* (G) did not demonstrate any deviance from the general factor analysis.

Above average innovation culture profiles were demonstrated by *financial and insurance activities* (K), *construction* (F), *professional, scientific and technical activities* (M) and *administrative and support service activities* (N). From the group, *construction industry* could be distinguished as featuring above average factor means in terms of inflexible organizational structure and below average factor means in recognising innovation as a management field, but still achieving above average performance in resource acquisition and allocation for innovation, establishing innovation partnership facilitating infrastructures, effective innovation communication and learning processes. This points to the organizational focus on processes excellence leading to the higher than average innovation culture profiles in business.

On the contrary, *financial and insurance activities* (K) were demonstrating low level of organizational structure determination, but also failed to establish an effective system of innovation activity monitoring and results management as compared to average. Despite this fact, they were demonstrating high performance in adequacy of resource allocation for innovation and high level of effectiveness of innovation communication and learning for innovation from internal experiences.

Professional, scientific and technical activities (M) demonstrated above average performance in establishing innovation partnership facilitating infrastructure, effective system of innovation communication, learning for innovation from internal experiences, while maintaining average values in other factors and indicators. This points to the focus on knowledge management support in organizational processes and culture with regard to innovation.

Administrative and support service activities (N) were demonstrating above average means in all factors, despite the fact that organizational structures were also fixed and clearly determined, as an opposite to other above average performing business sectors in terms of innovation culture. This deviation might be explained by the fact, that selected sample consisted of modern business blocks and specialised providers of facilities for innovative enterprises.

Table 2: Factors, determining innovation culture variety across business sectors (NACE Rev.2, factor loading means).

	Adequate resources dedicated for innovation (p=0,04; F=2,25)	*Fixed organizational structure (p=0,03; F=2,75)*	*Innovation partnership facilitating infrastructure (p=0,02; F=3,15)*	*Effective system of innovation activity monitoring and innovation results measurement (p=0,04; F=2,48)*	*Effective system of innovation communication (p=0,02; F=3,58)*	*Learning for innovation from internal experiences (p=0,03; F=2,72)*	*Distinction of innovation as a management field (p=0,04; F=2,42)*
Manufacturing (C)	Medium (3,58)	High (3,85)	Medium (4.2)	Medium (3,35)	Medium (3,2)	Medium (3,8)	Medium (3,58)
Transportation and storage (H)	Moderate (2,91)	High (3,75)	Medium (4,11)	Medium (3,25)	Moderate (2,55)	Moderate (3,08)	Medium (3,16)
Information and communication (J)	Medium (3,47)	Medium (3,25)	Moderate (3,4)	Medium (3,46)	Moderate (2,58)	Medium (3,85)	Medium (3,21)
Wholesale and retail trade (G)	Medium (3,85)	Medium (3,5)	Medium (4,09)	Medium (3,19)	Medium (3.36)	Medium (3.93)	Medium (3.64)
Financial and insurance activities (K)	High (4,71)	Moderate (2,35)	Medium (3,9)	Moderate (2,82)	High (3,57)	High (4,5)	Medium (3,47)
Construction (F)	High (4,22)	High (4)	High (4,77)	Medium (3,25)	High (3,5)	High (4,66)	Moderate (2,5)
Professional, scientific and technical activities (M)	Medium (3,66)	Medium (3,5)	High (4,41)	Medium (3,75)	High (3,85)	High (4,2)	Medium (3,4)
Administrative and support service activities (N)	High (4,29)	High (3,65)	High (4,44)	High (4,3)	High (3,64)	High (4,4)	High (4,14)

4.2 Factors, determining diversity of innovation culture profiles along business organization size

In terms of organizational innovation culture profiles by organization size, 9 factors differed significantly, namely *explicitness of innovation strategy*, *flexibility and initiative supporting* *organizational procedures*, *existence of IT platforms facilitating participation* (of users and employees), *effectiveness of innovation activity monitoring and results measurement system*, *organizational climate supporting diversity of ideas and opinions*, *effectiveness of innovation activity communication system*, *R&D activity for innovation*, *concentration and direction of human resources towards innovation activity* and *competence based dynamic management* (see Table 3).

While analysing factors along enterprise groups, certain features of innovation cultures as related to enterprise size emerged, as a unique innovation culture profiles complementary to the universal factors, across which no statistically significant differences were found (see Table 1 and Table 3).

Table 3: Factors, determining innovation culture variety across business organization size (factor loading means).

	Explicit innovation strategy p=0,018 F=4,225	*Effective system of innovation activity communication* p=0,01 F=6,619	*Competence based dynamic management* p=0,01 F=9,645	*Flexible and initiative supporting organizational procedures* p=0,006 F=5,595	*Organisational climate supporting diversity of ideas and opinions* p=0,003 F=7,289	*Concentration and direction of human resources towards innovation activity* p=0,02 F=4,187	*Participation (of users and employees) facilitating IT platform* p=0,07 F=4,171	*Effective system of innovation activity monitoring and results measurement* p=0,021 F=4,412	*R&D activity development for innovation* p=0,004 F=7,089
Small enterprise (1-49 empl.)	High (4,26)	High (3,69)	High (3,97)	High (3,91)	High (4,10)	High (3,17)	Medium (3,53)	Low (3,14)	Low (2,11)
Medium enterprise (50-249 empl.)	Medium (3.82)	Medium (3,25)	Medium (3,42)	Low (3,01)	Low (3,36)	Low (2,78)	Low (3)	Low (3,09)	Medium (2,67)
Large enterprise (250+ empl.)	Low (3,68)	Low (2,85)	Low (3,11)	Low (3,31)	Low (3,28)	Medium (2,92)	High (3,85)	High (3,83)	High (3,11)

The *Small size enterprises* were able to achieve most favourable innovation culture performing significantly above average in such factors as explicit innovation strategy, flexible and initiative supporting organizational procedures, organisational climate supporting diversity of ideas and opinions, effective system of innovation activity communication, concentration and direction of human resources towards innovation activity and competence based dynamic management, being at the average in the development of IT platform, facilitating participation in innovation (of users and employees), but significantly below in designing and implementing effective system of innovation activity monitoring and results measurement and R&D activities.

Medium size enterprises seem to meet innovation culture development organizational challenges with difficulties, as they significantly failed below average in 5 factors out of 9 and performed at the average in 4 factors. They failed significantly below average in such factors as flexible and initiative supporting organizational procedures, participation (of users and employees) facilitating IT platform, effective system of innovation activity monitoring and results measurement, organisational climate supporting diversity of ideas and opinions, and concentration and direction of human resources towards innovation activity, while explicit innovation strategy, effective system of innovation activity communication R&D activity development for innovation and competence based dynamic management met the average.

Large size enterprises demonstrated below average performance in such factors as explicit innovation strategy, flexible and initiative supporting organizational procedures, organisational climate supporting diversity of ideas and opinions, effective system of innovation activity communication and competence based dynamic management, but above average performance in participation (of users and employees) facilitating IT platform, effective system of innovation activity monitoring and results measurement and R&D activity development for innovation, while maintaining average in concentration and direction of human resources towards innovation activity.

5 Discussion

As a result of our analysis, we can distinguish two large groups of innovation culture profiles as related to business sector determined factors, i.e. organizational innovation cultures, supporting well-structured innovation activities and innovation cultures, supporting "liberal" innovation activities. The two can be further distinguished between moderate and high level of innovation awareness in business organizations, resulting in different innovation culture profiles, as presented in Table 1.

The industry specific innovation focus here is important, as traditional industries, such as construction and finance management have addressed innovations only recently in search for new sources of competitiveness, as their traditional behaviour was addressing process management excellence, reliability and high quality outcomes. These sectors were also heavily shaken by economic downturn in 2008 – 2010 and were forced to rethink their competiveness. The typical industries featuring *innovation cultures that support well-structured innovation activities*, are manufacturing and construction. These industries feature *process focused innovation cultures*, with a weak focus on innovation management, but dedicating high attention to organizational processes and their facilitation via resource allocation and established communication and organizational learning systems implemented via well-established fixed organizational structures. The increasing level of innovation management awareness across industries leads to the modification of innovation cultures. They still remain process excellence focused, but also start demonstrating the focus on innovation process excellence explicitly, with the main emphasis on managing and facilitating innovation in an organization (in our case, these are administrative and business support service industries, including knowledge intensive business support services, which partially merge with the professional service activities).

Innovation cultures supporting "liberal" innovation activities within organizations and featuring moderate innovation management awareness (typically, financial and insurance industries), but high customer driven innovation dynamics, can be characterised as creative search focused cultures, with highly established innovation communication, learning from experiences, creativity facilitation by loose organizational structures and weak innovation performance monitoring and results control, i.e. climates open for experimentation and ideation across organizations. With the increased level of innovation management focus, "liberal" innovation culture profiles become more condensed and can be characterized as knowledge focused innovation cultures, with strong emphasis on knowledge management facilitation within and across organizations (these are typically featured by professional, scientific and technical activities).

Table 4: Organisational innovation culture profiles, based on industry specific factors.

	Innovation cultures, supporting well-structured innovation activities	Innovation cultures, supporting "liberal" innovation activities
Moderate level of innovation management awareness	Process focused innovation cultures, with the weak focus on innovation management, but high attention dedicated to organizational processes and their facilitation via resource allocation and established communication and organizational learning systems implemented via well-established fixed organizational structures	Creative search focused cultures, with highly established innovation communication, learning from sharing of experiences, creativity facilitated by loose organizational structures and weak innovation performance monitoring and results control
High level of innovation management awareness	Innovation process focused innovation cultures, with the main emphasis on managing and facilitating innovation in an organization	Knowledge focused innovation cultures, with strong emphasis on knowledge management facilitation within and across organizations

In terms of diversity in innovation culture profile as related to organization size, small organizations demonstrate highest performance levels across significantly different factors, with the focus on establishing favourable organizational climate and effective communications, dynamic management practices based on competence, organizational flexibility, which all are achieved due to small size of the organization and ability to interact freely for innovation purposes across innovation agents. The below average innovation support infrastructures at the same time points to the importance of direct interactions and knowledge flows across agents, which significantly decreases with the increase of organization size. The research results demonstrate that medium size organizations are tending to lose the advanced innovation culture features due the increased complexity of interactions for innovations and still not existing innovation and knowledge support infrastructures. High reductions as compared to small size enterprises are approached in flexibility and initiative support, organisational climate favourability for the diversity of ideas and opinions, concentration and direction of human resources towards innovation activity. Average performance is maintained in explicitness of innovation strategy, efficiency of innovation communication and competence based management dynamism. New processes, as compared to small enterprises related to R&D, are emerging, however at moderate level. The growth related challenges and transition from entrepreneurial small business structures towards medium size organizations require implementation of new management practices, as the practices that worked well for SSE, are failing when an organization grows and thus, reorganization of processes is demanded in order to maintain favourable organizational innovation culture.

Lithuanian large size enterprises are moving towards infrastructure and formal R&D activity driven innovation culture profiles and thus are able to compensate the lost flexibility and informal innovation communication practices, as well as competence based rotation for innovation tasks via well-established partnership and collaboration platforms, productive management of innovation via monitoring and control systems and established R&D processes.

Based on the entire discussion, innovation culture profiles depending on enterprise size were condensed, as presented in Table 5.

Table 5: Innovation culture profiles in business organizations based on the organization size variety.

	Organizational climate and communication driven innovation cultures	*Management dynamic and new competence development driven innovation cultures*	*Infrastructure driven innovation cultures*
Concentration and direction of human resources towards innovation activity	Explicit innovation strategy, effective system of innovation activity communication , competence based dynamic management, flexible and initiative supporting organizational procedures, organisational climate supporting diversity of ideas and opinions,	Explicitness of innovation strategy, efficiency of innovation communication, competence based management, emerging R&D activities	Participation (of users and employees) facilitating IT platform , Effective system of innovation activity monitoring and results measurement, R&D activity for innovation
	Small size organization	*Medium size organization*	*Large size organization*

6 Conclusions

As a result of our analysis, we provide an extensive overview of emerging innovation culture profiles within the transition of a small Baltic economy. It is important to note that the findings describe a distinct moment of transition towards innovation driven economy and this can be well noted in organizations, aiming at maintaining production and management process controls, but also the need to liberate organizational structures, communication and leadership towards more innovation related uncertainty favourable domains. However, we note immature systems and innovation culture development drawbacks, especially as organizations grow and higher requirements for management professionalism and sophistication of organizational designs are set. As recent innovation developments demonstrate (OECD, 2018), Lithuanian organizations still lack innovation, especially in organizational designs and consequently, in marketing and design innovations, that require high level of creativity and experimentation.

Our study represents the variety of underpinnings between the organizational variables, that support or hinder the development of innovation culture, as a systemic outcome of organizational interactions. The findings also point to the importance of organizational design variables while developing organizational innovation culture, providing a sustainable organizational context for innovativeness in business. The study also demonstrates that organizational innovation cultures are highly influenced by both, the industry specific and organizational determinants, such as size. This is an important practical implication for innovation management designs and implementation across industries. Two large groups of innovation culture profiles as related to industry sector determined factors were distinguished, i.e. organizational innovation cultures, supporting well-structured innovation activities and innovation cultures, supporting ‘liberal’ innovation activities. The two are further differentiated between moderate and high level of innovation awareness in organizations. The well-structured innovation culture profiles with low innovation management awareness lead to the core process focused and process embedded innovation cultures, while high innovation management awareness maintains well-structured processes but the innovation becomes a core shaping process that defines the remaining processes and routines of the organization. Innovation cultures, supporting 'liberal' innovation activities with low innovation management awareness demonstrate creative search driven organizational profile, while high level innovation management awareness leads to the knowledge management focused innovation cultures. This kind of matrix allows us to draw paths for innovation culture transitions as based on the industry requirements and move in a unique way towards better performance.

In terms of variations in innovation culture as related to organization size, three diverse innovation culture profiles were condensed, i.e. organizational climate and communication driven innovation cultures, featured by small organizations, management dynamic and new competence development driven innovation cultures, featured by medium size organizations and organizational infrastructure driven innovation cultures, featured by large size enterprises.

Thus, we argue that innovation cultures are differing significantly across industries and they also change with the increased demand for innovation driven competitiveness. Organizational size is an important determinant for innovation culture development, as the size of the organization implies the features of "soft" innovation processes and also defines the need for "hard" organizational structures to support innovation. Therefore, we can not study organizational innovation cultures independently from the organizational demographies, business growth stages and associated innovation behaviours.

The common finding for the economies in transition from productivity driven growth towards innovation driven growth, is the need to increase innovation management awareness and professionalization of innovation processes and transition towards innovation as a core business process.

In terms of practical implications, the paper reveals industry and size specific defining factors for the formation of innovation culture. These define the areas of organizational interventions in order to support innovation culture as it cannot be developed as such but only impacted through the changes in the complex settings of organizational characteristics. The analytical toll applied might be converted into the organizational diagnostic tool, which allows to understand and develop business organization as a sustainable innovation ecosystem, featured by high innovation culture profile. The practical implications of research also assist management task setting and design of implementation tools for developing a sustainable platform for continued innovation embedded in innovation culture.

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Chapter 6

Caught in inaction?!? How do companies respond (or not) to the business implications of demographic change

Florian Kohlbacher

Abstract

Identifying or recognizing a business opportunity is a necessary but by far not a sufficient condition for doing business. Once identified, measures need to be taken in order to exploit that opportunity. Many companies currently fail to make that transition from recognition to exploitation of opportunities arising from demographic change. Rather than passively waiting for something to happen, managers need to become more proactive in dealing with demographic change and this will involve the pro-active shaping of the conditions that make it feasible to exploit the opportunity in question. This chapter serves as a call to arms for academics to conduct more research and for practitioners to become more active in this segment.

Keywords: Demographic change; Silver Market Phenomenon; Ageing Societies

1 Introduction

This chapter is a mix of a personal reflection, presentation of research results and recommendations to business practitioners. It is probably no exaggeration that without Cornelius Herstatt, I might have never ended up doing research on the 'silver market'. Even though I had already done some research around knowledge management and human resources management related issues in connection with demographic change, it was Cornelius who encouraged me to apply for a job at the German Institute for Japanese Studies (DIJ) in Tokyo and start a joint research project on "The Silver Market Phenomenon: Business Opportunities and Responsibilities in an Era of Demographic Change" in 2007[1].

2 Demographic change

I originally became interested in the business implications of demographic change and subsequently the silver market phenomenon during my research stay at Hitotsubashi University in Tokyo from April 2005 to March 2007. After an initial interest in the HR and knowledge management implications of demographic change, my co-editor Professor Cornelius Herstatt from Hamburg University of Technology and I started a joint research project on the silver market phenomenon in 2007 and as a result of that, the first edition of 'The Silver Market Phenomenon' was published in the autumn of 2008 (Kohlbacher and Herstatt 2008). Thanks to the many positive reactions to the book and its successful development on the market, we

[1] The focus of the joint research with Cornelius was obviously on innovation management, e.g. the new product development process for innovations for the silver market (e.g. Kohlbacher and Herstatt 2016).

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R. Tiwari and S. Buse (eds.), *Managing Innovation in a Global and Digital World*, https://doi.org/10.1007/978-3-658-27241-8_7

soon started working on a more focused second edition that was eventually published in 2011 (Kohlbacher and Herstatt 2011). The Chinese language edition of the book was published in 2016, and Cornelius and I are currently working on the 3rd edition of 'The Silver Market Phenomenon'.

In my research – even though global in nature – I had initially focused on Japan, the country most severely affected by demographic change, with a rapidly aging as well as shrinking population. Japan is the world's most 'mature' market and can be considered a 'lead market' for products for older people and there are many lessons to be learned (Kohlbacher 2011; Kohlbacher, Herstatt, and Levsen 2015; Kohlbacher, Gudorf, and Herstatt 2011; Kohlbacher and Rabe 2015; Prieler and Kohlbacher 2016). Are we going to see a new 'Japan as number one' with Japan being the number one country in terms of population ageing – but possibly also in terms of innovative responses to the demographic challenge?

But population ageing is a global trend and China is now also on its way to become a global lead market for the silver industry. According to the China Report on the Development of the Silver Hair Industry 2014 (Zheng 2014), the domestic market for providing essential services and products for the aging population is estimated to be worth 4 trillion yuan ($651 billion) in 2014, or 8 percent of GDP, but it will climb to 33 percent of GDP in 2050. China will become the largest market for businesses serving senior citizens by 2050, when its aging population will account for about one-fourth of the global total and its consumption is expected to reach 106 trillion yuan (Zheng 2014).

On 29th March, 2015, the Financial Times ran a piece on its website entitled "Ageing population in China creates business opportunities"[2]. The print edition of 30th March, 2015 featured the same article but with the title "China's ageing society sets minds ticking" (Bradshaw 30th March, 2015). This article suggested that China "presents a fascinating case for those interested in the social and economic challenges of ageing populations, not to mention the business opportunities" and that "For just this reason Florian Kohlbacher moved to China in August after 11 years studying demographic change in Japan" (ibid). It is true that after more than a decade in Japan, I had moved to China in 2014 to join the International Business School Suzhou (IBSS) at Xi'an Jiaotong-Liverpool University (XJTLU). Apart from my appointment as Associate Professor of Marketing and Innovation in the business school (IBSS), I had also become the Founding Director of the XJTLU Research Institute on Ageing and Society (RIAS), an interdisciplinary research institute at the university level. In 2016, I returned to Japan as the North Asia Director of the Economist Corporate Network, the executive networking and private briefing service of the Economist Intelligence Unit (EIU). In this new role as well – now managing a business – I keep working on ageing and business, as demographic change is one of the global key megatrends that shapes our societies, economies, industries and the way we do business.

Let me take this opportunity to reflect upon more than a decade of research on the silver market phenomenon. As mentioned above, I first got interested in the issue of demographic change in the form of population aging while I was a visiting researcher at Hitotsubashi University in Tokyo from 2005-2007. Looking at the data, there was no doubt: This is huge! And

2 http://www.ft.com/intl/cms/s/2/3e4fd3e2-7fc4-11e4-adff-00144feabdc0.html#axzz3vb9j6vHD, Ftchinese.com posted a Chinese translated entitled "中国人口老龄化蕴含巨大商机" on 10 April, 2015: http://www.ftchinese.com/story/001061456

it's gonna be a no-brainer for businesses to do something to respond to this trend. At the very least to fend off the challenges – but more importantly to leverage new business opportunities. But when I set out to talk to executives and managers from companies in all kinds of industries, I was surprised. I seemed to get the same answer all the time: "Yes, this is a very important topic. And yes, there is a business opportunity here." Great! I thought and continued to ask: So, what does your company do about it? And this is where it started to get really interesting – and disappointing. "Oh, us, we haven't started looking into this in detail yet." Or: "Oh, us, no we are in the B-to-B business and so this is not really relevant to us; but the consumer goods industry has plenty of opportunities there."[3] Or: "We're currently working on this big business restructuring project, but I am sure that once we're done, we can have a go at this.", etc. etc.

At first, I was a little puzzled. Almost every executive I talked to was knowledgeable about the demographic trends and the business opportunities. But when I asked about their own companies, they all of a sudden presented me with all kinds of excuses why they are just not ready yet or why this does not really matter to them. I call this the difference between a first-person opportunity and a third-person opportunity (Kohlbacher, Herstatt, and Levsen 2015). I.e. the potential opportunities for anyone – or possibly even everyone – are third-person opportunities, while those potential opportunities for a specific actor – i.e. a specific entrepreneur or company - are first-person opportunities. Obviously, most executives do recognize the general potential of aging as a business opportunity; but only for someone else out there and not necessarily for their own businesses. In other words, it seems that many companies fail to be able to translate the third-person opportunity into a first-person opportunity. How is this possible? I decided to start a research project to find out what is going on.

Together with Professor Ken Matsuno from Babson College, we conducted field work involving qualitative interviews as well as a large sample survey with 545 marketing managers in Japan (Matsuno and Kohlbacher 2019; Matsuno and Kohlbacher in press). As usual, we chose Japan for our research, because it is the country that is most severely affected by population aging in the whole world and frequently identified as a lead market in terms of 'silver' products (see also above). What we found was that most companies are:

- Aware of/sure about the state demographic change
- Not so sure about/ convinced of the effect (for their business)
- Not really prepared in terms of responses (with exceptions)

So far, this seemed to confirm the anecdotal evidence from my previous discussions with managers. But what is the reason for the gap between 1) and 2) and thus subsequently 3)? Our survey provided the answer (Matsuno and Kohlbacher 2019).

There is something that negatively affects the impact of an understanding of the situation (i.e. demographic change) and the response to it (i.e. marketing strategy and tactics). It is called *ambivalence*. This occurs when one's evaluation of a phenomenon's potential implication is not fully captured on a bipolar continuum from positive to negative, but rather is expressed as both positive and negative. In our case this means that managers have both a positive and a negative evaluation of what demographic change means for their own business. It could be good, but it could also be bad – or possibly even both at the same time. Or it could be that

[3] But of course there is also a B2B silver market, e.g. in the form of more ergonomic workplaces, shop floors and easier to handle and safer equipment etc. (see e.g. Kohlbacher, Herstatt, Levsen 2015).

they are just not really sure about it and this means that they are ambivalent about it and thus are also ambivalent about how to respond. In the absence of ambivalence, there is a strong direct relationship between an understanding of demographic change and the business response to it, i.e. the better the manager understands the phenomenon (= the implications of demographic change), the more likely he/she is to respond (and the better he/she can respond in terms of marketing solutions). But if there is ambivalence, the direct effect is weakened and in the case of very high ambivalence, it can be completely turned off, thus leading to a non-response. When this happens, the company is *caught in inaction*. It goes without saying that this is a highly dangerous situation.[4]

Table 1: Common mistakes when dealing with demographic marketing challenges

Mistake	Reason and tip for manager
Segmenting exclusively according to age	Very tempting due to demographic development; but modern marketing left the simplistic segmentation based on age behind a long time ago. Individual lifestyle, financial, professional and health situation, etc., significantly influence the needs and wants of consumers.
Measuring all "seniors" by the same yardstick	50+, 55+, 65+ may sound handy and may generalize the silver market. But it may not make sense to work this way. With today's high life expectancy, 50+ can almost refer to half of the human life-cycle.
Underestimating and/or patronizing seniors	Nowadays, it is more and more important to know exactly what consumers want and to cater to their individual needs. End-users are more and more tied into the development process providing ideas or even start an innovative process. Instead of asking seniors or incorporating them into development, many companies active in the silver market seem to believe that they know what customers want much better than they do. As is the case for segmentation: do not take a step backwards but be innovative and approach consumers.
Fear of age and "seniors" (no, seriously!!)	Many companies fear that their image among other age groups will be damaged if they appeal to the silver market. Parallel success among young and senior people is indeed a big challenge and not completely without risk. The key to success refers to "universal design" or "trans-generational design" as well as to "ageless" or "age-neutral" marketing. As usual: exceptions confirm the rule and depending on the product, an age-emphasizing strategy can also lead to success (e.g., Dove pro-age). However, in general it is true: beware of ageism, think trans-generationally!

So, why do managers become ambivalent in the first place? We believe that there are several reasons for this. First of all, there is a lack of in-depth knowledge and understanding about demographic change in terms of its marketing implications. While we have legions of marketing studies about younger or even middle-aged consumers, older cohorts remain widely neglected by both academic and professional marketing research i.e. we don't really know who the older consumer is and how he/she makes purchasing decisions. Second, the level and time line of the information are not suitable to make specific, tactical marketing decisions. Macro data about demographic change are valuable to understand the bigger picture, but what is needed to make decisions on the response is detailed, micro-level data. And oftentimes the data presented in reports and presentations show future trends up to the year 2050 or even

[4] Let me just hasten to add that I am not at all ambivalent about the exciting opportunities for researching the silver market phenomenon and its business implications.

2100 (*I must know because I am doing this all the time myself*). But where is the executive who is planning ahead for decades or even centuries into the future?

No wonder that many decide to put the decision about silver marketing off until later and focus on – seemingly – more urgent and immediately pressing issues first. And finally, there are still many preconceptions and misunderstandings about age and aging and often even outright ageism. Again the only remedy to this situation is to do proper, in-depth marketing research, i.e. we need to do our homework first. Table 1 contains four tips about the most common mistakes when dealing with demographic marketing challenges and how to avoid these.

3 Final remarks

I hope readers have not become too depressed by now by all the bad news about what is going wrong with the business (non-) response to demographic change. Fortunately, there is some good news as well. As explained above, while executives generally seem to acknowledge the importance of demographic trends, relatively few companies take concrete action to try to develop the older market segment. But there are a few notable exceptions. Yes, there are some pioneering firms out there that got it right (Kohlbacher 2011; Kohlbacher, Gudorf, and Herstatt 2011; Kohlbacher, Herstatt, and Levsen 2015). The most impressive one is probably Fujitsu's Raku-Raku Phone that has developed into a long-seller over almost 20 years already. Having started as a just simple-to-use mobile phone with a reduced set of functions it has quickly turned into a high-tech device that remains easy-to-use but offers a full range of functions and technological innovations that ensure a great customer experience (Kohlbacher and Hideg 2011). In China, the consumer electronics company Xiaomi Technology Co., Ltd – famous for its smartphones and other mobile devices – successfully developed a special version of its popular Hongmi (Redmi) smartphone series targeted at older people.

The research by Ken Matsuno and me (forthcoming) has showed that there can be various types of responses:

1) *moving up* That is the most straight forward solution as it means embracing the silver segment as an addition to current activity. In most cases, it means developing this segment in addition to the current customer base rather than exclusively moving into the older segment. The Raku-Raku Phone is an example of adding a product line to the portfolio in order to 'move up'. In a similar vein, Pearson Publishing introduced English language books/seminars for those affluent silver consumers who enjoy traveling abroad but with limited language proficiency. This is definitely a big move for a company that has traditionally focused on college and high school educational publications.

→ *ACTION IDEA: reconsider existing products and look at how to re-message, re-package with little new development. We saw this with the move diaper makers have made in adapting existing technologies to adult needs. Many other products are now adapting such as the move from Seven-11 and other convenience store chains to develop single serve ready to eat meal packaging for increasing single older people households*

2) *moving down:* This one is kind of counterintuitive as it means to develop (even) younger segments. We encountered this case with a Japanese education company whose core business is to help Japanese senior high school students prepare for the university entry exams. Rather than deciding to go into the market for educational products for older people – a segment

where they do not have any experience – they decided to start targeting younger, junior high school students and start the preparation support even earlier.

→ *ACTION IDEA: pushing the products available to younger groups is a short time strategy that will work for a while. More importantly target the affluent retiring grandparents to support grandchildren with higher end products. The move by many toys and game manufacturers to develop more hi-tech toys for younger children and then appeal to grandparents for purchase*

3) *moving deep:* This strategy involves improving quality/service and/or adding additional features or services to create value-added for which higher prices can be charged. This means that even when selling less in terms of units (due to the shrinking of the younger age groups), revenue can remain stable or even grow due to higher margins per unit. The children's education and toy industry is a case in point, especially in Asia where e.g. the Chinese 'little emperors' that get spoiled by their parents and grandparents have already become famous. In Japan, supermarket chains (e.g., Aeon, Ito Yokado) are offering smaller packaged prepared food but with higher quality raw materials (e.g., organic vegetable, domestic beef/pork, free-range chicken) for health conscious, educated, and affluent older people, and convenience store chains now offer special home delivery services for older people who have difficulties carrying their shopping bags back home.

→ *ACTION IDEA: we are seeing more higher end entertainment aimed at seniors such as "revival tours" and "nostalgia visits". A few years ago Tokyo Disneyland realized that there was an uptick in older visitors taking their grandchildren to their parks. They then found some were visiting as couples to celebrate anniversaries etc. So campaigns were successfully launched to encourage older couples to "relive" young memories with higher end packages*

Finally, 4) *moving out:* i.e. going international/global. Companies that have been focusing overly on the domestic market have to consider going international and explore foreign markets to compensate for decreasing business volume on their home turfs. Indeed, this is one of the reasons for an increase in international activities by more and more small and medium sized companies from Japan that traditionally were only offering on the Japanese market. One obvious industry is babies/infants/children apparel where manufacturers are shifting their emphasis to Southeast Asia (e.g., Singapore, Thailand). Other examples including education company Benesse expanding its Asia business or real estate business Mitsui Fudosan trying to utilise their accumulated know-how in developing cities in Japan during the growth era to the still-growing Asian cities (e.g., suburban development collaborating with railway companies, shopping centers).

ACTION IDEA: the growth and export of ageing care expertise to China and other markets both for the building of Japanese older people wanting to live cheaper in South East Asia etc. and also catering to the ageing populations of other countries.

Let me close by coming back to the perception of business opportunities. Identifying or recognizing a business opportunity is of course a necessary condition for doing business, but it is not a sufficient one. Once identified, measures need to be taken in order to exploit that opportunity. As explained above, many companies currently fail to make that transition from recognition to exploitation of opportunities arising from demographic change. Rather than passively waiting for something to happen, managers need to become more proactive in dealing with demographic change and this will involve the proactive shaping of the conditions that make it feasible to exploit the opportunity in question. It's time now to seize the golden opportunity of silver marketing and silver innovation. I hope this short chapter will serve as a call to arms for academics to conduct more research and for practitioners to become more active in this segment.

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Part II

Developments in Open and User Innovation

Check for updates

Chapter 7

Lead users and the organization

Christopher Lettl

Abstract

Lead user research has branched out into many different research streams. In this paper I take an organizational view and differentiate three different perspectives which historically emerged in this sequence. First, lead users as external creators of ideas for focal firms. Second, lead users as creators of organizations. Third, lead users as internal creators of ideas for focal firms. I elaborate on opportunities for further research in each of these perspectives. As becomes apparent, Cornelius Herstatt has been a pioneer researcher in each of these perspectives and a significant source of inspiration for his students.

Keywords: Lead Users; User Innovation; Innovation Process

1 Introduction

More than thirty years after Eric von Hippel has introduced the concept of lead users (von Hippel, 1986), lead user research has developed into several branches. According to von Hippel (1986) lead users are defined by two characteristics. First, they are on the leading edge with respect to important trends in markets or technology. They therefore encounter needs months or even years before the bulk of the marketplace encounters them. In this sense lead users already today live in the future as they are embedded in a context that is somewhat representative for the future. Second, they derive a high benefit from innovative solutions to their needs. Lead users can be positioned in the target domain, but they may also be positioned in analogous domains. The latter are fields where the need in question is experienced in an extreme form and thus there is a high likelihood that leading edge solutions have already been developed (von Hippel, Thomke and Sonnack, 1999). Lead users' activity starts way before first adopters purchase new product or services (Hienerth and Lettl, 2017).

Research has found that trend leadership is positively associated with commercial attractiveness of solutions and benefit from an innovation is positively associated with the likelihood of innovative behavior (Franke, von Hippel and Schreier, 2006). Due to their characteristics and the associated outcomes lead users are rare subjects. Con-sequently, lead user research has developed four basic approaches to identify lead users. A first approach is screen-ing user populations according to lead user indicators (Herstatt and von Hippel, 1992). It is comparable to the so-called grid manhunt applied by law enforcement agencies. A second approach is pyramiding (Stockstrom et al., 2016; von Hippel, Franke and Prügl, 2009) which uses referrals: a user is asked whether he or she knows another user who has lead user characteristics. Via a series of such referrals one literally moves up the pyramid. On top of the pyramid one will find the actors with the highest lead user characteristics. A third approach is using the social network positions of actors. Research has shown that lead users tend to have specific

© Springer Fachmedien Wiesbaden GmbH, part of Springer Nature 2020
R. Tiwari and S. Buse (eds.), *Managing Innovation in a Global and Digital World*, https://doi.org/10.1007/978-3-658-27241-8_8

positions in social networks. They tend to be bridging links between different social clusters (Kratzer and Lettl, 2009; Kratzer et al., 2016). Lead users can be individuals or organizations. A fourth approach is netnography where online communities are systematically screened for lead user attributes (Belz and Baumbach, 2010).

In this paper I focus on lead users as individuals and take an organizational view. I differentiate three different perspectives which historically emerged in this sequence.

2 Lead users as external creators of ideas for a focal organization

This was the first perspective that pioneers in lead user research explored. The concept of lead users was introduced as an alternative approach to conduct market research for innovation (Herstatt and von Hippel, 1992; von Hippel, 1986). Traditional market research methods for new product development such as quality function deploy-ment, focus groups, user panels or large-scale customer surveys target mainstream customers as a passive informant. In contrast, the concept of lead users targets individuals that may not (yet) be the customers of a focal organization and that are not representative for the user population. One of the major foundations of the lead user concept stems from psychology. Several experiments have revealed that individuals tend to be constrained in their ability to use artifacts in different ways, i.e. to use a given artifact for new functions, the more use experience they have gained (e.g. Birch and Rabinowitz, 1951). This phenomenon has been coined functional fixedness. Lead users do not suffer from this functional fixedness as their leading edge position puts pressure on them to challenge the status quo. If the lead user approach really shows to work in real-life projects, then it would have the potential to reduce the costly and lengthy trial-and-error processes associated with the development of radical innovation (Herstatt and Lettl, 2004).

Even though compelling in theory, pioneer lead user researchers needed to test whether this concept is valid and applicable in reality. One could characterize this stage of lead user research as the "test of concept"-phase. For this phase two important prerequisites needed to be developed. First, pioneer researchers needed to develop a systematic approach to (a) identify lead users and (b) to involve them into the focal organization's innovation process. The result of these research efforts has been the so-called lead user method (Herstatt and von Hippel, 1992; Lüthje and Herstatt, 2004; Urban and von Hippel, 1988). This method provides a framework and guidance on how to conduct a lead user project and therefore allows a consistent application of the lead user concept across a broad variety of markets and industries. Second, researchers needed to find focal firms that were willing to experiment with this new approach. In this process it was crucial to find company representatives that were open to new methods and that were willing to take the associated risks. 3M and HILTI proved to be these pioneering firms. These early studies provided compelling evidence that the lead user approach is able to yield significantly higher performance compared to more traditional market research approaches. Specifically, these studies have shown that ideas generated by lead users have significantly higher originality, sales potential, and strategic importance (Lilien et al., 2002). Prior research has therefore compellingly shown that lead users may be a very important source for commercially successful radical innovations (Herstatt, Lüthje and Lettl, 2003).

There are a few promising directions for future research. First, we need to better understand the organizational prerequisites. A fruitful avenue could be to link prior lead user research with work on so called promotors for innovation (Lettl and Gemünden, 2006). Promotors are employees of the focal firm that overcome organizational barriers against innovation (e.g. Salomo and Gemünden, 2015). Four promotor roles are distinguished: Expert promotors, power promotors, process promotors and relationship promotors. Expert promotors possess subject knowledge to develop an innovation. Power promotors defend an innovation via their hierarchical power. Process promotors serve as bridging links between expert and power promotors. Relationship promotors establish networks to relevant external stakeholders such as for example users, customers, universities, consultants. With respect to implementing the lead user approach within a focal firm, employees that transcend the expert promotor role with the relationship promotor role may be particularly important. An employee needs to know how to identify lead users and needs to recognize the potential of lead users' ideas for the focal firm. In order to do so, an employee needs to have procedural knowledge on lead user identification, subject knowledge to recognize the opportunity and needs to have networks to contexts where technological and market trends emerge. Such a promotor approach may only work if the organizational culture moves away from a "not invented here"-syndrome towards a culture of "proudly found elsewhere" (Huston and Sakkab, 2006)

Another promising direction for future research may be to study the success factors of lead user workshops organized by the focal firm. So far conducting lead user workshops is still more an art than science. We need to better understand which kind of incentives (intrinsic, non-monetary extrinsic, monetary extrinsic, and combinations), team compositions, and team dynamics may yield superior effort and outcomes (Perkmann-Berger and Lettl, 2013). Furthermore, the role of lead users' perceived trust and fairness needs to be studied and how signals by the focal firm such as incentives relate to this.

3 Lead users as creators of organizations

Besides serving as a feedstock for the new development process of focal firms, lead users have also been found to be creators of organizations (Hienerth, 2006; Lettl, Herstatt and Gemünden, 2006; Shah, 2000; Shah and Tripsas, 2007). In this respect lead users take over an entrepreneurial role: like entrepreneurs they recognize opportunities and build an organization based upon it (e.g. Dyer, Gregersen and Christensen, 2008). There are several connections to be made between lead user research and entrepreneurship research. The latter emphasizes opportunity recognition, opportunity evaluation, and opportunity exploitation as distinctive processes for entrepreneurship as a field of research (Shane and Venkataraman, 2000). Such processes may be a suitable framework to study the entrepreneurial role of lead users (Lettl, Hienerth and Gemünden, 2008).

With respect to opportunity recognition Shane (2000) points out the crucial role of prior knowledge arguing that it is the idiosyncratic knowledge corridor of individuals that enables them to recognize opportunities, and not others. According to Shane (2000) prior knowledge can be technological knowledge, knowledge about markets or knowledge how to serve markets. Lead users possess a specific kind of market knowledge, namely leading edge use- and need-related knowledge. They are the locus where needs initially emerge that later become the needs of mainstream users. This kind of need- and use-related knowledge is sticky as it is costly to transfer to third parties (von Hippel, 1994; von Hippel and Katz, 2002). The opportunity recognition process of lead users is based on needs that they encounter themselves and for which they develop novel solutions. Similar to opportunity recognition processes based on prior knowledge as described by Shane (2000), Lüthje, Herstatt and von Hippel (2005) find for the field of mountain biking equipment that innovative users tend to utilize use- and need-related information as well as technical information that is local, i.e. that is already in their possession.

With respect to opportunity evaluation, research has shown that user communities play an important role (Hienerth, 2006; Hienerth and Lettl, 2011; Shah, 2000; Shah and Tripsas, 2007). User communities are social networks that are formed around a certain field and its members share an interest in this field. Often members of such communities are users with a high involvement in a certain field or product category (e.g. Franke and Shah, 2003; West and Lakhani, 2008). Once lead users have developed novel solutions to their needs, these solutions often become visible to other users as well. This then can lead to demand on side of these users as they may find the solutions of lead users superior to those that are available on the market. The more a lead user encounters such a demand, the more the lead user may recognize that what he or she has developed is actually of value to others as well and may constitute a viable business opportunity. Such patterns have been found in industries as diverse as medical equipment (Lettl, Herstatt and Gemünden, 2006), sport equipment (Hienerth, 2006; Shah, 2000) or juvenile products (Shah and Tripsas, 2007).

Regarding opportunity exploitation lead user research has observed two patterns. One pattern is that lead users create networks around their invention to develop the invention further towards a sophisticated and functioning physical prototype. They then hand over the prototype to producer firms which develop the prototype into a marketable product and introduce it into the market. This pattern has been observed by Lettl, Herstatt and Gemünden (2006) in the field of medical equipment. Here, lead users approached producer firms with their initial ideas. However, they were rejected as they were a radical departure from the firms' core competences and the projected markets seemed to be too small and uncertain. As the surgeons were in urgent need for novel solutions they created an informal organization in the form of networks of contributors that could help develop the ideas into functioning physical prototypes. The lead users, however, in most cases did not proceed to create new firms themselves. One of the major reasons for this behavior was that the lead users' lacked the complementary assets that were required to produce and commercialize medical equipment. Another pattern is that lead users indeed create new firms as has been observed in sport equipment such as rodeo kajaking (Hienerth, 2006), surfing (Shah, 2000) or juvenile products (Shah and Tripsas, 2007). In this pattern lead users perform a functional role shift from being a user innovator to a producer innovator. While a user innovator innovates to develop superior solutions for his or her needs, a producer innovates to derive profit from it (von Hippel, 2005). Lead users that start-up their own firms are no longer user innovators in this sense but become producers.

The entrepreneurial role of lead users as described above raises interesting opportunities for further research. One direction may be to study whether and how lead user entrepreneurs are distinct to other types of entrepreneurs. For example, one could study how crucial entrepreneurial processes are performed by lead user entrepreneurs compared to other types of entrepreneurs (Bhave, 1994). Such processes may include effectuation (Sarasvathy, 2001), the involvement of users, or the role of communities (Fauchart and Gruber, 2011). One could also study the long-term innovative capability and performance of lead user entrepreneurs. Do they lose their specific innovativeness after a while due to the functional role shift? After all, sustaining their trend leadership may be jeopardized by the many business-related activities of a firm founder and producer.

4 Lead users as internal creators of ideas for a focal organization

This third perspective has been established by Schweisfurth (2012), Schweisfurth and Herstatt (2015) and Schweisfurth and Raasch (2015) by introducing the concept of embedded lead users. Such lead users are employees of the focal organization and users at the same time. The concept of embedded lead users may overcome some of the challenges when lead users are external to the organization. When lead users are not members of the focal organization there may be several frictions. First, there may be high transaction costs (Schweisfurth and Raasch, 2015) as the rewards for the lead users including intellectual property rights need to be negotiated. Lead user studies as being organized by focal firms can create perceptions of unfairness by lead users both in a procedural as well as in a distributional sense (Franke, Keinz and Klausberger, 2013; Chesbrough, Lettl and Ritter, 2018). Second, there may be internal barriers to adopt and absorb the lead users' ideas due to "not-invented-here" syndromes or lack of absorptive capacity. Third, there may be high costs associated with the identification and integration of lead users into the innovation process of the focal organization. Fourth, external lead users may develop ideas that are hardly feasible to be developed by the focal organization. This may be the case as the external lead users lack knowledge about the core competencies of the focal organization and its products. Fifth, external lead users may lack resources especially access to sticky technological knowledge. Integrating lead users by making them part of the organization may be a very useful approach to overcome the frictions mentioned above.

There is empirical evidence that embedded lead users are of significant value for their employer firms. Research has shown that embedded lead users have a high customer orientation behavior, function as internal boundary spanners and show innovative work behavior (Schweisfurth and Raasch, 2015). They therefore show behaviors that are associated with behaviors of relationship promotors, process promotors, and expert promotors respectively. The study from Schweinfurth and Herstatt (2015) reveals that embedded lead users can serve as catalysts for product diffusion by playing the roles of first adopters and opinion leaders. This applies even more so the more they access to users, use experience and cognitive empathy to other users. Schweisfurth and Dharmawan (2019) analyze 452 ideas of 87 internal process users, i.e. embedded users, in an idea management system and find that lead userness is positively associated with the likelihood of suggested ideas being implemented and diffused. Ideas developed by lead users were more than two times more likely to be implemented and more than three times more likely to be diffused than ideas coming from non-lead users.

At the same time, employing lead users as part of the focal organization may constrain some of their innovative capabilities. Compared to their external counterparts, embedded lead users may be constrained by corporate policies, routines, and organizational inertia. They may also be constrained to develop or sustain their full trend leadership position as they are exposed to the typical innovation barriers inside organizations. External lead users are able to innovate in low cost innovation niches as they have access to other users from whom they may receive resources and valuable feedback and they can immediately test their solutions in the use environment (Hienerth, von Hippel and Jensen, 2014; von Hippel, 2005). Embedded lead users may not be able to use such advantages in the same intensity.

Considering the advantages and disadvantages of embedded lead users compared to their external counterparts, it seems important to distinguish two types of embedded lead users. One type is a formerly external lead user that the focal firm may have identified via a lead user project and now decided to hire as an employee ("transcending embedded lead users"). The other type is an employee who developed lead user characteristics while being employed in the focal organization ("home-grown embedded lead user"). Further research could compare the innovative capability over time of transcending embedded lead users with home-grown embedded lead users. It could also compare the innovative capability over time of embedded lead users with external lead users. To make the comparison more nuanced one could also compare how the different lead user types perform with respect to different indicators of idea quality such as originality, market potential, usefulness, feasibility or internal fit.

5 Conclusion

Lead users are a significant source of radical innovation. So far lead user research has predominantly focused on product innovation. Skiba and Herstatt (2009) show that the lead user concept can be extended to service inno-vation as well. Further research needs to explore whether the lead user concept can be extended to other types of innovation as well. Such innovation types may be process innovation or social innovation. With respect to process innovation, novel techniques may be a particularly interesting field to study (Hienerth, 2016; Hinsch, Stockstrom and Lüthje, 2014). It can be expected that lead users play also a major role with respect to the development of novel techniques. Another interesting field for future research may be how artificial intelligence (AI) can support the identification of lead users. AI applications could significantly support each of the four lead user identification approaches, i.e. screening, pyramiding, social networks, and netnography, and even combinations of those.

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Chapter 8

When patients become innovators

Harold Demonaco, Pedro Oliveira, Andrew Torrance, Christiana von Hippel, and Eric von Hippel

Abstract

Patients are increasingly able to conceive and develop sophisticated medical devices and services to meet their own needs - often without any help from companies that produce or sell medical products. This "free" patient-driven innovation process enables them to benefit from important advances that are not commercially available. Patient innovation also can provide benefits to companies that produce and sell medical devices and services. In this article, we look at two examples of free innovation in the medical field - one for managing type 1 diabetes and the other for managing Crohn's disease. We will set these cases within the context of the broader free innovation movement that has been gaining momentum in an array of industries and apply the general lessons of free innovation to the specific circumstances of medical innovation by patients.

Keywords: Free innovation; Medical innovation; Medical devices; User Innovation; Patient Innovation

1 Introduction

Patients are increasingly able to conceive and develop sophisticated medical devices and services to meet their own needs - often without any help from companies that produce or sell medical products. This "free" patient-driven innovation pro-cess enables them to benefit from important advances that are not commercially available. Patient innovation also can provide benefits to companies that produce and sell medical devices and services. For them, patient do-it-yourself efforts can be free R&D that informs and amplifies in-house development efforts. In this article, we will look at two examples of free innovation in the medical field - one for managing type 1 diabetes and the other for managing Crohn's disease. We will set these cases within the context of the broader free innovation movement that has been gaining momentum in an array of industries (von Hippel, 2016) and apply the general lessons of free innovation to the specific circumstances of medical innovation by patients.

1.1 Managing type 1 diabetes

In 2013, Dana Lewis, a professional in health communications in her 20s, joined forces with a software engineer and a few other individuals with type 1 diabetes to develop for themselves what the medical device industry had been promising to deliver for decades: an artificial pancreas. As patients, they sought to solve the problem of low overnight blood sugar levels, a

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R. Tiwari and S. Buse (eds.), *Managing Innovation in a Global and Digital World*, https://doi.org/10.1007/978-3-658-27241-8_9

common occurrence that can be deadly. They wanted to design a system that could automatically monitor blood sugar levels every few minutes and provide the right insulin dose to keep the number in a healthy range.

Within months, Lewis and her co-innovators designed an artificial pancreas that used computer code they wrote themselves and off-the-shelf hardware to connect commercially available continuous glucose monitors with commercially available insulin pumps. The device significantly improved Lewis's ability to manage her own blood sugar levels. She and her colleagues decided to make the design available to others online and make their software open source. This was the start of the Open Artificial Pancreas System (OpenAPS) movement (https://openapps.org). Today, multiple communities participate in this movement, multiple noncommercial DIY artificial pancreas designs are being shared, and thousands of individuals with diabetes use these DIY systems daily to monitor, manage, and improve their health.

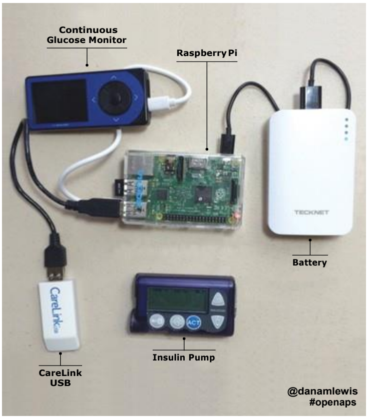

Figure 13: A DIY artificial pancreas

1.2 Managing Crohn's disease

Sean Ahrens, a computer science and business graduate from the University of California, Berkeley, became frustrated in his early 20s that there wasn't any detailed medical information on what he could do to minimize debilitating flare-ups from Crohn's disease. Although several drug treatments for Crohn's existed, all of them had significant toxicities and none was effective for every patient. As a result, many people tried to manage and reduce their symptoms through dietary choices. To fill a resource gap for patients, Ahrens, who was diagnosed with Crohn's when he was 12, created a website in 2011 called Crohnology, where fellow patients were invited to share their experiences regarding interventions and outcomes through an online questionnaire. The site compiled the data so that everyone could see which factors others found troublesome and which were helpful (https://chronology.com). Today, the site has more than 10,000 registered users. Crohn's patients throughout the world have come to find the information invaluable for managing their chronic disease.

2 The general practice of free consumer innovation

What is striking about both of these cases is that neither commercial medical producers nor the clinical care system offered a solution that these patients urgently needed. Motivated patients stepped forward to develop solutions for themselves, entirely without commercial support (Lewis, 2018).

Free innovation in the medical field follows the general pattern seen in many other areas, including crafts, sporting goods, home and garden equipment, pet products, and apparel (von Hippel, 2016). Enabled by technology, social media, and a keen desire to find solutions aligned with their own needs, consumers of all kinds are designing new products for themselves (see "About the Research").

Consumers innovate and diffuse their innovations in ways that are very different from producers, and it is important to understand the differences (see "Consumer Versus Producer Innovation," p. 84). Unlike traditional producers, who start with market research and R&D, free innovation begins with consumers identifying something they need or want that is not available in the marketplace. To address this, they invest their own funds, expertise, and free time to create a solution. Rather than seeking to protect their designs from imitators, as commercial innovators do, we found that more than 90% of consumer innovators make their designs available to everyone for free. What's more, they let other people test and improve on the initial design and make the new version available for free as well. Once a design is fully developed, it gets diffused still further, allowing consumers to make their own noncommercial copies, and allowing producers to commercialize the designs without having to license them from the consumer innovators[1].

You might wonder why individuals would bother to invest time and money in innovations without any expectation of being paid foreither their labor or their product designs. The answer is simple: Consumers who innovate are attracted by the personal benefits, such as the opportunity to use their innovations and the fun and learning they gain from the process of developing them. They also get satisfaction from sharing their innovations with people with similar needs (de Jong et al., 2015). In other words, they are self-rewarded.

As different as the consumer and commercial paradigms are from each other, they are complementary rather than opposing. Indeed, research shows that consumers, producers, and society at large are best served when both paradigms are used simultaneously (Gambardella et al., 2017). Producers can benefit from consumer innovation by adopting consumer product designs developed and tested by consumers for free; consumers benefit from producer-developed modules for DIY projects such as Raspberry Pi microcomputers and also from producer-

[1] A small number of consumer innovators take steps to protect their innovations from free copying, using patents and other means, and then try to sell them. Surveys show that these innovators (making up less than 10% in our re- search sample) follow the "producer paradigm" path and become entrepreneurs. Both the entrepreneurs and pro- ducers look for unmet needs and then invest in R&D to develop products and services that are likely to become profitable.

developed innovations that serve mainstream needs. And, of course, society as a whole benefits when consumer and producer innovators focus on what they do best and most efficiently[2].

Table 1: Sharing Crohn's disease information globally; Source: chronology.com

TOP MEDICATIONS	**Remicade**	★★★★	2,698 people
	Prednisone	★★★★	4,783 people
	Imuran	★★★★	2,355 people
TOP DIETS	**No Beer**	★★★★	2,348 people
	No Dairy	★★★★	2,010 people
	No Spicy Food	★★★★	1,936 people
TOP SUPPLEMENTS	**Vitamin B12**	★★★★	2,536 people
	Vitamin D	★★★★	3,165 people
	Probiotics	★★★★	3,095 people

3 Applying the ideas of consumer innovation to health care

Surveys show that medical-device development by patients is taking place on a massive scale. In nationally representative surveys conducted from 2010 to 2015 in the United States, the United Kingdom, Japan, Finland, Canada, and South Korea, approximately 1 million individuals reported that they had developed medical innovations to serve their own needs in the three years preceding the surveys[3]. Although the basic practices underlying free consumer innovation apply across sectors, innovators must make adaptations for their own personal and market environments. In the case of patient innova- tion, the most important adaptations have to do with ensuring safety and supporting free diffusion.

When a medical product that meets patient needs is available on the market, patients often prefer to buy that product rather than developing their own or copying another patient's free design. However, if a solution isn't available commercially and the need is urgent, many try to design and build their own product. Things patients need may not be profitable to produce for reasons including the following:

[2] Consumers, being self-rewarded, tend to pioneer new products and appli- cations. Since they give away their designs for free, they are not concerned with how much demand they generate from others. In contrast, producers prefer to enter markets after consumers have pioneered prod- ucts. They can then evaluate the reactions of free adopters to consumer-developed innovations and better understand the likely extent of market demand (von Hippel, 2016).

[3] The country surveys used a standard definition for medical innovations. Each had to be a new or modified product for personal or family use, developed by patients or their nonprofessional caregivers, and provide improvements over products already available on the market. Innovations that individuals developed at home for their jobs or for sale, or were paid to develop, were not included. See C. von Hippel, "A Next Generation Assets-Based Public Health Intervention Development Model: The Public as Innovators," Frontiers in Public Health, Sept. 4, 2018.

- Thousands of rare diseases are chronic and challenging for patients to manage on a long-term basis. In many instances, the diseases afflict rela- tively few patients and represent markets that are too small for producers to profitably serve.
- Often, even when a large number of patients have the same need, producers don't have sufficient incentive to innovate because there's no good way for them to profit from the type of solution that's needed. Crohn's disease offers a case in point. As useful as it may be for Crohn's patients to manage and reduce their symptoms through diet, getting companies to invest in the clinical trials is a hard sell. They would want to recoup the costs via patented food products or other measures.
- Even if an innovation can be protected and is potentially profitable, the regulations governing clinical trials tend to make it costly and slow for producers to get approvals. For example, in the United States, getting Food and Drug Administration approval for a device of low or moderate risk takes an average of 10 months. Approvals for high-risk devices - such as an artificial pancreas - could take four to five years and cost $75 million (Makower et al., 2010). As demonstrated by the history of the patient-developed artificial pancreas, patient innovators (whose noncommercial activities are exempt from FDA regulation) may be able to develop and produce something in a matter of weeks or months, at very little cost.

One or more of these constraints can inhibit the commercial provision of many things that patients need. This makes the free patient innovation system a critical resource that must be recognized and supported.

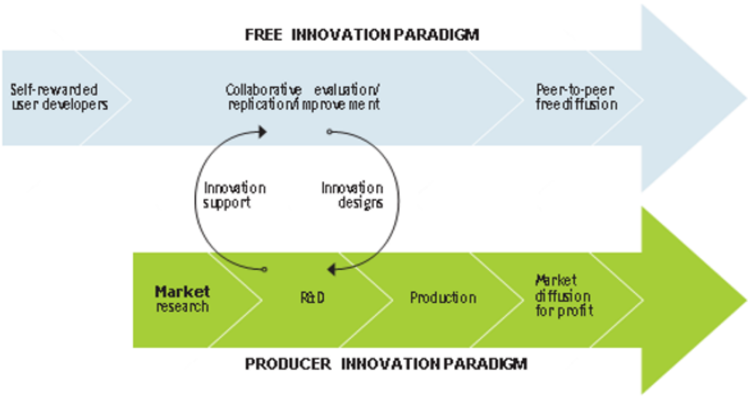

Figure 2: Consumer versus producer innovation; E. von Hippel, Free Innovation, 2017

4 Supporting patient innovation

Would-be patient innovators grapple with important questions about legality and safety, what the future of patient innovation looks like, and how the DIY system can be supported and improved. We address these questions here.

Is it legal for patients to develop and diffuse DIY medical innovations? Different countries have different laws regarding patient-developed innovations, although many Western countries follow similar guidelines. In the United States, freedom for patients to innovate is firmly rooted in the country's legal traditions. Under the U.S. Constitution's Fourth Amendment, which enshrines the right toprivacy, citizens may create medical innovations at home and use them on themselves. This right is protected whether others consider an innovation to be effective or ineffective or its use wise or unwise. The First Amendment, moreover, protects the right to free speech, thereby entitling people to tell the world about their innovations and to share details about designs and their use. In addition, the Commerce Clause of the U.S. Constitution and the governing statutes of federal regulatory agencies such as the FDA restrict agencies from regulating noncommercial activity.[4]

Is patient innovation safe? It's important to acknowledge that safety is not guaranteed. For example, a software coding error in the design of an artificial pancreas could lead to dangerous miscalculations in a patient's insulin dose. Such an error would be far more serious than, say, erroneously advising a Crohn's patient to avoid drinking beer. Offsetting this sort of risk is the fact that very few patient-created medical innovations fall into the highest FDA risk category.[5] Even in cases where there are significant safety risks, we think it would be a mistake for governments to limit patient innovation. In our view, there are two compelling reasons to encourage it.

First, the proper way to evaluate the dangers of patient innovation is to compare the risks patient DIY devices pose with the harm patients suffer when no such innovation exists. Consider again the artificial pancreas. Once building one became technically possible, it was hard to overlook the fact that the lack of an FDA-approved commercially available product contributed to the deaths from hypoglycemia of thousands of people with diabetes and a worsened quality of life for thousands more suffering from the disease (Seaquist et al., 2013).

In other words, when patients innovate to address medical problems unserved by commercial solutions, we may well see that their innovations provide a net gain rather than a loss in safety and quality of life for the whole population of affected patients. We expect safety will improve further as low-cost clinical trial methods are developed to enable patient communities to test their own innovations, utilizing similar ethical standards to those used by hospitals and universities for clinical research involving human subjects. (See "Low-Cost Clinical Trials by and for Patients.")

Second, as already noted, individual patients have the legal right to make their own choices, and these rights are very broad. By way of comparison, extreme sports are widely recognized as risky - those who participate in them can face injury or even death. Yet, in the name of personal freedom, society doesn't ban people from taking part in ex- treme sports. Similarly, some patient innovators will develop devices that could be seen as overly risky. But society shouldn't use that as an excuse for banning patient innovation.

[4] Sharing information about medical innovations for free is not a commercial activity. However, it is not legal for medical patient innovators to sell copies of their innovations to others without first receiving FDA clearance. See A.W. Torrance and E.A. von Hippel, "The Right to Innovate," Michigan State Law Review, no. 2 (2015): 793-829.

[5] According to the U.S. Food and Drug Administration, the devices (called Class III devices) "usually sustain or support life, are implanted, or present potential unreasonable risk of illness or injury."

What does the future of patient innovation look like? The ability of patients to develop new medical products to serve their own needs is growing, and we expect the system to become stronger over time for several important reasons. First, the DIY design tools that patient innovators need are becoming cheaper and increasingly capable. People with fairly rudimentary engineering skills can acquire powerful design software that can run on an ordinary personal computer either for free or for very little money. Second, the materials and tools used to build products from DIY designs are also becoming both cheaper and increasingly capable. For example, the original DIY artificial pancreas system design used a microcomputer that sells for about $30 today. Newer DIY solutions don't require a special-purpose computer at all, instead using smartphones and specially designed apps[6]. Third, the search and connection functions of today's internet enable patients - even those with extremely rare diseases - to find others with similar problems throughout the world. Patients and caregivers can collaborate online to build DIY projects. Indeed, thousands of patients have found their way to the OpenAPS and Crohnology websites, and many people have contributed their technical skills.

How can the free grassroots patient innovation system be supported and improved? We believe that patients, medical product and service producers, and government regulators should all support the patient innovation system and help it develop in medically and socially valuable directions. How can this be done?

At present, the early stages of the patient innovation process seem to be working well. It can leverage the same tools and systems used for consumer innovation in other fields - everything from open-source software development to hardware hacking in maker spaces. However, clinical testing and certain aspects of free diffusion are unique to medical innovation. These elements require special attention and improvement, and that's where innovating patients, commercial producers, and governments can all play a role.

4.1 Improving clinical testing

In the case of clinical trials, patient innovators cannot simply adopt FDA gold-standard trial designs. These designs - including randomized double-blind placebocontrolled trials - are generally too expensive for patient communities to conduct on their own. However, less elaborate designs can produce high- quality results at much lower cost and in less time[7]. Support for improvements here would involve creating websites and tool kits to provide guidance to patients who have little knowledge of trial design, appropriate privacy and safety standards for trial participants, and statistical analysis (much as other websites help software development newbies set up open-source projects with pretested tools and procedures). Such tool kits are being developed by DIY patient communities and offered by commercial sites like ProofPilot (https://proofpilot.com) to support both commercial and community experimentation.

4.2 Improving diffusion

Since patient innovations are exempt from FDA regulation only if they are diffused noncommercially, patients must make their own noncommercial copies from free designs. Given this

[6] An example is the RileyLink, "the communication highway between your insulin pump, CGM, and iPhone"; see "RileyLink."

[7] For example, n-of-1 clinical trial designs are applicable to many patient innovations; see "Low-Cost Clinical Trials by and for Patients."

restriction, how can noncommercial diffusion be simplified to make innovations more accessible to individuals who lack technical skills?

We see some promising opportunities in taking advantage of increasing openness of governmentapproved medical devices to DIY attachments and in the increased availability of commercial off-the-shelf, open-source components suitable for DIY projects. Consider the artificial pancreas project. In 2013 commercial medical devices such as continuous glucose monitors and insulin pumps were designed to protect the data these devices collected on patients, using encryption. Patients didn't have access to their data because the assumption was that only doctors would understand it and have use for it. As a result, innovators had to find ways to hack the devices to gain access to their own patient data, overriding the producer's intent. Today, device makers have incentives to make their interfaces open so that they can be a valued part of DIY systems[8].

As the benefits of patient-developed innovations become increasingly evident, many new types of specialized platforms and services to support free diffusion are likely to emerge. For example, Patient Innovation, a nonprofit online platform devoted to facilitating the evaluation and sharing of innovative solutions developed by patients with any disease, is available for free[9]. It complements special-purpose platforms like OpenAPS and Crohnology.

As the free patient innovation system expands and strengthens over time, we expect to see greater complementarity between it and the commercial medical innovation systems. Patients, medical product and service producers, and government regulators all have vital roles to play in supporting the free patient innovation system and helping it develop in medically and socially valuable directions. The economic reality is that commercial producers and medical service providers will never be able to deliver everything patients need. Innovative patients can fill many of the gaps if they are properly supported. A richer set of available medical innovation options will benefit patients, commercial medical caregivers, producers, and society at large.

Acknowledgements

This chapter was first published as DeMonaco, H., Oliveira, P., Torrance, A., von Hippel, C., & von Hippel, E. (2019): When patients become innovators, *MIT Sloan Management Review*, 60(3), 81-88, under a Creative Commons license. Republished with the authors' permission.

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8 South Korean insulin pump producer SOOIL Development has done this, and Dexcom, a producer of continuous glucose monitors based in California, has made a similar move. See M. Hoskins, "News: New Dana RS Insulin Pump Embraces #WeAreNotWaiting Open Design!" Diabetes Mine (blog), Sept. 12, 2017, www.healthline.com; and A. Tenderich, "News: Dexcom Opens API to Embrace Collaborative Diabetes Innovation!" Diabetes Mine (blog), Sept. 20, 2017.

9 The Patient Innovation platform was recognized in 2016 by United Nations Secretary-General Ban Ki-moon for supporting the UN Sustainable Development Goals of promoting good health and well-being (SDG3) and fostering innovation and building resilient infrastructure (SDG9); the U.N. goal itself, however, is to "ensure healthy lives and well-being at all ages."

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Chapter 9

Communities of practice as collective lead users

Hans Koller, Benjamin Schulte, Florian Andresen, and André Kreutzmann

Abstract

In today´s world of rapid technological changes and high-velocity markets, one of the central challenges many organizations face is to create truly novel products and services that can secure sustainable competitive advantage. While most organizations are quite capable of improving their products and services, they often lack the ability to break from their own treaded pathways. In this article, we elaborate on the collective side of lead users. We argue that intra-firm communities of practice as social entities can display similar lead user characteristics although no single individual member possess all criteria commonly associated with lead-userness. We ground our arguments predominantly in conceptual deliberations based on the conjunction of the concepts of lead users and communities of practice. However, as we have studied these communities of practice in the German Federal Armed Forces (an end-user-organization in the public sector), we are providing first evidence from different case studies supporting our concept of collective lead users.

Keywords: Lead Users; Communities of Practice; Collective Lead Users; End-User-organization

1 Introduction

In today´s world of rapid technological changes and high-velocity markets, one of the central challenges many organizations face is to create novel products and services in order to gain competitive advantage. While most organizations are quite capable of improving their products and services, they lack the ability to break from their own paths. Although marketing research early on tried to understand customer needs and the increasing research on user integration provided many great insights, the central problem of breaking from the existing path´s endured. In the face of this challenge von Hippel (1986) introduced the concept of lead users as innovators. As the identification and subsequent integration of these lead users would directly address the challenge to overcome path dependency regarding product and service innovation, the concept quickly attracted scholars and practitioners alike.

Within the emerging field of lead user theory scholars early on began to construct and refine a systematic approach to identify and integrate lead users. Beside the founder of this field Cornelius Herstatt was at the leading edge of this field. Engaged in the lead user method (Herstatt & von Hippel, 1992), uncovering new loci of lead users (Schweisfurth & Herstatt, 2015, 2016; Tietz, Füller, & Herstatt, 2006), as well as advancing the overall lead user theory and the characteristics of lead users (Lettl, Herstatt, & Gemuenden, 2006; Lüthje & Herstatt, 2004), Herstatt shaped this field quite substantially. In fact, we have to admit that his ideas led us to include lead users into one of our recent research projects. Especially his focus on

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R. Tiwari and S. Buse (eds.), *Managing Innovation in a Global and Digital World*, https://doi.org/10.1007/978-3-658-27241-8_10

lead users embedded in organizations and his focus on user communities sparked our imagination to hypothesize if we could carry these ideas to communities of practice within end-user organizations.

In particular, we expected to spot lead users within the manifold, highly specialized domains of the German Federal Armed Forces, in which soldiers are often users of sophisticated equipment and products in extreme and novel situations such as missions abroad (e.g., Afghanistan). To our surprise, we did not recognize one single person who exhibits all commonly known lead user characteristics. Instead, we found that communities of practice that describe self-organized practitioners, who share knowledge and develop innovative solutions to their practice problems, can display all lead user criteria as a collective, social entity.

Given this unexpected finding, we turned back to the impressive research on lead users and noticed that the lead user is most commonly depicted as a singular person (Hienerth & Lettl, 2017). Although a collective side was always present in the literature on lead users (Hienerth & Lettl, 2011; Hienerth, von Hippel, & Jensen, 2014; Kratzer, Lettl, Franke, & Gloor, 2016; Morrison, Roberts, & Hippel, 2000; von Hippel, 2001), for the most part researchers envisioned collectives as support networks around lead users. However, as the market dynamic is rising and the complexity of products and services is constantly increasing, we were wondering if specific contingencies might call for more than individual lead users. We further found support for this assumption as research on lead-userness and the turn from dichotomous to continuous lead user characteristics (Faullant, Schwarz, Krajger, & Breitenecker, 2012; Morrison, Roberts, & Midgley, 2004; Schreier & Prügl, 2008) opened new possibilities to explore heterogenous groups of people, displaying different lead user characteristics.

In this article, we will elaborate on the collective side of lead users. We argue that intra-firm communities of practice as social entities can display similar lead user characteristics although no single individual member possess all criteria commonly associated with lead-userness. We ground our arguments predominantly in conceptual deliberations based on the conjunction of the concepts of lead users and communities of practice. However, as we have studied these communities of practice in the German Federal Armed Forces (an end-user-organization in the public sector), we are providing first evidence from different case studies supporting our concept of collective lead users.

2 Theoretical background

2.1 Lead users and collective entities

The initial concept of lead users was formulated by von Hippel (1986) in order address internal and external barriers in firms to break from familiar trajectories inhibiting the development of „very novel products“. In the original approach lead users are defined as individuals who (1) are facing needs ahead of the market and (2) would benefit significantly from solutions to address these needs (von Hippel, 1986). As this concept addresses one of the fundamental questions of developing a (dynamic) capability with regard to product development, researchers quickly flocked to this emerging field within the wider area of user or open innovation (Lüthje & Herstatt, 2004; Mahr & Lievens, 2012; Mahr, Lievens, & Blazevic, 2014). Especially scholars concerned with marketing and innovation management have been very active in pushing the theoretical and practical boundaries of the lead user concept and method (von Hippel, 1986; Herstatt & von Hippel, 1992; Lüthje & Herstatt, 2004).

In this line, early research on lead users focused on the interaction between manufacturing firms and lead users with the aim to identify and integrate such extraordinarily sophisticated users and their breakthrough ideas into the fuzzy front end of the new product development process (Herstatt & von Hippel, 1992; Lilien, Morrison, Searls, Sonnack, & Hippel, 2002; Lüthje & Herstatt, 2004). The reasoning behind this lead user method is to identify individual leading-edge users from a population of users and utilize their knowledge about future needs for the focal firm's innovation capability (Urban & von Hippel, 1988; von Hippel, 1986). The described interaction, therefore, is mainly dyadic between singular entities: incumbent firms and selected lead users.

Particularly the identification of lead users sparked research in order to flesh out more detailed characteristics and traits which would allow distinguishing lead users from other user groups like regular users, user innovators, and expert users (Hienerth & Lettl, 2017). Thus, the bulk of the research is conducted regarding the lead user method, while the construct itself, as well as connections to other research streams, is rather underrepresented, sometimes leading to conceptual dilution (Hienerth & Lettl, 2011, 2017).

Research on the characteristics of (potential) lead users has gained much traction, especially with regard to the concept of lead-userness. In line with the overall aim to uncover lead users, the central focus of this research stream is directed on the antecedents of lead-userness. Angur and Nataraajan (1998) early on used the term lead-usership as a latent variable explained in part by innovatorship, which in turn is explained by adoption behavior. It is argued that users with unsatisfied needs would search their environment and adopt new products or services fitting their needs (Angur & Nataraajan, 1998). Following in this line especially Schreier and Prügl (2008) have systematically uncovered additional antecedents of lead-userness. First, they outline that within the original framework consumer knowledge and use experience are critical components of lead-userness. Consumer knowledge refers to the body of knowledge users' possess in a broader use context, providing a sound basis of understanding that can be used to integrate new information and experience into their existing mental schemas (Schreier & Prügl, 2008). Use experience, on the other hand, is a more specific type of knowledge originating from direct interaction with tasks and products or services (Schreier & Prügl, 2008). Both types of knowledge are positively correlated as consumer knowledge is the basis from which use experience could be generated and interpreted, while use experience is one source to build up consumer knowledge (Schreier & Prügl, 2008). Additionally, Schreier and Prügl (2008) carve out the variables of innovativeness and locus of control. The latter is a measure for users' believe that outcomes rely on their actions, while innovativeness measures a predisposition of users for innovations, thus, being similar to the adaptation measure proposed by Angur and Nataraajan (1998).

Finally, the construct of lead-userness is no longer adhering to the implied logic of a dichotomous construct but instead assumes a gradual measure (Hienerth and Lettl, 2017). Thus, research on lead users is opened up substantially to include wider populations of users exhibiting different degrees of lead-userness. Furthermore, this opens up the avenue to argue that there might not only be a single lead user or a small group of dispersed lead users but different users exhibiting different traits of lead-userness. Taking this argument even further, while reconnecting it to the increasing expectations put on lead users due to rising product or service complexity in high-velocity environments, we might argue that the lead user must not always be considered as a specific individual. Rather, a lead user can also be conceived as a collective of heterogeneous users with different degrees of lead-userness or even with different lead user characteristics who collectively shape the lead-userness as a group.

Consequently, in more recent studies, researchers' focus increasingly shifts from investigating singular lead users and their characteristics to exploring what kind of social contexts such users are embedded in. For instance, one research strand explores the role of lead users within user communities (Franke & Shah, 2003; Hienerth & Lettl, 2011; Hienerth, Lettl, & Keinz, 2014; Mahr & Lievens, 2012; Shah & Tripsas, 2007). Such communities describe informal social networks in which individuals from diverse backgrounds share knowledge and innovative thoughts about a common topic or field of interest (von Hippel, 2001, 2007). These communities can be a vibrant arena for innovation because members engage in mutual problem-solving, develop innovative ideas or advance new technologies for new or existent applications (Franke & Shah, 2003; Hienerth, 2006; Hienerth, von Hippel et al., 2014; Jeppesen & Frederiksen, 2006; von Hippel & Krogh, 2003).

Another emerging literature stream recognizes that some firm employees can be lead users of the company's products and services (Schweisfurth & Herstatt, 2015, 2016; Schweisfurth & Raasch, 2015). Schweisfurth and Raasch (2015) refer to such employees as embedded lead users that are simultaneously embedded in the social context of a focal firm but also engage with other users in their user communities outside the organization's boundaries (Schweisfurth & Herstatt, 2015, 2016). Schweisfurth and Herstatt (2016) point out that such embedded lead users function as boundary spanners because they, on the one hand, hold sticky knowledge about user needs and experiences through their use of the firm's products and their interactions with other users. On the other hand, embedded lead users also possess knowledge about the focal firm's internal processes, routines, and its culture, which enables them to translate specific user needs and ideas into new products.

Furthermore, several authors point out that lead users often are members of and participate in such user communities (Hienerth & Lettl, 2011; Hienerth, Lettl et al., 2014; Jeppesen & Laursen, 2009; Shah & Tripsas, 2007). This research argues that it seems unlikely that one individual alone possesses all capabilities needed to develop an initial idea into a full-fledged innovation. Thus innovative users will probably seek the help of others who are also interested in the same topic (Kratzer et al., 2016). In this context, Shah and Tripsas (2007) point out that lead user innovations are often rooted in collective processes in which user communities provide the space for trial and error experimentation, learning by doing, and recombination of knowledge. In a similar vein, Hienerth and Lettl (2011) elaborate that communities evolving around lead users help to evaluate initial lead user' ideas and facilitate the development of prototypes because members possess heterogeneous but complimentary knowledge and skills. Besides, the user community is said to play a crucial role in adapting the lead user innovation and diffusing it, thus reducing the risks involved in innovating (Hienerth, Lettl et al., 2014). On a related note, scholars have found that lead users often function as boundary spanners between several local user communities. They are thus critical for importing and sharing new knowledge from other distant fields, helping the local community to extend or recombine its existent knowledge which is a fundamental premise for exploration (Jeppesen & Laursen, 2009; Kratzer et al., 2016; Kratzer & Lettl, 2008, 2009). Otherwise, user communities would only incrementally build on aspects already known in their field, making true breakthroughs unlikely. Lead users' solution or market knowledge from outside domains paired with the distributed intelligence and peer review mechanisms of local user communities thus build the base for developing fruitful innovations.

It becomes evident through this review of the recent literature that research on lead users increasingly studies the collective side of the lead user phenomenon by exploring miscellaneous social settings in which such users are situated. Albeit the manifold lines of research, we would like to tie all these strings together to flesh out a manifestation of the lead user that is not bound to the individual. Following the argument that lead users gain their leading edge status from use experience in extreme or novel practice, while considering the subsequent arguments for collaborative experimentation and the combination of different (tacit) knowledge sources in the context of a community, we are suggesting that communities of practices can be considered as settings to study collective lead users.

2.2 Communities of practice as collective lead users

The literature on communities of practice can be differentiated into at least two different streams, reflecting their underlying schools of thought: a rather institutional view originating from an organizational learning perspective and a rather instrumental view rooted within a knowledge management perspective. First and foremost there are the studies of Lave and Wenger (1991), Wenger et al. (2002) as well as Brown and Duguid (1991) that paved the way for communities of practice to be recognized as an important asset within organizational learning processes. Their main focus is to show that communities of practice as loci of specialized knowledge play a vital role in creating, preserving and sharing practices with respect to organizational tasks (Bechky, 2003; Brown & Duguid, 1991; Contu & Willmott, 2003; Jagasia, Baul, & Mallik, 2015; Kogut & Zander, 1996; Lave & Wenger, 1991; Wenger, McDermott, & Snyder, 2002). Related to the organizational learning perspective but far more management driven is the literature stream investigating the contributions of communities to the organizational knowledge and innovation management (Bertels, Kleinschmidt, & Koen, 2011; Franke & Shah, 2003; Harvey, Cohendent, Simon, & Borzillo, 2015; Kimble & Hildreth, 2005; Mahr & Lievens, 2012).

Within this article we adhere to the organizational learning side, understanding communities of practice as a web of relationships emerging within the realm of a more or less pronounced identity connected to a specific knowledge area or field of expertise shaped and reshaped in the day-to-day practices (Bridwell-Mitchell, 2016; Brown & Duguid, 2001; Lindkvist, 2005; Wenger et al., 2002). In order to connect the community of practice perspective with the concept of lead users, we further need to elaborate if communities of practice could theoretically be considered as entities that collectively develop needs ahead of the market on the one hand and would benefit from solutions for said needs. However, before we dive into the internal mechanisms of communities of practice in order to theorize if we find similar antecedents for lead user behavior, we are taking a short look at the side of the consequences attributed to lead users: “come up with attractive user innovation” (Schreier & Prügel, 2008: 334).

Regardless of the scholarly stance either on the organizational learning or the knowledge management side, research seems to agree that communities of practice can be envisioned as a vibrant source of product, service, or process innovation. Kodama (2000) for example mentions that the usage of communities of practice fosters the development of an innovative mindset, which leads to the evolution of an innovative subculture within the organization (Bertels et al., 2011), while Harvey et al. (2015) stress the importance of communities within the front end of innovation. Consequently, several scholars concentrate on communities of practice serving as loci for the successful collaborative development of innovations (Belz & Baumbach, 2010; Franke, von Hippel, & Schreier, 2006; Hienerth & Lettl, 2011; von Hippel, 2005, 2007). Besides empirical research on brand (Füller, Matzler, & Hoppe, 2008) and open source communities (Lakhani & von Hippel, 2003), several studies elucidate the outstanding potential of communities of practice with regard to user-driven innovation (Franke & Shah, 2003; Hienerth & Lettl, 2011; Jeppesen & Laursen, 2009). Withal, a central argument for these collaborative ventures is made by Harhoff, Henkel, and von Hippel stating that the creative innovation process is often characterized by complementary contributions of several actors *"since none of them has sufficient knowledge or information to produce the innovation on their own."* (2003, p. 1757). In summary, the assumption that communities of practice as collective entities produce similar outcomes as lead users, thus, carrying our overall proposition of collective lead users.

However, regarding the question, if the antecedents used in the lead user theory are similar in communities of practice, we need to look at the internal mechanisms of these entities. At first, research has shown that communities of practice provide an error-tolerant and risk-rewarding atmosphere (Kirkman, Cordery, Mathieu, Rosen, & Kukenberger, 2013; Kirkman, Mathieu, Cordery, Rosen, & Kukenberger, 2011) which stimulates the members to articulate new ideas and concepts in connection to their workplace (Brown & Duguid, 2001; Jeppesen & Laursen, 2009). Due to this specific context members are enabled to deviate from common practices or engage with ideas deviating from routines and believes ingrained in the organization. Therefore, communities of practice could not only be perceived as possessing an innovation capability, but they can also hold the potential to create radically new solutions.

Furthermore, within formal organizational contexts communities of practice emerge as informal entities serving as a sphere for interaction and exchange of the experts in their specific field of expertise (Brown & Duguid, 2001; Pattinson & Preece, 2014; von Hippel, 2005). Their expertise is, on the one hand, a result of their constant engagement with barriers and opportunities emerging in their day-to-day practices and on the other hand increased by their collective attempts to make sense of said barriers. In particular, scholars have argued that the formation of communities of practice can sometimes be seen as a reaction to barriers (or opportunities) encountered by individuals within the same or a similar domain (Swan, Scarbrough, & Robertson, 2002; Topousis, Dennehy, & Lebsock, 2012). Barriers in this sense can be interpreted as challenges originating from products or processes that could no longer be used to fulfill the organizational tasks in the face of changing environments, thus, bringing us back to the original definition of von Hippel (1986) regarding lead users‘ dissatisfaction with existing solutions. Combined with the notion that communities of practice provide low-risk environments of creative exchange, we can hypothesize that these entities are not only at the leading edge of their specific domains but are also able to overcome the negative influence of familiarity. Additionally, research on the motivation of members of communities of practice shows that, apart from advancing their domain out of joy, members also want to improve their task fulfillment (Jeppesen & Frederiksen, 2006; Pastoors, 2007; Probst & Borzillo, 2008; Shah, 2006; Sole & Edmondson, 2002). Within organizational settings, community members are at the same time located in their formal and their informal contexts. In turn, we can argue that the members of a community of practice will directly benefit from solutions they develop.

In summary, we argue that a community of practice could comprise all lead user characteristics. Communities of practice are often at the leading edge of their domain due to the interconnection of experts in similar practices. Their highly specialized practices do not only provide the possibility to identify emerging threats and opportunities, but they are also the reason why members of a community of practice would highly benefit from addressing them, as their task fulfillment within a formal context depends on it. Furthermore, as most members are domain experts motivated to exchange knowledge with their peers to advance their overall field of expertise, communities of practice provide ideal spaces for collective sensemaking and creativity. This is increased by the fact that, in contrast to their surrounding formal and often hierarchical context, communities of practice provide spaces that allow its members to deviate from existing practices. In order to undergird these theoretical arguments, we are using the remainder of this article to present first empirical insights in the form of short case descriptions.

3 Collective lead users in the German federal armed forces

The following impressions stem from a four-year study of informal, self-organized communities of practice within the German military. These communities spontaneously emerged around various practices of the armed forces that were characterized through a dynamic and increasingly complex environment for task-fulfillment. For example, we studied the following communities of practice:

- The demolition community; a group of soldiers concerned with military blasting procedures within missions abroad such as Afghanistan or Kosovo that necessitated more precise and indulgent demolition techniques.
- The culture community; which evolved within the domain of intercultural competence, a critical capability within nowadays' out of area assignments that require a fundamentally renewed approach of interacting with the civilian population and the local cultural context.
- The electronic safety community; a self-organized group in the field of operational safety of electronic devices that are increasingly technologically sophisticated, modular, and delicate.
- The link community; an informal network that emerged around the operation and maintenance of state of the art radio systems utilized for the encrypted exchange of tactical information among numerous units.

During our investigations of these communities of practice, we could not identify an individual member who embodied all of the above-outlined lead user characteristics. We, however, observed that these informally networked practitioners located at the organizational frontlines developed what could be termed a collective lead-userness through their ongoing self-organized interactions. To put it differently, instead of a single extraordinary individual, it seems that the community as an emergent, social entity displays lead-userness on an aggregate level.

In particular, we observed that these self-organized communities of practice often function as collective need detectors and sensors on the practice levels. That is, community members engage in their practices within dynamic and volatile circumstances in out of area missions, which regularly results in the extreme and novel applications of operating procedures or equipment. Within these new use contexts, frontline soldiers are often confronted with practice dilemmas as they reach the limits of existing routines or technical equipment parts. Due to this field-related experience in a novel use context, community members are often the first to recognize the needs for adapting routines and procedures or innovative military equipment.

For example, in the demolition community members sensed changes in their task-related context regarding the use of demolition devices in contemporary peace-keeping or peace-enforcing missions. To be more specific, traditional blasting procedures usually involve employing high amounts of explosives to destruct infrastructure (e.g., buildings, bridges, roads), whereas within the context of modern out of area missions requirements shift towards precise blasting in urban terrain (e.g., doors, windows, walls to gain access) without destructing civilian infrastructure. Trained demolition experts were the first to notice this profound change in their practice that requires new explosive devices, new training in the use of these devices, and new military equipment such as backpacks, tools, and tool bags to effectively transport and use the new explosives. Note, that not one single member recognized all the needs mentioned above but that these experts continuously exchange their experiences within these missions abroad from which a collective consciousness of the practice problems gradually evolves. Regarding missing equipment one informant, for example, noted:

> *"We do not have a specialized backpack for blasting materials. When we are in exercises or missions, and we have to dismount (from the combat vehicle) we have to take everything with us like tools, explosives and so on and every soldier has 10 pounds of explosives, and this becomes heavy. However, we do not have an extra backpack for it."*

Besides these strong needs for innovating procedures and products, the community members regularly pointed out that they would expect a high benefit from obtaining a solution to their practice problems. Take, for example, the blasting experts mentioned above; they literally have a vital interest in obtaining the best solution possible to their practice problems when they handle explosives in dangerous, stressful, and complicated situations. In other words, community members' benefits from obtaining innovative solutions were always connected to improving the task-fulfillment for themselves and their comrades. Additionally, informants often emphasized that finding a more effective and efficient way to perform their duties would not only facilitate individual benefits but could also increase overall organizational effectiveness of the armed forces. As one community member noted:

> *"...because we would not work in this community if there were no benefits to the Federal Armed Forces."*

Lead users, however, are not exclusively characterized by experiencing unique needs and expecting high benefits but are also often capable of developing first solutions or prototypes to the identified needs (von Hippel, 2005). Innovation emerges from knowledge about needs but also from solution knowledge. Within our investigations, we did not detect one single individual lead user developing an innovative solution, but instead, we observed a collective problem-solving process within these communities of practice. The collective development of new operating procedures or prototypes for military equipment parts relied on the distributed and heterogeneous knowledge of several community members. Returning to the example of the backpack for demolition experts, one soldier sketched out an initial draft for a new backpack that would be feasible for various mission scenarios. After that, he introduced the idea to other community members, who then began to refine the backpack relying on their knowledge about different use scenarios and their individual experiences from different missions. This is because the community involves soldiers, who are posted in various units and service areas ranging from Army Special Forces to Naval divers, and therefore, have distinct user experiences within unique contexts. Sharing this context-specific knowledge within the community thus enabled members to further develop the backpack. Besides this knowledge about different use contexts, some community members know how to process and integrate novel ideas into the official system of the armed forces. These often more experienced members hold organizational knowledge that entails knowledge about the bureaucratic requirements that need to be fulfilled. They also knew whom and which authorities to contact during such a bottom-up induced innovation process. For example, in the case of new military equipment, all newly procured items and products need to be internally tested for their military applicability. Considering the backpack again, one member established a link to one of the internal testing facilities of the armed forces to verify the backpacks' material quality. After these tests, the community was able to prototype the backpack with the help of a civil manufacturer. Subsequently, several community members were invited to test the backpack during their day-to-day activities. One informant summarized this as follows:

> *"Moreover, we had the contact to the technical center and to the experts, who make all these experiments: when does it break under pressure, what is happening if you attach it to a parachute and so on."*

Additional to this internal organizational knowledge, the studied communities of practice often fulfill the role of boundary spanners because some members cultivate connections to manufacturing firms of military equipment or civil institutions in their field of expertise such as universities or professional associations. These connections enable members to incorporate external knowledge into their solutions and on the other hand transfer their prototypes and solutions to manufacturers to stimulate the production of new, much-needed products on the producer side. In many cases, the communities were able to initiate improvements of existing products or technical devices as they transferred their context-bound use knowledge to manufacturing firms, who were willing to integrate these experiences into their products. For example, in one of the studied CoPs informants explained how they improved the design concept of a large, industrial power generator mostly used in camps, which was later introduced into the armed forces with the second generation of the generator because members exchanged their innovative ideas with the manufacturer.

In summary, the impressions from the armed forces indicate that community members collectively detect new needs regarding their practices as they engage in extreme and novel use-contexts. Besides that, the communities of practice are able to generate adaptive solutions through their self-organized interaction as complementary knowledge and perspectives are brought together. Finally, some members of the communities act as boundary spanners enabling the transfer of sticky, context-bound use experiences and local solutions to manufactures. In light of these impressions, we suggest that the lead user in our cases is best understood on the collective level of the community. That is, lead user innovation depicts a collective phenomenon socially embedded in the self-organized interactions among practitioners on the organizational frontlines. It is this self-organization that brings the heterogeneous need and solution knowledge as well as the diverse capabilities of members required for innovation (e.g., prototyping, testing, boundary spanning, and diffusing by official acceptance) together.

4 Conclusion

Proceeding from the literature on lead users and the outstanding contributions that our dear colleague Cornelius Herstatt made to this field, we aimed at exploring the collective side of the lead user phenomenon in more detail. To this end, we reviewed prior work about lead users in the field of open and user innovation, noting that recent research increasingly studies the social contexts in which sophisticated users are embedded such as user communities (Hienerth & Lettl, 2011), user ecosystems (Hienerth, Lettl et al., 2014), or as employees in incumbent firms (Schweisfurth & Herstatt, 2016). Although this literature provides several hints regarding the collective nature of the construct as firms or entire user communities are sometimes labeled as lead users, scholars mostly concentrate on singular entities that possess a high degree of lead-userness when they refer to these extraordinary users.

To shed more light on the collective nature on lead users we, therefore, turned to the concept of communities of practice and provided empirical impressions from our fieldwork with such self-organized, informal groupings in the Federal Armed Forces. Based on these anecdotes, we suggest that communities of practice can develop what we refer to as collective lead-userness. That is, we identify lead user characteristics on the aggregate level of the community. First, members of such communities sense, articulate, and collectively discuss their needs stemming from novel use-contexts, which echoes the lead user characteristics of recognizing needs ahead of others (Lüthje & Herstatt, 2004; von Hippel, 1986). Second, community members express a high expected benefit from obtaining a solution (Morrison et al., 2000; Urban & von Hippel, 1988; von Hippel, 1986) because this would enable effective task-fulfillment in dynamic environments. Third, communities collectively hold the capabilities and the knowledge needed to address these needs. That is, they also embody the lead user characteristics of being capable of developing novel solutions (von Hippel, 1986). Finally, some members of these communities of practice act as boundary spanners (Jeppesen & Laursen, 2009; Kratzer et al., 2016; Kratzer & Lettl, 2009) helping to integrate external knowledge as well as initiating product innovations from manufacturers.

Given these observations, we assume that in complex and dynamic changing environments such as the above-mentioned domain of demolition procedures, lead-userness depicts a collective phenomenon. This is because, a community of practice is – under these contingencies – more capable to detect needs and develop innovative solutions more effectively and efficiently than a single person. Single individuals might be quickly overwhelmed by such complex and ever-changing environments due to their bounded rationality, i.e., their limited cognitive capacity to process information. Indeed, the community of practice comprises members with heterogeneous but complementary knowledge, skills, and roles and thus is capable of finding and implementing a solution of high quality more rapidly.

In outlining this collective lead-userness, we are the first to our knowledge who suggest a collective construct of lead users. However, we admit that the provided evidence is only a first step and that further research employing qualitative, as well as quantitative methodologies, is needed to verify this assumption more rigorously. An especially fruitful avenue for future inquiries at this point might be exploring the boundary conditions of collective lead-userness; that is, under which conditions and in what kind of organizational settings is it more likely that collective lead users emerge from interacting users, instead of being concentrated on single, innovative individuals.

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Chapter 10

The role of retailers as generators and mediators of new product ideas

Christian Lüthje

Abstract

Research on open and user innovation has not addressed the role of retailers as a source of innovation. This paper investigates the activities of retailer employees to develop own ideas for product innovations (retailer as innovator) and explores the retailers' efforts to obtain new product ideas from their customers (retailer as gatekeeper). We develop a model on potential facilitators that explain how active the retailers are with respect to both activities. Using data collected on 106 mangers of stationary sports equipment stores the analysis shows that a substantial fraction of the surveyed retailers develops new ideas, concepts, or prototype solutions for the products they sell in their stores. The findings also indicate that retailers, although they are the primary contact for end users of sport equipment, rarely receive substantial innovation-related input from their customers. Findings may help product manufacturers to select appropriate retailers for cooperation in new product development.

Keywords: user innovation, retailers, sports equipment

1 Introduction

There is little controversy in the marketing literature about the crucial role of retailers in the transfer of product innovations from producers to customers. Retail acts as gatekeeper of new products that are introduced by the brand owners. As most consumer goods markets are characterized by a continous stream of new product releases, retailers are able to exercise a significant market power. Consequently, there is extensive research investigating the antecedents that influence the decision of retailers to adopt new products and to put them into their shelves (e.g. Rao et al., 1989; White et al., 2000, van Everdingen et al., 2011). In addition, retailers also introduce innovations themselves. One main area of retailer innovations lies in the introduction of new customer interface technologies to improve the customer experience at the point of sales (e.g. Pantano and Laria, 2012). On the product level, retailers offer so called "store brands" or "private labels", i.e. brands owned, controlled, and sold exclusively by a retail company (Raju et al., 1995). Again, numerous studies have investigated the implementation of new technologies in retailing or have explored the factors that motivate retailers to introduce private labels (Corstjens and Lal, 2000; Shankar and Yadav, 2011; Liu et al., 2018). One can conclude that the transfer of product innovation from producers via retailers to consumers is well-understood.

Clearly less is known about the transfer of innovations from consumers via retailers to the producers. The influence of retailers on the generation of the manufacturers' product innovations has not been addressed in channel management literature. Most of the research examining the relationship between retailers and brand owners focuses on the day-to-day exchange

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R. Tiwari and S. Buse (eds.), *Managing Innovation in a Global and Digital World*, https://doi.org/10.1007/978-3-658-27241-8_11

of routine information on product inventory, sales numbers, the success of promotional activities, pricing structures and market changes (Hunt, 1995). Retail is hardly interpreted as a potential source of innovation for producers.

Also the literature on the relationships between retailers and their customers has rarely picked up the issue of innovation. The predominant discussion does not encompass the opportunity for retailers to obtain innovative ideas and concepts from their end customers. Considering the rich empirical evidence on the user innovation phenomenon, this can be interpreted as a critical research gap. Several studies have documented a high level of innovation activities performed by the users of products and services (von Hippel, 2005; Lettl, Herstatt and Gemünden, 2006; Lüthje, Herstatt and von Hippel, 2005). Consumer and household innovators have been found to frequently modify or develop new items of products for their own personal use (von Hippel, 2017). Particularly concepts developed by lead users are often rated very highly on innovativeness and use value (Herstatt and von Hippel, 1992, Lüthje and Herstatt, 2004). Since most consumer goods are sold through a channel of distribution via wholesalers, dealers, and retail shops to the consumer, store owners and their employees may play a crucial role in mediating the innovation link between consumers and producers.

In this study we focus on the activities that retailers show to stimulate the innovation work of manufacturers. We differentiate between two roles that retailers can play in this context: Firstly, retailing salespeople could act as innovators by conceiving new solutions for the products they sell (retailer as innovator). In some industries, retail salespeople are both, sellers and users of the products. Retail store employees therefore often build up an extensive experience in product use. We conclude that retail employees, due to their use experience, technical expertise and product involvement, may be well-prepared to develop solutions for modified and new products. This idea is very similar to the concept of embedded lead users, i.e. employees of producer firms who have lead user characteristics in relation to their employing firm’s products (Herstatt et al., 2016).

Secondly, retailers can act as information hub by identifying innovative input of their customers and by forwarding this information to the manufacturers (retailer as gatekeeper). Taking into account that the retailers’ salespeople have direct access to the product users, retailers should be able to build up a productive relationship with innovating customers visiting their stores (Beatty et al. 1996; Reynolds and Beatty 1999). Consumers should find it much easier to talk with employees working in retail than with representatives of the product manufacturers.

In this study, 106 sport shop managers were interviewed to explore the retailers’ efforts to generate own innovations and to mediate new product ideas from their customers. We develop and test a model on potential retail characteristics that may explain how actively the retailers take the role of innovators and innovation gatekeepers. The descriptive findings show that a substantial fraction of the surveyed retailers report having developed new ideas, concepts or prototype solutions for the products they sell. The results also show that retailers, albeit being the primary contact for users of sports equipment, rarely receive and forward substantial innovation-related input from their customers. The test of the model shows that the proposed characteristics of the retailers give significant explanation for the respondents’ own development activities and their efforts to act as gatekeepers for new product ideas of the end customers.

2 Model on retailers' innovation-related activities

In the following we propose a model on potential facilitators that may explain why some retailers act as innovators or mediators of end user innovation and others show no effort in this respect (see Figure 1).

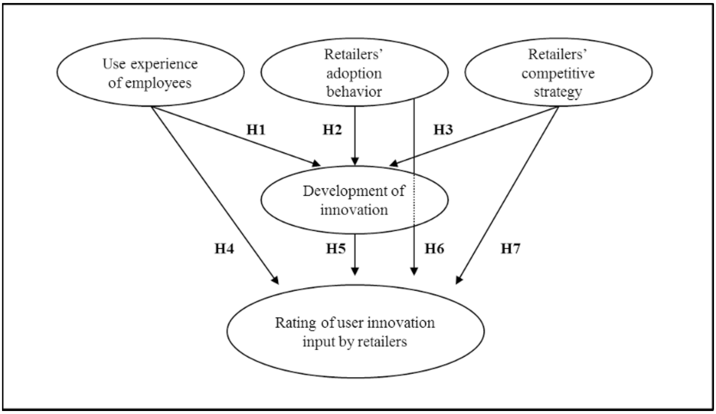


Figure 1: Model on the role of retailers as innovators and innovation mediators

2.1 Retailers as innovators

One cannot expect all retailers developing substantial ideas for innovations. We expect a high variance of innovation activities across retailers. To develop a testable model, three retailer characteristics are proposed that may facilitate original innovation efforts within the retail entities. In this first exploration of the retailers' contributions to innovation, we focus on characteristics of the dealers that are measurable and could therefore be used by producers to select attractive retailers for cooperation in new product development: use experience of employees, adoption behavior, and the generic competitive strategy of the retail stores.

Retail store salespeople with a high level of use experience (H1) may anticipate a higher benefit by innovating because they can expect to profit via personal and in-house use of their inventions (Schreier and Prügl, 2008; von Hippel et al., 2012; Stock et al., 2015). At the same time, higher levels of use experience are likely to be associated with lower costs of innovation. Retail employees with use experience are able to analyze existing use-related problems at no incremental costs. They can obtain a vivid and germane knowledge about use problems and promising solutions to those problems during activities that they engage in anyway. Retail employees having high levels of user experience have the opportunity of conceiving and testing solutions in practice and can therefore operate in a low-cost corridor of product development and refinement (Lüthje, Herstatt and von Hippel, 2002; Lüthje and Stockstrom, 2006).

Also the retailers' speed of adoption (H2) may indicate innovation-related benefit expectations (Morrison et al. 2000). Retailers that tend to integrate innovations very early in their product assortment can be expected to usually associate a high benefit with new products. Early adopters should therefore have a higher likelihood to initiate own innovation activities as well (Franke et al., 2006; Schreier and Prügl, 2008). Also, the costs for innovation may be lower for early adopting retailers. Early adopters usually have a good understanding about new product technologies and emerging product trends. This should bring them into a better position to conceive their own new product solutions.

It is proposed that the generic strategic position of a retailer as quality leader (H3) in combination with a specialized product assortment is associated with a higher probability of own development efforts. It seems reasonable that quality leaders often strive to hire experienced staff with in-depth product knowledge in order to be able to offer a superior service to their customers (McGee and Peterson, 2000). Similarly, the distinctive marketing competencies that quality leading retailers usually need to develop should positively correlate with innovation activities. For instance, Smart and Conant, (1994) found that independent quality leading stores often reflect a strong entrepreneurial orientation in the stores' staff. In the same vein, a study in a sample of drug stores suggests that small independent quality leaders often achieve higher performance due to their superior ability to put plans into action (McGee and Peterson, 2000). Implementation capabilities might also positively correlate with autonomous innovation activities.

2.2 Retailers as mediators of end customer innovations

As already noted, studies on consumer innovations strongly indicated that users often design new product solutions (von Hippel, 2005; Lettl, Herstatt and Gemünden, 2006; Lüthje, Herstatt and von Hippel, 2005). The question arises, if retailers actually recognize this innovation potential of their customers. This study aims at investigating antecedents that possibly influence the retailers' appreciation of innovative consumer input. Again, we expect that the retailers' speed of adoption, the level of their use experience, own innovation efforts and their competitive strategy determine how retailers evaluate the user input potential.

The first three factors are assumed to influence the ability and willingness to recognize the ideas and solutions developed by users. A minimum level of use experience (H4) should help retail salespeople to develop the "absorptive capacity" in order to grasp the key advantage behind the suggestions of their customers (Cohen and Levinthal 1990). After all, the users' ideas are often rooted on tacit knowledge that can only be developed in the course of a continuous and skillful use of the products (von Hippel 1998; Lüthje, Herstatt and von Hippel, 2005). Similarly, the adoption behavior (H5) and their inclination towards own innovation efforts (H6) are indicators of high-expected innovation-related benefit. This, in turn, may foster the alertness and openness of retail staff for innovative suggestions from their customers.

The generic competitive strategy (H7) is assumed to primarily impact the actual possibility of users to communicate their ideas to a given retailer. Quality-leading, specialized stores need to be more pro-active in the management of the relationship with their customers than cost-leading mass-merchandisers (McGee and Peterson 2000; Too et al. 2000). If strategy impacts culture, it can be expected that the staff generally responds to customer needs in a manner that is congruent with the retailer's competitive strategy (Siguaw, Simpson, & Baker, 1998). Consequently, employees working in quality-leading stores should have an interaction-oriented communication style and should be more inclined to enable their customers to describe their ideas (Williams and Spiro 1985). Also the willingness of the consumers should be higher to transfer their promising ideas if a given retailer shows a stronger emphasis on customer relations and service (Beatty et al. 1996). In the same vein, users may prefer to exchange innovation ideas with innovation-active retailers having high levels of personal use experience. Use experience and own innovation activities as shown by the retailers' staff signal expertise and interest for innovative solutions (Clark, 1996).

3 Research methodology

3.1 Sample and data collection

The sport equipment industry provided the setting for this study. The selection of this product field was stimulated by several studies documenting a high level of user innovation in sports equipment (Shah, 2000; Franke et al., 2003; Raasch, Herstatt and Lock, 2008). A minimum level of user innovations is a prerequisite for an active role of retailers as innovators and as mediators of innovative end user input.

The data for the main survey was collected from the target population of sports retailers in Vienna (Austria) encompassing stores in four different sport fields: outdoor (e.g. trekking, climbing, hunting), biking (street cycling, mountain biking), water-sport (e.g. sailing, surfing, scuba diving), and winter-sport (e.g. skiing, snowboarding). All the sport stores that were listed in the Yellow Pages Vienna were selected. Also retailer directories published on the web pages of sports equipment manufacturers were screened and, finally, search engines were used to complete the list of retail stores. In total, 151 sport shops were identified and contacted (full census). After one reminder, 106 store owners and managers agreed to participate in the study (70% participation rate). The data was collected through a fully-structured interview with the shop managers or store owners. The questionnaire was pre-tested with three managers of sport shops.

3.2 Measurement

To our knowledge, no standard scales exist to operationalize most of the factors included in the present model. The main survey was therefore preceded by a pilot study. We sent out questionnaires to 32 sport shop managers and owners and asked them to provide feedback to our model and scales. The purpose was both to develop new valid scales for constructs in the model and to assess the relevance of items that were extracted from various previous studies.

Table 1: Measurement of variables in the model

Construct	Formulation of items
Use experience of employees	5 point rating scale (1= not at all true; 5= very true) *Please indicate to what extent you agree with the following statement:* “The employees in my store are active in sports and use the products intensively.“; “It is an imperative requisite for hiring a candidate that he/she is active in sports.”
Retailer’s adoption behavior	5 point rating scale (1= not at all true; 5= very true) *Please specify your adoption behavior with respect to new products:* ”I integrate new products immediately into my assortment.”; “I rather stick to the established and reliable products than to adopt new products (reverse scale).”; “I order new products only after I get requests from my customers and after preliminary market experience exist (reverse scale).”I am usually better informed about new products than other dealers.“
Retailer’s generic competitive strategy	*Are you a dealer with a small assortment of products for a narrow market segment or rather a broad-line dealer for a large customer segment?* 5 point rating scale (1= large segment/large assortment; 5=narrow segment/small assortment) *Are you a quality leader (high-priced, high-quality products) or rather a price leader (low-priced products, satisfactory product quality)?* 5 point rating scale (1=price leader; 5= quality leader)
Generation of own innovation prototype	dichotomous scale (yes / no) Have you or the employees in your store ever had an idea for new or improved sports products?
Frequency of user input	(1= never; 5= very often) *How often do you get the following innovation-related input from customers in your store?*

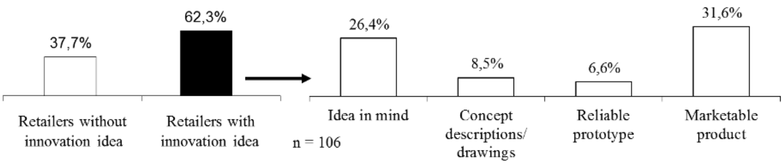
	"Suggestions for improving existing products", "Substantial ideas for developing totally new products"
Potential of user input	(1= never; 5= very often) *Please rate the suggestions and ideas from your customers:* "Are the ideas new and innovative?"; Are the ideas sophisticated with respect to the incorporated technology?"; "Do the ideas have a high market potential if commercialized?"

Most variables were measured by multi-item scales (see Table 1). Internal consistency of the scales was ascertained by calculating Cronbach's coefficient α and conducting exploratory factor analysis. Items were deleted based on low item-to-whole correlation and low factor coefficients, if this helped to increase α or the percentage of explained variance by the factor. All constructs proved to be satisfactorily reliable. As an exception, the retailers' own innovation activities were measured by a single item. The respondents had to indicate if they or their employees have ever developed a reliable prototype or marketable solution for a new piece of sports equipment.

4 Findings

4.1 Descriptive findings

Retailers seem to play an important role as innovators of the sports equipment they sell. Over sixty percent of the 106 store managers/owners reported that they or their employees had developed one or more ideas for innovations. Of all respondents, 6.6% indicate that they had built a reliable prototype embodying their idea, and 20.8% of all respondents went even a step further by transferring their idea into a marketable product. The results are displayed in Figure 2.



How do you rate the **newness** of your invention? a) **mean: 2.2** ; 20.9% high or very high newness (scale point 4 and 5)
How do you rate the **technical sophistication** of your invention? b) **mean: 2.3** ; 19.4% high or very high newness (scale point 4 and 5)
How do you rate the **market potential** of your invention if commercially produced? c) **mean 2.7** ; 28.8% high or very high market potential (scale point 4 and 5)
Do manufacturers, currently or in the foreseeable future, **market your invention**? **48.6% yes** 51.4% no

a) 5-point-rating scale; 1=small modification of existing product; 5=totally new proc
b) 1=very low tech; 5=very high tech
c) 1=very low market potential; 5=very high market potential; n = 66

Figure 2: Descriptive findings for respondents' own innovating activities

Most ideas are relatively minor improvements of existing products and often incorporate a low-tech solution. However, quite a few store managers assign a high market potential to their inventions, with 28.8% being expected to be adopted by many customers if introduced into the market. Similarly, a notable fraction of the innovations (48.6%) are currently or will be marketed in the foreseeable future, either by the retailer and/or by a manufacturer of sports equipment. Altogether, the findings clearly suggest that innovation efforts are disseminated through an important portion of the retailer sample.

To investigate the second role (retailers as mediators of user innovations), we asked the retail managers if they see retails as the primary communication partner for the consumers' product-related complaints and suggestions. Most of the respondents (81.1%) believe that the end users prefer to approach the retailers rather than the manufacturers. To understand the reasons for this assessment, the retail managers were asked to substantiate their assessment in an open question. Many respondents stated that consumers see the store where they usually buy their equipment as their most convenient and most logical contact. The customers often have repeated interaction experience and often built up a relationship with sales associates. In contrast, consumers find it difficult to contact the manufacturers, either because direct and personal communication channels are limited or due to spatial and cultural distance to the headquarters of a manufacturer. In sum, this finding underlines the important function that retailers, in principle, could play as mediators or gatekeepers of innovation-related customer input.

However, the results show that respondents do not perceive their customers to be an important source for innovative ideas (see Table 2). Almost two out of three respondents (62.9%) indicate that the salespeople in his/her store have never received substantial ideas for new products from their customers. As for the frequency of user input, also the potential that the respondents attribute to the ideas communicated by the customers is rather low. These findings are surprising considering the consistent empirical evidence for a high level of innovation activities among users in different sports fields (see studies cited above).

Table 2: Frequency of innovation-related input of the customers (from the retailers' perspective)

How frequently do your customers provide innovative input?					Sum (n=105)
	Never	Seldom	Occasionally	Often	Very Often
Substantial ideas for new products	62.9%	26.7%	4.8%	3.8%	1.9%

4.2 Model testing

In this section we explore if the proposed retailer characteristics can explain how active a given retailer is, both in designing own innovations and in recognizing the innovation ideas of consumers. For this, a Logit model was applied (Aldrich and Nelson 1984; Agresti and Finlay 1997). In the following analysis, the binary prototype developing activity (developing vs. not developing a reliable prototype for new equipment) serves as the dependent variable. The findings are presented in table 3. All global fit measures indicate a good fit of the estimation model. The rate of correct classified respondents in both groups (active and passive retailers) is 77.2% which is higher than the proportional chance criterion of 54.1%. Also in the smaller group of innovating retailers the percentage of correctly classified cases is satisfactory (66.7%).

Table 3: Logit model to determine influence of antecedents on prototype developing by the retailers

Independent variables	logit-coefficient	Standard error	Wald statistic
Use experience of employees[a]	0.716	0.280	6.53 **
Retailer's speed of adoption[b)]	0.994	0.286	12.09 ***
Quality leadership strategy [b)]	1.352	0.331	16.63 ***
Constant	1.024	0.306	11.12***

*n = 101; * p < 0.1; **p<0.05; *** p<0.01; Correct classified respondents = 77.2% (PCC=54.1%); LR = 47.70; df=3; p<0.001; McFaddens R^2 = 0.36*

As highlighted in Table 3, all three retailer characteristics have a clear impact on the likelihood that a given retailer starts to develop prototypes for improved or new products. With respect to use experience (H1), the result suggests that retailer employees who are at the same time users of the products in fact seem to associate a higher benefit with innovations. At the same time, they might be able to innovate at comparatively low costs, since they can base their development upon information already in their possession. Furthermore, the results support the hypothesis that retailers that accept new products from industry early in the diffusion process also tend to be innovators themselves (H2). The results finally confirm that retailers with a strategic focus on carrying fewer high-quality product-lines for small market segments are more likely to innovate (H3). Thus, the distinctive competencies that quality leaders develop to stay competitive seem to foster the ability and motivation for initiating own innovation activities.

Table 4: Results of regression analysis on perceived potential of innovation-related user input

Antecedents of perceived user input potential	OLS coefficient	t-value
Constant	0.19 (0.12)	1.48
Use experience of employee	0.18 (0.10)	1.95**
Retailer's speed of adoption	0.23 (0.10)	2.43**
Quality leadership strategy	0.09 (0.11)	0.85
Generation of own innovation prototype	0.54 (0.24)	2.218**
n =94 ; Adjusted R^2 = 0.25 ; F-value = 8.63 ***		

** p < 0.1; **p<0.05; *** p<0.01; Standard error is shown in brackets*

To test the link between the retailer characteristics and the perceived potential of the end user ideas we used straightforward linear regression analysis (OLS). The results of this computation are presented in table 4. The model is significant and explains 25% of the overall variance of the dependent variable. In alignment with our expectations, three of the four antecedents have a significant relationship with the perceived potential of the consumer suggestions. If, in a given sports shop, the employees are also users of the products (H4), if new products are usually integrated quickly into the sales program (H5), and if the employees have already developed own prototypes for innovations (H6), the store managers are more likely to appreciate the value of customer suggestions and ideas. However, the generic competitive strategy shows no significant link with the perception of user input quality (H7). Even if quality leading stores with a specialized product offer have a stronger emphasis on customer relation and service quality, the retail type has no impact on the evaluation of the innovation potential of end customer input.

5 Discussion and implications

This study examined the role of retailers as innovators and innovation gatekeepers. The model proposes antecedents that influence the likelihood that a given retailer develops new solution for the sports products it sells (retailers as innovators) and suggests factors influencing how retailers evaluate the value of consumers as an important source of innovation (retailers as mediators of user innovations).

With respect to the first role, the results show that a significant share of the sports equipment retailers in the sample develop own ideas, concepts and prototypes for new products. Most of these ideas do not represent major innovations but rather constitute product improvements and low-tech solutions. Manufacturers that decide to use the creative potential of retailers in new product development should therefore not expect to find much breakthrough innovation. However, despite their low-tech character, a notable fraction of the ideas found in this sample are judged to be of high potential value for the end users if produced commercially. Producers are therefore well-advised to enrich their relationship with retailers and to expand the interaction and communication with retail employees to the field of innovation. As such, it is suggested that future research on channel management should consider this important objective of the producer-retailer dyad.

The test of our model shows that the three proposed retail characteristics give significant explanation for own development activities of the retailers in the sample. If manufactures strive to involve their distributors and retailers in new product development projects, they can use the results to carefully select appropriate retailers as cooperation partners. The results presented in this study strongly suggests that this selection can be based on characteristics that distinguish between innovation-active and innovation-passive retailers: information on the use experience of the employees, on the speed of adoption with respect to new products, on the competitive strategy of the retailer, and finally, on the retailers' innovation activities should enable manufactures to efficiently search for retail staff with high innovation potential. This procedure differs from the standard procedure of producers to primarily interact with their largest and most profitable retailers.

Regarding the second role, i.e. the activities of retailers as mediators of user-initiated ideas, we find a rather low appreciation of consumers as a source of innovation. This finding is surprising in light of the consistent empirical evidence for a high level of innovation activities among users in different sports fields. Perhaps a significant part of the user inventions never finds its way to retail employees because the users explicitly refuse or simply lack the motivation to contact the retailers. In addition, one cannot rule out the possibility that user suggestions, although they are communicated to retail employees, are still not registered or underestimated with respect to their potential. However, it is a limitation of this study that we cannot assess if the retailers' perception is a valid reflection of the "true" consumers' creative potential. Future research should seek to simultaneously collect data from retailers and their customers to better control for perceptual biases and, by this, to arrive at valid estimations about how appropriately retailers play the role of innovation gatekeepers.

The model test with respect to the experienced quality and potential of the users' creative input also provides clear results. The competitive strategy (specialized, quality leader versus broad-line price leader) is the only factor that does not show a significant relationship with the perceived potential of consumer input. In alignment with our expectations, however, high levels of use experience, own innovation activities and the tendency to be early in adopting new products are significantly associated with the perceived potential of the user innovation input to retailers.

Overall, this study indicates that large price-leading chains and other mass-merchandisers will be less valuable sources of innovation for producers, both because they receive less creative input from their customers and because they do not forward innovation the user ideas to the product firms. If manufacturers want to avoid losing external innovation input, they can try to prompt large retailers to intensify their activities as innovation gatekeepers and to act as innovation agents of the suppliers. An indirect measure taken by the manufacturers could be centered on active signaling that they are open for innovation-related cooperation and that this cooperation is likely to pay for the participating retailers. This approach can be supported by direct measures, such as formal reward systems to motivate retail managers to act in the manufactures' best interest. In addition, manufacturers can support training activities directed to enhance the alertness, openness and absorptive capacity of retail employees regarding new product ideas and concepts of their customers.

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Chapter 11

To share or not to share – Exploring how sharing behaviour impacts user innovation

Frank Tietze, Thorsten Pieper, and Carsten Schultz

Abstract

This paper conceptually and empirically explores the impact of users' product sharing behaviour on user innovation. This study contributes (i) a new concept labelled "sharing experience" and its operationalization based on the well-established use experience construct, (ii) a typology that categorizes four user groups based on their sharing activity, (iii) an empirical analysis exploring the impact of sharing experience on user innovativeness and (iv) five case studies that provide insights into how sharing impacts the user innovation process. Qualitative and quantitative primary data was collected from a large German farmer sharing community established since 50+ years. Following a pre-study based on 26 interviews with key stakeholders to understand the empirical setting, in a first study we analyzed survey data from 563 respondents. The results indicate that users' sharing experience is positively associated with user innovativeness in certain situations and that users' technical expertise appears to positively moderate this relationship. In a second qualitative study we conducted five case studies based on 14 in-depth interviews with user innovators that we identified from the survey finding that users employ two distinct strategies when innovating in sharing settings, namely permanent modifications and reversible add-ons.

Keywords: sharing experience construct, sharing types, ownership

1 Introduction

When tangible products are not sold, typically users gain access to them via different kinds of sharing models. Despite that sharing has ever been essential element of all communities, we currently observe increasing attention being paid to it as a contemporary phenomenon of societal and economic importance. Examples of recently emerging sharing-based business models are numerous. They range from manufacturer operated car-sharing solutions (e.g. car2go offered by Daimler) (Neely et al., 2011; Tietze et al., 2013) to telemetric health monitoring solutions in the medical sector (Schultz, 2009) and complex service solutions in the B2B manufacturing environment (e.g. Rolls Royce power by the hour) (Neely, Benedetinni, and Visnjic 2011). Related sharing models also include cloud based software as a service (SaaS) solutions (e.g. salesforce, google docs) or platform based sharing models, also known as peer to peer sharing (e.g. AirBnB), which we focus particularly in this paper (Lamberton and Rose, 2012; Schultz and Hölzle, 2014; Schultz and Tietze, 2014). Recent literature also discusses sharing as access-based consumption (Bardhi, Fleura, Eckharft, Giana M., 2012) or collaborative consumption (Botsman and Rogers, 2011). Lamberton and Rose (2012) label the models concerned in our study as "physical product sharing systems".

© Springer Fachmedien Wiesbaden GmbH, part of Springer Nature 2020
R. Tiwari and S. Buse (eds.), *Managing Innovation in a Global and Digital World*, https://doi.org/10.1007/978-3-658-27241-8_12

Some previous user innovation studies touch upon sharing models. For instance, when collecting empirical data from employed users, these users commonly share resources with their colleagues and hardly own the products they use and upon which they innovate (e.g. doctors in hospitals (Braun and Herstatt, 2008)). However, these studies do not seem to explicitly investigate sharing aspects. Within the user innovation literature also studies on open source innovation come close to the sharing concept (Balka et al., 2014). These studies mainly take the community perspective and often ask why users contribute to communities in which sharing takes place, again, without explicitly studying the sharing concept. Furthermore, this research largely focusses on software and not tangible products. Among the few studies on hardware open source (Balka et al., 2010) we are not aware of any that discusses sharing explicitly and how users' sharing behaviour impacts the innovation process. Even in the wider innovation management literature we do not find many studies that systematically investigate product sharing. Although product sharing appears to be an essential element in numerous service and business model innovations, it is probably fair to say that only few studies that particularly focus on product services systems (PSS) touch upon the sharing concept (Tietze et al., 2013), but rather discuss it indirectly by investigating the related concept of ownership (Tietze et al., 2015). In this regard this study is very related as ownership and control are often separated in sharing communities when users borrow equipment.

German machinery rings (MR) are institutions with the aim of facilitating sharing of agricultural equipment, improving labour conditions and offering consulting services. Machinery rings have been highly appreciated institutions among farmers ever since the first association was registered in 1958 in the South of Germany and today they have a significant impact on the agricultural sector. 260 machinery rings across Germany are organized in 12 regional associations and one federal association (BMR e.V. - Bundesverband der Maschinenringe) with close to 200,000 members that jointly represent approximately 8 million hectares of agricultural land (roughly 49% of Germany's total agricultural land or 22% of Germany's total state area). In total, all associations generate a considerable revenue of close to 1.1 billion Euros with a fairly diversified portfolio of business activities. A membership fee is mandatory but once having entered the community, farmers benefit from flexible offerings at comparably low costs when sharing their equipment (Maschinenring, 2017).

The research question we explore in our study is whether being a more or less active member in a sharing community impacts the member's innovativeness, i.e. the user of shared equipment. Two examples from our data illustrate below why we have good reason to believe that a causal relationship exists between users' involvement in a sharing community and users' innovativeness.

One example is a MR member who frequently used his own field sprayer equipment for providing pest management services to other farmers. Using his own equipment frequently under different soil conditions on neighbouring farms and interacting with these farmers, he recognized that his equipment was not appropriate for such variety of use cases. He could not find any product available on the market that would satisfy his special needs. The extensive use of his equipment on neighbouring farms under very different conditions helped him to develop a detailed understanding of how a suitable field sprayer needed to be designed. The possibility to generate additional income from sharing his equipment with other farmers provided him with the financial means to realize his ideas and build his product; a self-propelled all wheel driven field sprayer that can be used through muddy spots and steep slopes. While this appears to be a classical user innovation case where increased use experience facilitates idea generation, in this particular case the intensive interaction with community members in connection with the equipment sharing actually mattered for the innovation process.

The purpose of this paper is to provide the conceptual and operational foundations as well as first empirical evidence to better understand the relationship of users' sharing behaviour and their user innovativeness, respectively the impact of sharing activity on the user innovation processes. We primarily contribute to the user innovation literature by proposing (i) a new concept that we label "sharing experience" and its operationalization based on the well-established use experience concept, (ii) a typology to categorize users according to their sharing behaviour, (iii) an exploratory empirical analysis quantifying the relationship of sharing expertise and user innovativeness and (iv) five case studies that provide further insights into how sharing impacts the user innovation process . The following section outlines relevant theoretical foundations on which we build throughout the paper. Section three presents the research approach, with the results being shown in section four. Section five concludes this paper, provides managerial implications and reflects on limitations of our study.

2 Theoretical foundation

Since decades research has shown the considerable importance of users and their capabilities to develop new products, services or product modification of all kinds (Franke et al., 2016). Innovative products which are developed by a user who desires to benefit from using them are defined as user innovations (von Hippel, 1986, 1988). Users thereby can be defined as individuals that benefit from using a product or service (von Hippel, 2005). The occurrence of user innovations is not a small phenomenon. Various user innovation studies show that a wide range of new products and processes in various fields is developed by users. In these studies 10 – 40% of the participants were identified to act innovatively by modifying products or developing new ones (see table in von Hippel, 2005, 65f). Despite the magnitude of this phenomenon and given the fundamental nature in communities, hardly any attention has been paid to how users share products and how this sharing potentially impacts their user innovativeness.

2.1 Sharing in user innovation studies

In this study we focus on sharing as the exchange of tangible products. Accordingly, sharing must happen in a community with at least two members. Several user innovation studies have collected data from user communities, such as communities in sports like kite surfing (Tietz et al., 2005), kayaking (Hienerth et al., 2014) and mountain biking (Lüthje et al., 2005) or communities for technical products like vehicles (Hyysalo and Usenyuk, 2015). However, these and other studies primarily focus on personal traits of users (e.g. technical expertise) and how users innovate, but hardly touch upon the interactions of innovative users with their peers and how that impacts their innovativeness.

What comes closest to the sharing conceptualization of our study are user innovation studies that focus on open source communities, which investigate motives that drive users to contribute to joint software development projects, i.e. collaborative innovation (e.g. Janzik and Raasch, 2011). Early on von Hippel (2005) argued that the spreading of the internet enormously alleviated the way people can coordinate and combine their innovating efforts and exchange their knowledge over innovating communities. In addition to the early opportunities of the internet, later a variety of new and improved technologies and changed behavioural patterns by the user were summarized under the umbrella term Web 2.0 (Janzik and Raasch, 2011). That opened up even more opportunities for users to connect, interact and exchange their knowledge, sharing their experience and simplified also the search for help to realize innovative ideas or concepts they have been thinking of. If sharing is touched upon in this context, the focus is however commonly on knowledge sharing (Franke and Shah, 2003; Jeppesen and Laursen, 2009), respectively the contributions of different users to joint development efforts taking place in a community. In that regard, for instance, the literature discusses reciprocity as an important concept referring to the give and take of contributions to joint development projects between community members, but also external firms (e.g. Bonaccorsi and Rossi, 2006; von Krogh et al., 2012; Schweisfurth et al., 2011). Given the distinctively different properties of knowledge compared to tangible products (Faraj et al., 2011), the findings from these studies are hardly applicable when investigating the effects resulting from the sharing of tangible products as focused in this study. Hence, one may conclude that prior user innovation studies hardly discuss and consider effects that may impact user innovativeness resulting from the sharing of tangible products.

2.2 The concept of sharing

In order to establish the theoretical foundations for our study we therefore searched other literature, such as consumer behaviour (and marketing) and sociology as well as consumer psychology (Hellwig et al., 2015; Lamberton and Rose, 2012). In the literature on marketing and consumer behaviour we found that Belk contributed substantially to the conceptual understanding and classification of sharing. He defines the interpersonal exchange of sharing as "[…] the act and process of distributing what is ours to others for their use as well as the act and process of receiving something from others for our use" (Belk, 2007, p. 127). This definition of the interpersonal connection between two parties shall be adopted to the meaning of sharing in the present study, but seen as a more general form of exchange between different parties in the sharing context, taking into consideration besides individuals (e.g. users) also other market players (e.g. companies or market intermediaries).

Belk (2010) focuses primarily on connections of people within a family and people who are close to the person considered. He identifies two main sharing types. These are income, respectively resource pooling within a family and "mothering". The latter refers to sharing without any return expectations (e.g. milk for the own baby), whereas the forms of pooling refer to fulfilling the basic needs of the own family (e.g. housing, food, furniture use etc.). He further distinguishes sharing from gift giving and commodity exchange. Gift giving is connected to a certain kind of self-interested expectation of the individual who gives something to another person. Commodity exchange is understood as a commercial trade of products between individuals where a buyer and seller situation exists (Belk, 2010, 2014). However, Belk's conceptualization of sharing does not consider economic transactions as they apply in sharing-based business models. Hence, his understanding is not completely appropriate for the purpose of this study. Thus, we propose to define sharing in the user innovation context as the "exchange of tangible products with other users in a community for monetary or non-monetary remuneration".

When considering sharing of tangible products the allocation of ownership rights appears to be of importance (Lawson et al, 2016). The great majority of user innovation research focuses on users who make adjustments, modifications or create completely novel ideas related to existing products where user innovators own the products. Innovating upon a product a user does not share and holds ownership rights to is rather unproblematic. When purchasing a product, the product and all property rights to use and to control the product are commonly transferred from the seller to the user. Product owning users can thus make adjustments to their products without fearing legal consequences by doing so (although loss of warrantee may be an issue when modifying products). However, with the trend towards access-based business and consumption models (also discussed under the notion of servitization, e.g. by Neely (2007)), where product sharing plays a major role, more and more users become temporary proprietors of products rather than owners (Tietze et al., 2015). Lawson et al (2016) consider this change regarding to ownership as pivotal with substantial impact of how business models works. Tietze et al. (2015) show that users may perceive a lack of ownership as additional barrier to innovate because it adds uncertainty to the innovation process. If users consider modifying products they do not own, no matter if these are owned by a company or a private person, they may fear legal consequences by the owner. Ultimately, this additional uncertainty creates higher costs to innovate (Pieper, 2019; Pieper and Herstatt, 2018).

While sharing business models becomes more and more prominent, the models are not all the same. Few typologies have been proposed to distinguish sharing models (e.g. Lamberton and Rose, 2012). A typology that fits particularly well for our study was proposed by Schultz and Tietze (2014). The authors distinguish four types of "physical product sharing systems". According to the allocation of ownership rights these four models can be grouped into two categories. First, the functional PSS and operator models imply that the products, which are shared by different users are actually owned by an organization, often a company that is either the manufacturer of the product or a market intermediary. Examples include the car-sharing system operated by automotive manufacturer such as car2go by Daimler and DriveNow by BMW in contrast to the car-sharing systems operated by ZipCar as market intermediary. Hence, these two models can be characterized by a non-user owned ownership structure. The club good and the platform models comprise the second category of sharing systems, where product ownership rights sit with the users, either directly with individual or collectively with many users. Examples for these models are German not-for profit sport clubs ("eingetragener Verein" abbreviated e.V.), which are associations jointly owned and run by all registered members where all equipment is owned by the club and thus indirectly by all users of the equipment. An example of the platform model are peer-to-peer car sharing systems where one user borrows a car from another user, but also AirBnB as a commercial example. In contrast to the first category, these two models are both characterized by a user-owned ownership structure. From a user perspective, both categories of sharing models are characterized by a distinctive difference with regard to what might be called the sharing direction. In the first category of models users only borrow products from an organization that centrally owns the products and lends them to the users. In the latter category users own products either directly or indirectly and lend them to other users, who borrow them. Our study focuses particularly on the latter category of sharing model so that we could both observe the effects of borrowing and lending on user innovativeness.

2.3 User's sharing experience

Having defined sharing and discussed different sharing models, this study is primarily concerned with the extent to which individual users actively engage in sharing activities within a community and respectively the impact of these activities on their user innovativeness. To be able to capture and measure users' sharing activities we propose a new concept that we label ‘sharing experience’ (SE). To some extent, SE appears to be similar to the well-established use experience construct.

Similar to use experience, SE can be measured by (i) the frequency or extent to which sharing activities are carried out and (ii) how long a user has participated in sharing activities (duration) (Schreier and Prügl, 2008). As explained above, however, in contrast to use experience, sharing frequency needs to be distinguished by what we call the sharing direction. Two types of sharing directions can be distinguished that describe how users participate in a community: (a) The behaviour of accessing a tangible product, owned by a second party through the sharing community (i.e. borrowing) and (b) the behaviour of providing a tangible product into the pool of tangible products to be used by others inside the sharing community (i.e. lending). Botsman and Rogers (2011) define users who show the former sharing behaviour as `peer users´ consuming the products and services available through a sharing community. Whereas users who show the latter sharing behaviour are considered as `peer providers´, who provide products to others. The two behaviour types described are not mutually exclusive, meaning a user can engage in both sharing directions.

The distinction of these two directions appears similar to the direction of collaboration activities discussed in the open innovation literature. Collaboration activities that aim to source an externally developed idea or technology are often described as inbound open innovation. In contrast, collaboration activities that aim to externally exploit an idea or technology are often referred to as outbound open innovation (Chesbrough and Crowther, 2006; Huizingh, 2011; West and Bogers, 2014). To describe the process of the sharing activity in an analogous way, in this study the sharing behaviour of accessing tangible products through a sharing community will be referred to as the activity of inbound sharing or `sharing-in´. A sharing-in example is the act of renting or lending tangible products from others, like cars, bikes or machinery for temporary use. The second direction of sharing behaviour, the process of providing products to be used by others will be labelled as an activity of outbound sharing or `sharing-out´. For instance, a community member provides his own tangible products (e.g. technical products or machinery) and offers them through a community to be used by others, known or unknown to him.

To summarize, while sharing experience is inherently similar to use experience it is distinctively different with regard to a second dimension, which therefore needs to be distinguished between sharing-in and sharing-out frequency. Thus, we propose to define user’s SE with the three concepts of frequency, duration and direction as “how often a user participates in sharing-in and sharing-out activities of tangible products within a community and its duration of membership with that community”.

3 Research approach

For the empirical data collection of this study we identified the Maschinenring association (MR; ‘machinery rings’) as a well-established sharing community founded in 1958. Up to date MRs have shaped the German agricultural sector decisively in means of organizational access to agricultural machinery, agricultural community building, mutual support among members and technological innovations (Hinterberger et al., 2006). Within regional MRs, farmers regularly share agricultural equipment and machinery of all kind and technical complexity with the huge majority of equipment owned by community members. About 193,000

German farmers are MR members, organized in 12 state organizations and a total number of 259 regional MRs. With 50+ years of sharing history, this community might be considered an early pioneer of today's sharing economy.

A pre-study confirmed the suitability of this empirical field. 26 interviews were conducted in summer 2014 with 11 CEOs, 8 board members, 5 MR employees and 2 of its members that identified 8 innovations from the federal association of Maschinenrings and public sources (5 service innovation, 2 process innovations, 1 product innovation). Interview data was collected by means of a pre-tested semi-structured interview guide, transcribed, coded and run through a content analysis.

3.1 Study 1: Quantitative analysis

To measure characteristics of users with different sharing behaviours as well as to determine the sharing effects on user innovativeness an online survey was conducted in spring 2015. CEOs of regional MRs were contacted upfront by email or phone and asked to forward the survey link to their members. To incentivize CEOs to participate in the study we offered a benchmark report to all regional MRs with 30 or more responses. Among all participating MR members we drew a lottery with low-value prices. Data collection was supported by the federal MR organization (Bundesverband). This approach yielded 1,064 overall responses. After intensive and conservative data cleansing following Müller and Freytag (2005), 563 responses remained for further analysis to shed some first light on the relationships between sharing experience and user innovativeness.

First, we explored the data aiming to find significant differences between different types of users based on the extent to which users engage in both sharing directions (in- and out-sharing), using t-test and ANOVA test of variance. All items considered for this analysis measure on a 7-point Likert scale. The analysis focuses on two personal traits of users as found in previous user innovation studies and the outcome of innovative user activities. Different studies show that lead userness impacts user innovation. Lead userness describes the extent to which a user is 'ahead of the trend' and the benefits the user would gain from innovating (von Hippel, 1986). We measured the two lead userness constructs based on nine indicators slightly modified, but largely in line with previous studies (e.g. Franke and Shah, 2003; Franke et al., 2006; Hienerth and Lettl, 2017; Schreier and Prügl, 2008; Schweisfurth and Raasch, 2014). Factor analysis confirms the operationalization with factor loadings ranging from 0.86 to 0.92 respectively 0.67 to 0.85. Previous literature also shows that technical expertise is an important personal trait for user innovation. Technical expertise describes the user's ability to actually make technical modifications or changes to products or help others by solving technical problems with products or machinery and therefore has the capability to be innovatively active (von Hippel, 1986). Again, we employed a common operationalization and factor analysis confirms it with loadings ranging from 0.63 to 0.88 and a Cronbach's Alpha of 0.894. We measure the outcomes of user's innovative activities similar to as done by Tietze et al. (2015), who modelled it after previous user innovation studies (Franke, von Hippel, and Schreier 2006; Lüthje, 2004). Accordingly, we distinguish between innovative ideas that users develop (idea generation) and the implementation of their idea (idea realization). As the study focuses on sharing apparently users not only use their own products, but also products they have borrowed from others. Accordingly, in addition to ideas for improving their own products users can also develop ideas to improve the products they borrow. The same reasoning applies for realizing ideas. Hence, in our analysis we distinguish between ideas developed/realized for own and foreign products.

In a second analysis, we explored the data to provide a first quantification of the effects of sharing experience. In order to do that we operationalized the sharing experience concept as conceptualized above. We developed the measure for sharing experience based on the well-established measure for use experience (Lüthje, 2004; Lüthje et al., 2005; Lüthje and Herstatt, 2004; Magnusson, 2009; Schreier and Prügl, 2008). However, giving the distinction between sharing-in and sharing-out as discussed above, in contrast to use experience, we measure sharing experience with three items instead of two. The first item captures how long a user has been participating in a sharing community (sharing duration), starting from 'lower than one year' to 'more than 25 years' in five year intervals. The second and third item capture how often a user engages in sharing-in, respectively sharing-out activities in that particular community (sharing-in/-out frequency) ranging from 'very rarely' to 'very often'. All items are measured on a 7-point Likert scale. Factor analysis confirms the operationalization with factor loadings ranging from 0.31 to 0.86 (see Appendix).

We employed factor analysis to establish validity for the sharing experience construct and to verify that lead userness and technical expertise show same effects in our dataset compared to previous studies. We used a hierarchical regression procedure to test direct effects of sharing experience on user innovativeness and also test for interaction effects with lead userness and technical expertise following the procedure proposed by Frazier et al. (2004), and Baron and Kenny (1986). Figure 1 shows our conceptual model applied for this second step of our analysis.

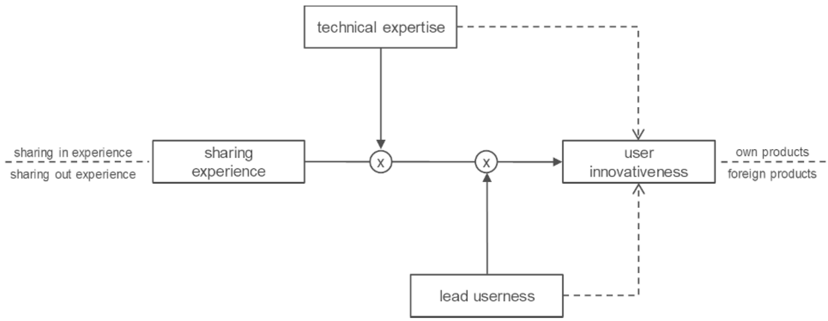

Figure 1: Conceptual framework

3.2 Study 2: Qualitative analysis

To gain further insights into the mechanics of how users' sharing activities impact the user innovation process we conducted semi-structured, personal and phone interviews with 17 persons in summer 2017. These include 13 interviews with innovating MR members selected from the 146 successful innovations that were contained in the 563 sample that we used for study 1 as well as four farmers that were recommended during our interviews, plus three interviews with MR officials and employees. The interviews scatter across the four sharing types (Figure 2), with however the group of commercialists being slightly under-represented.

The interviews covered a detailed explanation of (1) the actual innovation, (2) the innovation process, (3) the selection of the innovation strategy and 4) detailed discussions about the role of sharing during that process, particularly the direct and indirect effects. It turned out to be quite beneficial to meet with the interviewees as they could show and explain the innovation on site. While the interviews were all rich in data, we derived five case studies for deeper within and cross-case analysis for which we conducted follow-up interviews, predominantly by phone. The case analysis employs a framework that distinguishes direct and indirect, in- and out-sharing effects on a three-stage innovation process model (need identification, idea generation, idea realization).

4 Results

4.1 Results study 1

4.1.1 Sample description

Members from ten of the twelve MR state associations participated in the survey, respectively 98 of the 259 regional MRs equalling a 38% participation ratio. The dataset reveals a high share of innovative users. In the last ten years, 61% of all participants have started to develop at least one innovative idea. 95% of all participants are male farmers. That share corresponds roughly with data from the Statistical Office of Germany, according to which about 8% of the agricultural businesses in Germany are female led (Pöschl, 2004). 42% of respondents hold a medium level high school diploma, followed by a group with a basic (lower) school education (23%) and a group with a university diploma (22%). The age of the respondents in the sample appears normally distributed with an average age of around 44 years.

The large majority of respondents runs their agricultural enterprises themselves (70%). 27% of respondents run a small agricultural business with two to five employees. Medium-sized businesses employing six to 50 people are represented by 13 respondents (2%). The sample includes one large firm with more than 50 employees. Based on farmland size 37% of respondents work for very small enterprises with less than 50 hectares, followed by small enterprises (30%), medium-sized businesses (26%), enterprises with a large acreage (6%) and few very large enterprises (1%) with more than 500 hectares.

Survey participants are highly experienced, with an average of approximately 18 years working experience. 350 respondents (69%) have more than 20 years of job experience in agriculture and only 15 respondents (3%) have less than five years of job experience. 270 respondents (48%) are MR members between six and 20 years. 224 respondents (40%) are MR members since more than 20 years. Respondents concentrate mainly on three agricultural activities (multiple choices possible): (i) arable farming (391 respondents), (ii) dairy farming (181) and (iii) forage production (163).

4.1.2 Analysis of sharing types

The way how sharing experience is operationalized allows distinguishing users in four groups based on their sharing-in and sharing-out frequency (item 2 and 3) as illustrated in Figure 2. Discriminating low and high sharing-in and -out with a cut off value of four on a 7-point Likert scale we find the following:

Reciprocists frequently contribute their equipment to the community (high sharing-out frequency) and often use equipment from other community members (high sharing-in frequency). It is a small, but not the smallest group of members with 10.9% in our sample (n_r=27). *Commercialists* (9.7%, n_c=24) frequently contribute their equipment to the community (high sharing-out frequency) but rarely use equipment from other community members (low sharing-in frequency). In contrast, *freeriders* (22.6%, n_f=56) rarely contribute their own equipment to the community (low sharing-out frequency) but frequently use products from other community members (high sharing-in frequency). A large group in our sample (56.9%, n_{lw}=141) constitutes the *lone wolfs*. These users neither contribute their own products to the community (low sharing-out frequency) nor use products from other community members (low sharing-in frequency). Users in this group must be considered rather 'passive' community members, who hardly participate in the sharing model.

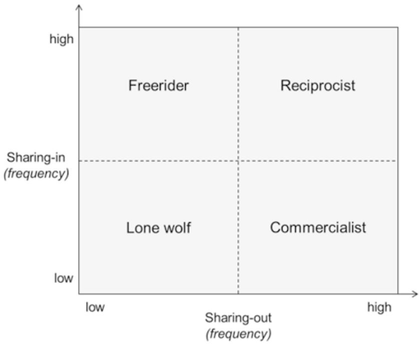

Figure 24: Four generic sharing types

Figure 3 compares three characteristics (age, working experience and education) across these four sharing types. Lone wolfs appear to be the oldest users with the highest working experience. In this group, we find the highest share of users with a university degree. Commercialists appear to be the youngest group with a slightly left skewed age distribution, similar to freeriders. Overall, reciprocists have lower educational degrees than the other three groups.

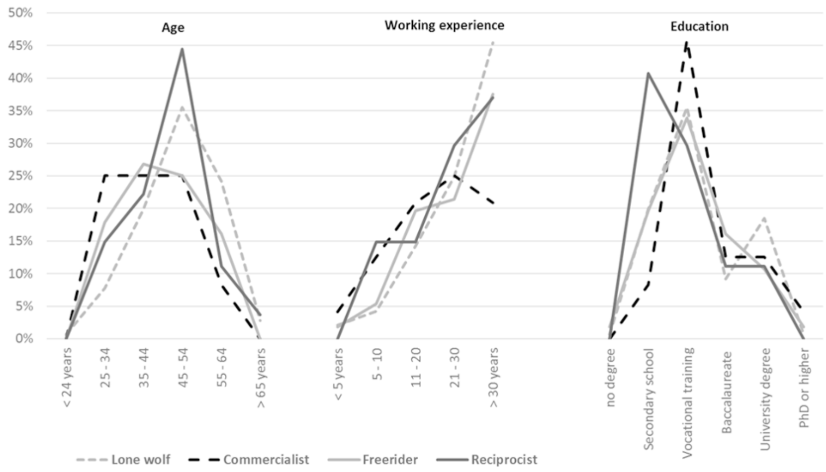

Figure 3: Age (left), working experience (middle) and education levels (right) of sharing types

Figure 4 compares the user characteristics (lead userness and technical expertise) and user innovativeness (idea generation and idea realization) across the four groups. Lone wolfs, who neither share-in nor share-out, are the worst performing users in terms of both idea generation (mean value 3.0) and idea realization (9.9% of those users have realized an idea). The lone wolfs also have the lowest lead userness and technical expertise scores. In contrast, the active in- and out-sharing reciprocists perform best with regard to idea generation (4.4) and realization (37.0%). In line with that, reciprocists also have the highest lead userness score. In between these two extreme types are the commercialists and freeriders. Both groups perform better than lone wolfs on all four characteristics. These results already indicate that sharing experience might be positively associated with user innovativeness.

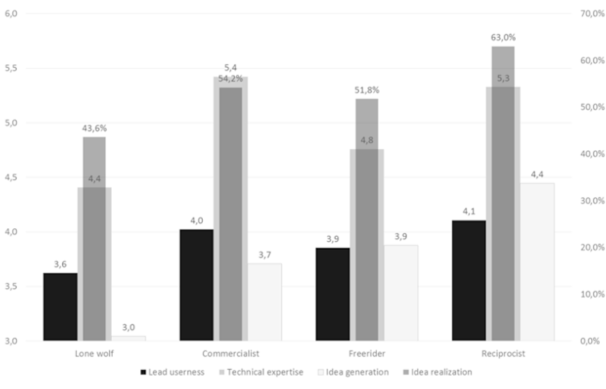

Figure 4: User characteristics and innovativeness across the sharing types

According to Model 1 reciprocists and lone wolfs differ significantly with regard to all four characteristics. Model 2 shows significant differences for all groups regarding technical expertise and idea realization rate.

Table 1: ANOVA of sharing type characteristics

	Model 1				**Model 2**			
ANOVA	df	Mean Squ-are	F		df	Mean Square	F	
Lead userness	1	5.336	4.935	*	3	2.702	2.588	†
Technical expertise	1	19.254	13.519	***	3	11.824	8.455	***
Idea generation	1	44.535	15.919	***	3	5.272	1.793	
Idea realization	1	1.665	14.621	***	3	.823	5.846	**

Notes: n=247; statistical significance †p<0.1, *p<0.05, **p<0.01, ***p<0.001

4.1.3 The relation of sharing and user innovativeness

To explore the relationship between sharing experience and user innovativeness we conducted correlation and regression analyses with the two dependent variables idea generation and idea realization. In line with previous studies (e.g. Lüthje, 2004; Magnusson, 2009; Schreier and Prügl, 2008) our results confirm that use experience and technical expertise are positively associated with user innovativeness. Also, in line with the descriptive results displayed in Figure 4 and Table 1, the results shown in Table 2 reveal significant positive correlations of sharing experience (5) as well as its different components (6-11) with idea generation and idea realization both for own (3 & 4) and foreign (1 & 2) products. For instance, sharing experience (5) correlates positively and significantly with all four dependent variables with coefficients ranging from 0.1 to 0.5. Sharing experience however seems to correlate stronger with user innovative behaviour for foreign products (0.3-0.5) than for own products (0.1).

Table 2: Correlation coefficients

	1	2	3	4	5	6	7	8	9	10	11
Idea generation *own*	1										
Idea realization *own*	.525***	1									
Idea generation *foreign*	.367***	.194***	1								
Idea realization *foreign*	.201***	.144***	.454***	1							
Sharing experience	.116***	.102*	.494***	.279***	1						
Sharing-in experience	.027	.051	.495***	.247***	.816***	1					
Sharing-out experience	.135***	.115***	.349***	.194***	.816***	.623***	1				
Sharing duration	-.056	-.029	.040	.089*	.435***	.419***	.394***	1			
Sharing frequency	.155***	.137***	.581***	.274***	.888***	.708***	.707***	.109***	1		
Sharing-in frequency	.061	.076†	.581***	.238***	.670***	.873***	.468***	.063	.772***	1	
Sharing-out frequency	.171***	.146***	.386***	.178***	.717***	.511***	.912***	.150***	.776***	.494***	1

Notes: n=563; Pearson correlations; statistical significance †p<0.1, *p<0.05, **p<0.01, ***p<0.001

Tables 3 and 4 present results from 12 multiple regression analyses. As users deal with own but also with borrowed (foreign) products in sharing communities we distinguish in our analysis these two product types. Accordingly, Table 3 shows the results for own products and Table 4 for foreign products. Each of both tables comprises three regression models. In model

1 and 4 'sharing' experience is measured based on all three items (duration, sharing-in frequency, sharing-out frequency). Model 2 and 5 omit the third item thus only measure sharing-in experience. Model 3 and 6 omit the second item and thus measure sharing-out experience. For each model we further distinguish between the two dependent variables: (a) idea generation and (b) idea realization.

First of all, we find that our results in both tables are consistent with prior studies showing stable positive significant effects of both established user innovation concepts on idea generation and realization alike with only three exceptions. In the three models with idea realization as dependent variable (Table 4) lead userness has no significant impact.

Table 3: Regression results for own products

	Model 1a		Model 1b		Model 2a		Model 2b		Model 3a		Model 3b	
Dependent variable	Idea generation		Idea realization		Idea generation		Idea realization		Idea generation		Idea realization	
Direct effects												
Sharing exp. (SE)	-.025		.013									
Sharing-in exp. (SE-in)					-.019		.022					
Sharing-out exp. (SE-out)									-.013		.019	
Technical exp. (TE)	.506	***	.355	***	.499	***	.354	***	.502	***	.352	***
Lead userness (LU)	.214	***	.116	**	.215	***	.116	**	.217	***	.117	**
Interaction effects												
SE * TE	.108	**	.044									
SE-in * TE					.095	**	.024					
SE-out * TE									.067	†	.023	
SE * LU	-.027		.002									
SE-in * LU					-.044		-.019					
SE-out * LU									-.018		.015	
Adjusted R^2	.380		.167		.379		.165		.375		.166	

Notes: n=563; b-values are standardized; all models are linear regressions; interaction variables are z-transformed; statistical significance †p<0.1, *p<0.05, **p<0.01, ***p<0.001

With regards to the relationship of sharing experience and user innovativeness the results in Table 3 do not reveal any significant direct effect of sharing experience on user innovativeness in any of the six models. However, we find significant positive interaction effects of sharing experience (1a) as well as sharing-in experience (2a) and technical expertise on idea generation. The interaction effect of sharing-out experience (3a) and technical expertise on idea generation is significant only on 10%-level. As mentioned above, Table 4 also reveals consistency with prior user innovation studies with regards to the effects of lead userness and technical expertise on user innovativeness, here however measured for foreign-owned products. Interestingly, the effect sizes of sharing experience are comparably larger than for technical expertise and for lead userness.

Table 4: Regression results for foreign products

	Model 4a		Model 4b		Model 5a		Model 5b		Model 6a		Model 6b	
Dependent variable	Idea generation		Idea realization		Idea generation		Idea realization		Idea generation		Idea realization	
Direct effects												
Sharing experience (SE)	.442	***	.229	***								
Sharing-in experience (SE-in)					.466	***	.223	***				
Sharing-out experience (SE-out)									.284	***	.147	**
Technical expertise (TE)	.131	**	.144	**	.182	***	.171	***	.157	***	.154	**
Lead userness (LU)	.132	**	.034		.132	**	.033		.125	**	.033	
Interaction effects												
SE * TE	.038		.063									
SE-in * TE					.101	**	.128	**				
SE-out * TE									.059		.037	
SE * LU	.061		.009									
SE-in * LU					.004		-.054					
SE-out * LU									.039		.013	
Adjusted R^2	.290		.096		.318		.101		.171		.057	

Notes: n=563; b-values are standardized; all models are linear regressions; interaction variables are z-transformed; statistical significance †p<0.1, *p<0.05, **p<0.01, ***p<0.001

Table 4 also shows that for foreign products the effects of sharing-in on both idea generation and idea realization are stronger than for sharing-out. Additionally, the sharing effects appear to be stronger for idea generation than for idea realization. Table 4 also reveals stable and significant direct effects for all three versions of sharing experience on both dependent variables. We also find a significant positive interaction effect of sharing-in experience with technical expertise on idea generation and idea realization (5a & 5b).

In summary, results in Table 3 strongly indicate the presence of indirect effects, which our dataset does not permit to investigate further. Findings presented in Table 4 indicate strong direct effects of sharing experience on users' probability to modify products they do not own. Further understanding these direct and indirect effects, for instance if users employ specific innovation strategies, also goes beyond what the survey dataset permitted to analyse. These questions have then been addressed by follow-up in-depth interviews.

4.2 Results study 2

When trying to identify user innovations for this follow-up study from the survey data set it turned out that is was much more difficult to pinpoint cases where users had innovated on products they do not own. Hence, we must conclude that the survey findings overestimate the frequency of user innovations of foreign owned products. However, from the five cases, which we analysed in more detail case 4 and 5 represent examples of product modifications carried out by a user who is not the product owner.

Case 1 represents an innovation that would be considered a "classical" user innovation where a user developed a novel self-contained product. Case 2 represents an example where a user developed an innovation for products that he does not own. However, he developed the innovation in a way that it can be attached or detached to/from the products he uses but does not own. We label this a reversible innovation strategy in contrast to a permanent modification. Case 3 is an example of a collaborative innovation jointly developed by different users. From the case analysis it emerged that the permission to modify a product is an important constraint for users when they have ideas to improve products they do not own. In case 4, a modification was carried out with the owner's permission while in case 5 the user modified the product without seeking permission.

Table 5: Case study overview

	Case 1[a]	Case 2	Case 3	Case 4[a]	Case 5
Product description	Novel field sprayer	Discharger for manure tankers	Additive tank for liquid manure spreader	Modified field sprayer	Trailer grain gate
Innovation type (own/foreign)	New product innovation developed by user that owned an inappropriate product	User developed a complementary product to be used with equipment owned by other users	Owner modified his equipment in collaboration with another user who had the idea	User modified equipment owned by other user	User modified equipment owned by other user
Innovation strategy (permanent/reversible)	A novel self-contained product	A novel product that can be attached and detached from different products circumventing the need for owner's permission	Permanent and collaborative modification	Permanent modification with owner's permission	Permanent modification without owner's permission

Notes: a=the two cases are related. Case 4 is an improvement carried out for the novel field sprayer (case 1).

From further case analysis, another two findings emerged. First, interviews revealed that sharing also impacts users' need identification, wherefore we have added this as a third respectively first stage of the innovation process in the analysis of the interviews. Second, while we have suspected that direct effects of in- and out-sharing on user innovativeness exist, the interview results indicate that additional indirect effects exist. Table 6 therefore also distinguishes direct and indirect effects along the user innovation process (need identification, idea generation, idea realization) with process stages in brackets.

Cases 4 and 5 reveal direct sharing-in effects on all three stages of the user innovation process. For instance, users who frequently in-share products seem to generate ideas for product improvement. Sharing-out however seems to affect only need identification and idea generation. For instance, users reported that they benefited from sharing-out their products to better understand needs for product improvements. In case 1 the user benefited from sharing-out through being exposed to other use cases. Hence, sharing-out seems to accelerate the accumulation of use experience. In cases, where owners share-out their equipment without however operating it themselves these direct effects may diminish. Owners still may benefit indirectly from feedback, which the users provide (case 3). Case 1 further demonstrates additional benefits for the idea realization through indirect out-sharing effects. In that case, the user was able to generate funds from sharing-out activities, which positively impacted his idea realization. Indirect effects from sharing-in seem to positively impact only users' idea realization probability. Particularly sharing-in seems to have an impact on the relationship between the owner and user in a positive or negative way.

Table 6: Direct and indirect sharing effects on innovation process stages

		Case 1	Case 2	Case 3	Case 4	Case 5
Direct effects	Sharing-in		Borrowing the equipment provided the user with access to the product to make the modification (3).		Using the same equipment borrowed from the owner multiple times let the user to identify a need for a product improvement (1) as well as a specific idea to solve the problem (2). Borrowing the equipment provided the user with access to the product to make the modification (3).	User borrowed equipment several times from the owner. After repair, the product was missing a specific feature (1). From the original product design, he was aware of how the specific solution should look like (2). Borrowing the equipment provided the user with access to the product to make the modification (3).
	Sharing-out	Frequently using an owned product for services provided to other users over a long period of time enhanced the owner's use experience and led the user to recognize that existing products are insufficiently suited for a range of use cases. (1)	Frequently providing services to other users exposed the user to other available products and innovations which generated an idea to his user innovation (2)			

		Frequently providing services with his own products led him to understand the concrete specifications for a new product (2)				
Indirect effects	Sharing-in		Frequently borrowing equipment led the user to develop a reversible solution preventing him from having to make a permanent modification (3)		Frequent equipment borrowing facilitated the development of a trust relationship between user and owner. The owner granted permission for the user to make the modification (3)	From previous sharing-in occasion the user was aware that the owner values the feature. Wherefore he felt that he did not need to ask for permission to re-install the feature (3)
	Sharing-out	The ability to share out equipment including highly novel products provided certainty of financial returns to be able to appropriate sufficient returns to cover for his product development costs (3)		A user who borrowed the product had already identified an innovation need and specific idea, which he fed back to the owner (1) (2) Together they realized the product modification (3)		

1=need identification, 2=idea generation, 3=idea realization

In summary, across all five cases the innovating users have benefited from engaging in sharing activities either directly or indirectly. It seems that users employ different innovation strategies whether they own or not the products upon which they innovate. We observe that users make permanent modifications in cases they own the products. Where they lack ownership and have to get permission to modify from the owner users may opt for reversible improvements unless trust remedies for the lack of ownership.

5 Discussion and future research

Studying the sharing-related literature for conceptualizing our understanding of the sharing construct revealed the need to distinguish between two sharing directions (in- and out-sharing). Based on the understanding that sharing has two directions, we propose to distinguish four sharing types (lone wolfs, economists, free rider and reciprocists). In our descriptive results we find significant differences across these groups regarding personal traits and user innovativeness. Future research should further investigate these groups, e.g. via in-depth interviews.

When designing our analysis, we recognized that because of the two sharing directions we had to distinguish two user types and two product types: First, product owning users who can modify products without seeking permission, and, second, users who borrow products from others (i.e. the owners) and thus do not possess ownership rights for the products, which some users however attempt to modify. With regards to products users modify, we had to distinguish (i) products users own from those (ii) they do not own (foreign products). Unfortunately, these distinctions induced more complexity into our analysis. Future studies may consider this distinction upfront, focus specifically on selected user groups, respectively products or find ways to simplify their analysis.

Our empirical results strongly indicate that users even develop innovative ideas and occasionally even realise them for products they do not own. These effects are however less prominent than the corresponding effects where users own their products. Hence, lack of product ownership seems to be a barrier to user innovation, which confirms the findings by Tietze et al. (2015) and Pieper (2019). These effects should be further studied as they might be of relevance in a wide range of settings. For instance, where users are employees, such as doctors in hospitals they could be less inclined to innovate than self-employed users, such as independent doctors (even though they may have more resources at hand, which could partly compensate for the negative effect). The effect could also be studied in sport communities where we know that user innovation is widespread, for instance comparing mountain bike users who own their equipment with team sports, where typically users do not own the equipment (e.g. team sailing).

T-tests and ANOVA analyses of user innovativeness across the four sharing types had originally revealed significant differences indicating that users who are actively sharing-in and -out are more innovative than less actively sharing users. However, regression analysis revealed that only significant (and rather surprisingly strong) direct relations exist between users' sharing-in and -out behaviour and user innovativeness for foreign products. In contrast with our expectations, for innovating own products, users do not seem to benefit from engaging in sharing activities with ideas for their own products. We find this difficult to explain, but a possible explanation might be that users actually borrow products from others that they do not possess and thus have no benchmark to compare against. Unfortunately, we cannot control for this in our analysis as we had not questioned this in the survey. Our insights from case study interviews point towards three types of products that users share: Equipment they do not have (e.g. a combined harvester), a product they own, but need more capacity (e.g. an additional tractor) or a product with complementary functions (e.g. users own a tractor and borrow a trailer). Better understanding and typologising these product types that users share-in and -out should be subject to future studies. Another explanation might be that potentially innovative (lead) users typically are very well informed already (e.g. have read about product alternatives in industry magazines or have tested alternative products during trade fair visits). This is however in contrast with the characteristics we found across the four sharing groups. Accordingly, the most innovative group are the reciprocists, which also appear to be those with the lowest educational degrees.

Our interviews indicate that users seem to pursue two innovation strategies for products they own, respectively foreign products. While users may prefer (i) permanent modifications as they can be better tailored to a specific need leading to a more efficient solution, they also develop (ii) reversible add-on innovations that can be attached and detached to/from a number of different products and thus are more flexible. For instance, our case 2 user developed a reversible innovation that he can attach/ detach to/ from products he regularly in-shares. This might not be surprising as one would not expect users to permanently modify products, which they do not own as this could lead to conflicts with the owner, if not damage claims. In other words, for permanent product modifications one would expect that users seek permission from owners. However, we found a case where a user had modified a product permanently that he does not own. The interviews revealed that in this particular case the user had a close relationship with the owner. One may thus argue that trust remedies for lack of ownership. While one could argue that users prefer reversible solutions for products they do not own, they may actually derive an additional benefit from reversible solutions in the sharing context. A reversible solution may allow them to use it for a range of different products they use, but do not own. While our interviews reveal initial insights into these two innovation strategies and causalities of the effects, future research would be helpful to develop a better understanding of these strategies and effects.

We had suspected to find from our analysis that users with high technical expertise particularly benefit from sharing-in activities by generating more ideas from getting exposed to other products, which our results support revealing positive and significant interaction effects. That finding indicates that users with high technical expertise are capable of generating even more ideas from borrowing equipment than users with low technical expertise. That this effect exists both for own and foreign products indicates that lenders and borrowers actually interact and possibly benefit both from these interactions. While we do not find significant interaction effects of sharing-out behaviour, however, our qualitative in-depth interviews indicate that users indirectly benefit from engaging in sharing-out activities through learning and network effects. For instance, during interviews we were told that owners, who share-out their products receive feedback on product performance when users return their product. They absorb the information about processes, solutions and different ways to use their equipment, which may lead to increased user expertise leading in turn to a higher degree of innovativeness. However, one may suspect that the *commercialists* are mostly interested in monetary benefits from sharing-out their equipment, which may distort our results and would require further analysis. The causalities of these interactions and possibly mediator effects with other variables should be explored further.

6 Conclusions, implications and limitations

Although sharing models are not entirely a new phenomenon - as the recent media coverage of the "sharing economy" may suggest (Cheng, 2016) - we observe a recent emergence of more and more sharing-based business models. This paper is a step towards a better understanding of how users innovate who are exposed to and participate in sharing of tangible products (not knowledge). This may not be entirely unimportant to companies that operate sharing-based business models.

Our results strongly indicate that sharing and user innovativeness are related. It seems that higher sharing experience is positively associated with user innovativeness. Accordingly, we propose sharing experience, as a new construct, to be considered in future user innovation studies. Furthermore, we set out and propose to distinguish four sharing types, which we typologized based on the users' sharing frequency of borrowing equipment (sharing-in) and frequency of lending equipment to others (sharing-out). Our empirical findings are in line with previous user innovation studies supporting that technical expertise and lead userness have an impact on user innovativeness. Hence, we can conclude that our dataset must be considered valid.

6.1 Managerial implications

The findings from our study offer one particular managerial implication for companies who wish to collaborate with innovative users. As we know from prior user innovation research (e.g. Schreier and Prügl, 2008), innovative users are difficult to find as user innovativeness and lead userness are mostly only assessible through surveys. Our findings reveal that sharing experience might be a relevant proxy for user innovativeness given that the most active sharing user group of *reciprocists* in our sample is the one with the highest lead userness. Hence, firms hunting for innovative users may opt to search for users with high sharing experience.

Given that today user activities are often digitally monitored not only in sharing-based business models, data on sharing experience could possibly be obtained relatively easy. For instance, in car-sharing systems one may identify users who have signed up early to the system (high sharing duration) and often use cars (high sharing frequency). In addition, one may actually use other indicators that further contribute to better assessing lead userness, such as frequent use of cars in different cities.

6.2 Limitations

Even though the results provide initial insights into relationships of sharing and user innovativeness, as all studies this one is subject to limitations. Although this study was preceded by a pre-study, the results presented here are based on a questionnaire answered by a single respondent only. Accordingly, the results might be subject to common method bias. While the survey sample is large, the different sharing types are not equally distributed in our sample, which may potentially lead to biased results. Furthermore, while we have discussed different sharing models in the theory section, we have only studied a peer-to-peer sharing model. It remains for further research to explore the relations of user innovativeness and sharing activities in sharing models, e.g. where products are not owned by the users and community members, but by manufacturers or market intermediaries that act as operators.

In addition, the question remains to what extent the results from an analysis of users that share farming equipment apply to other sharing models, such as more modern sharing approaches (e.g. AirBnB). It may seem very unlikely that users suddenly start to redecorate apartments they do not own, but only rent for a few days. However, users that regularly spend days and nights in flats they do not own may temporary adjust the interior to fit their own habits. Such users may actually start developing particular travel equipment (reversible innovations) that they can bring to and remove from the apartments they rent. Accordingly, more research remains to be done to gain further understanding in different empirical settings.

Acknowledgements

We thank Cornelius Herstatt who supported the development of this article and contributed as co-author in an earlier version of this paper. We further thank Kirsten Samson for supporting the pre-study data collection, Tom Oberquelle for collecting survey data and Kristian Lennart Knuth for conducting case study interviews. Gerhard Röhrl has kindly supported the survey on behalf of the German Maschinenring association. We also like to thank all survey and interview participants.

Appendix

Table 7: Factor analysis for sharing experience construct

	Sharing experience	Sharing frequency	Sharing-in experience	Sharing-out experience
Since how many years are you sharing products?	.313		.726	.754
How often are you currently sharing-in products?	.831	.861	.726	
How often are you currently sharing-out products?	.856	.861		.754
Cronbach's Alpha	.476	.650	.104	.239

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Chapter 12

Individuals' knowledge and their explorative and exploitative behaviors

Tim Schweisfurth, Christoph Stockstrom, and Christina Raasch

Abstract

A growing body of literature has been focusing on the question how individuals in organizations combine exploitation and exploration so as to help organizations become ambidextrous. We take a knowledge-based perspective to understand employees' explorative and exploitative behaviors and conceptualize knowledge-based precursors to these behaviors along two dimensions: (1) focus on internal and external knowledge (level of existing knowledge vs. absorptive capacity) and (2) knowledge domain (need vs. solution knowledge). This focus addresses two significant gaps in the ambidexterity research (Lavie et al. 2010; Raisch et al. 2009): (1) the tensions of focusing on internal vs. external knowledge and (2) the interactions between different knowledge domains.

Drawing on a sample of 864 employees in the home appliances sector, we use regression analyses to test six hypotheses. We argue that existing knowledge will relate positively to exploitative behavior, and that absorptive capacity for new knowledge from outside will relate positively to explorative behavior. Our data supports these conjectures, and shows that these relationships increase non-linearly for all tested relationships, except for the positive relationship between need knowledge and exploitative behavior. We also find support for the hypothesized negative interaction between need and solution knowledge on exploitation and a negative interaction effect of need and solution absorptive capacity on exploration.

Our findings make three primary contributions to the research on individual ambidexterity and absorptive capacity. First, we extend the understanding of the cognitive precursors of ambidexterity at the individual level by exploring how individuals' knowledge and absorptive capacities shape their exploration and exploitation. Second, we show that need knowledge and solution knowledge are substitutes in their effects on exploitative behavior and, analogically, that need knowledge and solution knowledge are substitutes in their absorptive capacity effects on explorative behavior. Third, we contribute to the literature on individual absorptive capacity, introducing individual absorptive capacity for need and solution knowledge as precursors of explorative behavior, which extends the understanding of the micro-level outcomes of this capacity.

Keywords: Explorative Behavior; Exploitative Behavior; Absorptive Capacity; Individual Ambidexterity

1 Introduction

To be successful in the long term, organizations must balance exploration and exploitation (Levinthal and March, 1993, March, 1991). Exploration includes activities such as "search,

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R. Tiwari and S. Buse (eds.), *Managing Innovation in a Global and Digital World*, https://doi.org/10.1007/978-3-658-27241-8_13

variation, risk taking, experimentation, flexibility, discovery, and innovation," while exploitation relates to "refinement, choice, production, efficiency, selection, implementation, and execution." (March, 1991, p. 71). The combination of exploration and exploitation has been labeled ambidexterity. While much of the research into ambidexterity initially focused on organizations (Lavie and Rosenkopf, 2006, Sidhu et al., 2007, Lubatkin et al., 2006, Cao et al., 2009, He and Wong, 2004, O'Reilly and Tushman, 2008, Raisch and Birkinshaw, 2008, Jansen et al., 2006), a growing body of research has come to acknowledge that organizational ambidexterity is rooted in its members' abilities to combine exploitation and exploration (e.g. Gibson and Birkinshaw, 2004, Li et al., 2008, Raisch et al., 2009, Ambos et al., 2008), focusing on the antecedents of individual ambidexterity and explored coordination mechanisms (Mom et al., 2009), social networks (Rogan and Mors, 2014, Simon and Tellier, 2011), cognition (Good and Michel, 2013, Laureiro-Martínez et al., 2014), and knowledge flows (Mom et al., 2007) to explain individuals' explorative and exploitative activities.

We take a knowledge-based perspective to understand employees' ambidexterity. We conceptualize knowledge along two dimensions that have been shown to be relevant concerning exploration and exploitation, domain (need knowledge vs. solution knowledge) (e.g. Gruber et al., 2013, Nerkar and Roberts, 2004), focusing on internal and external knowledge (level of existing knowledge vs. absorptive capacity) (e.g. Raisch et al., 2009, Rosenkopf and Nerkar, 2001). Knowledge has ambivalent effects on exploration and exploitation (Katila and Ahuja, 2002), and the relationships between knowledge types and origin of knowledge have not been explored at the individual level. This is a critical gap in the literature. On the one hand, knowledge is a crucial enabler of and basis for exploration and exploitation (Gupta et al., 2006, March, 1991); on the other hand, scholars have argued that excessive knowledge exploration or exploitation can lead to learning traps (Levinthal and March, 1993). Thus, we investigate how employees' focus on internal knowledge in specific domains (need knowledge and solution knowledge) (i.e. existing knowledge) and the focus on external knowledge (i.e. the absorptive capacity for such knowledge) relate to exploration and exploitation.

Drawing on a sample of 864 employees in the home appliances sector, we use regression analysis to test six hypotheses. We argue that existing knowledge will relate positively to exploitative behavior, and that absorptive capacity will relate positively to explorative behavior. Our data supports these conjectures, showing that these relationships increase non-linearly in each case, except for the positive relationship between need knowledge and exploitative behavior. We also find support for the hypothesized negative interaction between need and solution knowledge and exploitation and, analogically, a negative interaction effect of need and solution absorptive capacity on exploration.

Our findings make three primary contributions to the research into individual ambidexterity and absorptive capacity. First, we extend the understanding of the cognitive precursors of ambidexterity at the individual level by exploring how individuals' prior knowledge and their absorptive capacity shape their exploration and exploitation (Good and Michel, 2013, Mom et al., 2007). Second, we show that need and solution knowledge are substitutes in their effects on exploitative behavior and, analogically, that absorptive capacities for need and solution knowledge are substitutes in their effects on explorative behavior. Third, we contribute to the literature on individual absorptive capacity (Lowik et al., 2012, Tortoriello, 2014, Schweisfurth and Raasch, 2015). Our research introduces individual absorptive capacity for need and solution knowledge as precursors of explorative behavior, extending the understanding of the micro-level outcomes of these capacities.

The remainder of this paper is organized as follows: In Section 2, we review the existing body of research into individuals and their exploration and exploitation behaviors and present our research framework and hypotheses. Section 3 includes our methods, followed by our findings from regression analysis in Section 4. Finally, we discuss the contributions, limitations, and practical implications of our research.

2 Theory and research model

2.1 Employees' exploration and exploitation

Organizational ambidexterity, as the exploration of tomorrow's needs and the exploitation of today's business, is linked to organizational performance (e.g. Gibson and Birkinshaw, 2004, He and Wong, 2004, Hoang and Rothaermel, 2010, Lubatkin et al., 2006, Simsek, 2009, Simsek et al., 2009, Lavie et al., 2010). Scholars suggest different modes to achieve ambidexterity (Lavie et al., 2010, Raisch and Birkinshaw, 2008, Gupta et al., 2006). Many of these modes of exploration and exploitation are located at the organizational level, although March (1991) noted that tradeoffs between exploration and exploration must be made "at levels of a nested system – at the individual level, the organizational level, and the social system level." (p. 72). At the organizational level, ambidexterity can be achieved structurally or temporally (Gupta et al., 2006, Simsek et al., 2009). In structural separation, organizations have separate units dedicated to either exploration or exploitation (e.g. Cao et al., 2009, He and Wong, 2004, Tushman and O'Reilly 1996). In temporal separation, organizations traverse through oscillating phases of exploration and exploitation (e.g. Bierly and Daly, 2007, Rothaermel and Deeds, 2004). Below the organizational level (e.g. at the individual level), exploration and exploitation can happen simultaneously and may be carried out by one individual simultaneously. Gibson and Birkinshaw developed this notion of contextual ambidexterity (2004), arguing that organizations can achieve ambidexterity by providing a context "dynamic and flexible enough to allow individuals to use their own judgment as to how they divide their time between alignment-oriented and adaptation-oriented activities, and both are valued and rewarded." (p. 221).

In this view, ambidexterity is rooted in the deliberate behaviors and actions of individuals in organizations. Researchers and scholars have looked at employees' exploration and exploitation activities from socio-psychological and cognitive perspectives. Rogan and Mors (2014) took a network perspective on managers' ambidexterity and explore how their networks shape their exploration and exploitation behaviors. They found that higher informality of external ties leads to higher explorative behavior and lower exploitative and ambidextrous behavior. In contrast, higher informality of ties within an organization relates to fewer explorative activities. Mom et al. (2007) investigated how coordination mechanisms within an organization influence managers' ambidexterity, and showed that decision-making authority, cross-functional integration, and informal connectedness within the organization (as well as their interactions) relate positively and significantly to ambidexterity.

The cognitive perspective has explained exploration and exploitation in light of cognitive processes. Using fMRI studies, Laureiro-Martínez and colleagues showed that exploration and exploration are behaviors that are located in different regions of the brain (Laureiro-Martínez et al., 2014, Laureiro-Martínez et al., 2010). Divergent thinking, focused attention, and cognitive flexibility are cognitive factors that shape individual ambidexterity (Good and Michel, 2013). However, except for one study on the hierarchical origin of knowledge flows (Mom et al., 2007), scholars have not yet focused on how individuals' knowledge shape explorative and exploitative activities. This is surprising, because the research shows the importance of knowledge for organizational ambidexterity (Danneels, 2002, Danneels, 2007, Im and Rai, 2008, Tiwana, 2008, Katila and Ahuja, 2002) and stresses knowledge's key role in individual exploration and exploitation (March, 1991, Raisch et al., 2009). We address this gap and extend the knowledge perspective by investigating which knowledge types individuals rely on for exploration and exploitation. We structure the underlying knowledge by (1) knowledge domain (need vs. solution knowledge) and by (2) origin (internal vs. external knowledge).

Origin of knowledge	Outside organizational boundaries	**Focus on external solution knowledge** Absorptive capacity for solution knowledge	**Focus on external need knowledge** Absorptive capacity for need knowledge
	Inside organizational boundaries	**Focus on internal solution knowledge** Individual stock of solution knowledge	**Focus on internal need knowledge** Individual stock of need knowledge
		Solution knowledge	Need knowledge
		Type of knowledge	

Figure 1: Knowledge dimensions

Exploration and exploitation can relate to different knowledge domains (Lavie et al., 2010). Much research has focused on markets and technologies as relevant domains for knowledge exploration and exploitation (e.g. Danneels, 2002, Danneels, 2007, Gruber et al., 2012, Gruber et al., 2013, Li et al., 2008, Nerkar and Roberts, 2004, Sidhu et al., 2007, Burgers et al., 2008). For instance, Sidhu et al. (2007) showed that firms explore new opportunities via demand-side search (search for market insights), supply-side search (search for technologies), and spatial search (geographic dimension and local know-how). Nerkar and Roberts (2004) showed that, upon market introduction, exploration in distant market and technological domains positively affect product sales. Danneels (2002) argued that firms innovate by linking competences relating to technologies and customers; combining existing customer and technological competences involves exploitation, while combining customer and technological resources that are new to a firm is labeled as exploration. Gruber and coauthors (2012, 2013) presented evidence of firms combining exploration and exploitation by drawing on existing knowledge in the technological domain (existing technological competence) to explore new market opportunities. From a somewhat different perspective, scholars have reported how incumbents exploit complementary market assets, such as access to existing customers, while simultaneously exploring new technologies (Gupta et al., 2006, Rothaermel, 2001, Rothaermel and Deeds, 2004). Following this tradition, we distinguish between solution knowledge and need knowledge as relevant domains of explorative and exploitative behaviors in organizations. The former includes "solution related knowledge needed to develop technologies and products," while the latter is "problem-related knowledge about needs [firms] will face in current or future markets." (Alexy et al., 2013, p. 270).

The origin of knowledge for exploration and exploitation can be inside or outside a firm. Firms that seek to combine exploration and exploitation "require both internal and external knowledge processes." (Raisch et al., 2009, p. 689). Scholars found that learning from knowledge embedded in external relationships with partners or customers can involve both explorative and exploitative learning (Hoang and Rothaermel, 2010, Rothaermel and Deeds, 2004, Im and Rai, 2008, Lin et al., 2007). Rosenkopf and Nerkar (2001) showed, in their study in the optical disk industry, that exploration can be based both on internal and on external knowledge. Mom et al. (2007) pointed out that exploration and exploitation can both be based on internal knowledge flows, depending on the hierarchical origin of knowledge. Following this delineation of internal and external knowledge processes, we explore the extent to which existing internal knowledge resources affect individuals' explorative/exploitative behaviors and how their abilities to recognize, assimilate, and apply external knowledge (i.e. their absorptive capacity) (Cohen and Levinthal, 1990, Lane et al., 2006) relate to these behaviors.

2.2 Hypotheses

We draw an exhaustive picture of how employees focus on existing need knowledge and solution knowledge, including how they absorb such knowledge, which relates to their explorative and exploitative behaviors. We derive six hypotheses; Figure 2 summarizes our hypotheses and illustrates the research framework. These hypotheses address two gaps that ambidexterity scholars have deemed worth investigating (Lavie et al., 2010, Raisch et al., 2009): (1) the tensions of focusing on internal vs. external knowledge and (2) the interaction between different knowledge domains.

2.2.1 Individuals' knowledge and their exploitative behaviors

Exploitative behavior builds on past experience and existing knowledge and involves incremental learning from such knowledge (Gupta et al., 2006). The more knowledge individuals have in one domain, the more likely they will conduct activities that are based on exploiting this knowledge (Mom et al., 2007). If knowledge in one domain is well known to individuals, they tend use knowledge in predefined routines rather than in new ways. Thus, knowledge in one domain relates positively to exploitative behaviors. We also expect this relationship to be non-linear: The more knowledge individuals accumulate in one domain, the more they become experts in this field. More knowledge in one domain also means that this knowledge can be exploited more efficiently, because decision-making and the derivation of behaviors cause less effort once an individual is more experienced in a field (Levinthal and March, 1993), that is, each additional piece of knowledge is easier to exploit. Thus, higher knowledge in one domain will be non-linearly related to exploitative behavior in a way that one knowledge increment will relate to an increment in exploitative behavior greater than one. This argumentation holds for both need and solution knowledge. Therefore:

H1a: Individual's need knowledge relates positively to their exploitative behavior (quadratic).

H1b: Individual's solution knowledge relates positively to their exploitative behavior (quadratic).

We suggest that need knowledge and solution knowledge are substitutable resources concerning exploitative behavior in the sense that using one knowledge type marginally decreases the benefit of using the other (cf. Milgrom and Roberts, 1995). As noted, the amount of knowledge in a specific domain positively affects exploitation, because increasing specialization levels allow people to exploit the knowledge in this domain more efficiently and in more ways (Levinthal and March, 1993, Mom et al., 2007, cf. March, 1991). Further, if individuals draw on knowledge from another domain, they must shift their attention and cognitive processing to that domain, which requires using different mental models and schemes of interpretation to engage in exploitative behavior. Given limited mental capacities, individuals can no longer focus all their attention on exploiting one knowledge type, suggesting that the additional consideration of unrelated knowledge comes at the cost of missing out on some of the benefits of high specialization.

In our case, this means that need knowledge and solution knowledge relate positively to exploitative behavior, but there will be a negative interaction between the two knowledge types. This leads us to hypothesize:

H2: Need and solution knowledge are substitutes, such that their interaction relates negatively to exploitative behavior at the margin.

2.2.2 Individuals' absorptive capacities and their explorative behaviors

Employees' absorptive capacities are individuals' abilities to identify, transform, and exploit external knowledge for innovation within an organization. This ability is domain-specific, i.e. there are different absorptive capacities for different knowledge domains. Absorptive capacity helps one to make new external knowledge accessible within an organization. It supports individuals' abilities to learn from new knowledge and to apply that knowledge in their work contexts. These activities typically relate positively to individuals' explorative behaviors. Absorbing new need knowledge and solution knowledge includes recognizing new needs or technologies outside an organization as well as ideas for product and process innovation (Murovec and Prodan, 2009). Mom et al. showed that knowledge absorption relates positively to individual explorative behavior (Mom et al., 2015a).

Cohen and Levinthal (1990) argued that absorptive capacity is a path-dependent capability and "[a]ccumulating absorptive capacity in one period will permit its more efficient accumulation in the next." (p. 136). Following this argument, we suggest a non-linear relationship between individual absorptive capacity and explorative behavior. Once employees specialize in absorbing knowledge from one domain, it becomes easier for them to acquire additional knowledge from that domain. Since they have more new knowledge available, they also have more ideas and inputs for utilizing this knowledge within the organization, i.e. to engage in explorative behavior. In sum, we hypothesize:

H3a: Individual's need knowledge absorptive capacity relates positively to explorative behavior (quadratic).

H3b: Individual's solution knowledge absorptive capacity relates positively to explorative behavior (quadratic).

We argue that absorptive capacity for need knowledge and solution knowledge are substitutes concerning explorative behavior. The increase in explorative behavior is lower if individuals increase both absorptive capacity types than if they increase only one type. Individuals have limited cognitive abilities and limited attention they can allocate to different absorptive capacity types. We have argued that absorptive capacity in one domain leads to higher exploration. If individuals focus on knowledge absorption in more than one domain, they must simultaneously explore more than one knowledge type and must split their attention to exploration accordingly. As the effort shifts away from one domain absorption to the absorption of more than one knowledge type, the marginal effect of exploration will be lower, because individuals must supply cognitive power to absorbing knowledge from more than one source. This argumentation draws support from Hess and Rothaermel's (2011) study at the firm level in the pharmaceutical industry. They argued that absorbing knowledge from different sources is associated with diseconomies of scope at the firm level, and found empirical support for their argumentation. Firms specialize in absorbing knowledge from different sources and therefore experience transaction costs that relate to building absorptive capacity. These costs accrue for each absorptive capacity type. Formalizing this mechanism at the individual level, we hypothesize:

H4: Need absorptive capacity (NACAP) and solution absorptive capacity (SACAP) are substitutes, such that their interaction relates negatively to explorative behavior at the margin.

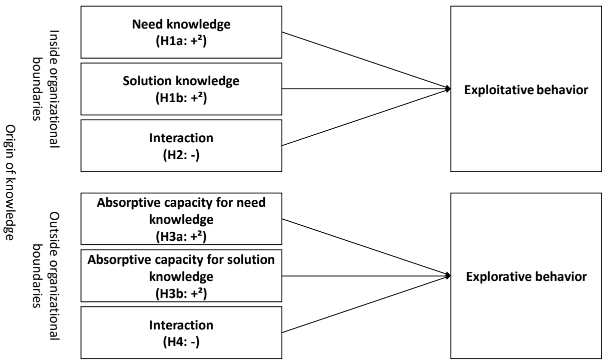

Figure 2: Framework

3 Method

3.1 Sample and the context of the study

We tested our hypotheses with a sample of 864 employees of the German branch of a home appliance manufacturer (e.g. ovens, dishwashers, washing machines, freezers, fridges, etc.). We developed the questions with the corporate technology unit, who also distributed the survey to supervisors and asked them to forward it to their subordinates. This sampling approach resulted in 864 usable answers. We estimated our response rate, because we did not know exactly how many employees received the email, relying on the corporate technology department's past experience with previous surveys. It estimated that 3,500 employees received the email inviting them to participate in the survey, a 24.7% response rate. Others calculate response rates by using the number of visitors to a survey site as the population size (cf. Balka et al., 2014); based on this approach, our survey achieved a 32.3% response rate based on 2,674 visitors to our site.

We conducted Armstong and Overton's (1977) test to check for non-response bias, comparing the first and the last 10% of respondents. This test assumes that late respondents are more similar to non-respondents than early respondents. While we found no significant differences between these groups in the main variables ($p > 0.05$), we did find significant differences in motivation and hierarchy, which we controlled for in our analyses.

Of the respondents, 205 were female. On average, respondents were 39.66 years old and had been employed by the organization for 11.85 years. Of the respondents, 292 worked in development (33.8%), 96 in marketing (11.1%), 37 in sales (4.3%), 51 in operations (5.9%), 42 in human resources (4.9%), and 22 in finance (2.5%). The remaining respondents indicated Other function or did not specify their role. Table 1 includes the descriptive data and the correlations of our constructs.

Table 1: The Descriptive data and the correlations

	min	max	Mean	s.d.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1. Cognitive style	1.000	7.000	5.067	.981												
2. Intrinsic motivation	2.000	7.000	6.039	.908	.481											
3. Job satisfaction	1.000	7.000	5.488	1.322	.344	.454										
4. Openness	1.000	7.000	4.681	1.387	.071	.178	.009									
5. Hierarchy	.513	4.000	1.308	.561	.001	-.005	.055	-.022								
6. Education	2.000	5.380	4.510	.825	-.049	.010	.013	.082	.210							
7. Age	19.000	64.000	39.658	9.324	.082	.025	.073	-.080	.395	-.167						
8. Need knowledge	1.000	7.000	5.194	1.298	.105	.115	.044	.339	.104	.117	.045					
9. Solution knowledge	1.000	7.000	4.695	1.584	.122	.091	.011	.282	.089	.087	.098	.738				
10. Needs absorptive capacity	.950	7.000	3.682	1.756	.039	.094	-.015	.408	.091	.217	-.055	.543	.619			
11. Solution absorptive capacity	.546	7.000	3.591	1.955	.067	.101	-.011	.331	.008	.186	-.068	.433	.656	.849		
12. Explorative behavior	1.000	7.000	3.904	1.734	.060	.106	.003	.325	.050	.208	-.093	.466	.573	.772	.778	
13. Exploitative behavior	1.000	7.000	4.629	1.378	.198	.232	.099	.259	.043	.114	-.053	.440	.501	.514	.499	.614

Correlations above 0.087 are significant at the level of 0.01

3.2 Measurement

3.2.1 Dependent variables

We measured the dependent variables, explorative and exploitative innovative behavior, using Mom and coauthors' scale (2009, 2007). We asked the respondents to what extent they engaged in specific activities, since both explorative and exploitative behaviors have mostly been measured by self-reports at the individual level (Mom et al., 2015b, Mom et al., 2009, Mom et al., 2007). They relate highly and significantly to supervisor ratings of the various behaviors (Mom et al., 2015a).

The scale for explorative activity included five items ($\alpha = 0.891$): *Searching for new possibilities concerning products, services, processes, or markets*, *Evaluating diverse options concerning products, services, processes, or markets*, *Focusing on strong renewal of products, services or processes*, *Activities that require one to have much adaptability*, and *Activities that require one to learn new skills or knowledge*. The scale for exploitative activities included six items ($\alpha = 0.876$): *Activities in which one has accumulated much experience*, *Activities* *that serve existing (internal) customers with existing services or products*, *Activities for which it is clear how to conduct them*, *Activities that primarily focus on the achievement of short-term goals*, *Activities one can properly conduct by using one's present knowledge*, and *Activities that clearly fit into existing company policy*.

3.2.2 Independent variables

We measured all remaining variables on a seven-point Likert scale (anchored between 1 = *I don't agree at all* and 7 = *I strongly agree*).

We gave the respondents descriptions of need knowledge and solution knowledge before we asked the questions about knowledge and absorptive capacity. The text for need knowledge read as follows: *Need knowledge comprises knowledge about problems that occur during product use. Need knowledge ensures user needs and market opportunities*. The description for solution knowledge was: *Technological knowledge comprises knowledge about technologies and techniques to solve problems and thus to satisfy user needs*.

To measure employees' prior need knowledge and solution knowledge, we used a measure adapted from the subjective knowledge scale developed by Flynn and Goldsmith (1999). We adopted three suitable items from the original five-item scale, measuring prior need knowledge along the following items: *I feel very knowledgeable about using home appliances*, *Compared to most other employees in this organization, I know more about using home appliances*, and *Concerning the use of home appliances, I know a lot* ($\alpha = 0.908$). Throughout the survey, we replaced *home appliances* with the product category the respondent originally chose as the one they knew most about. To measure solution knowledge, we used the following items: *I feel very knowledgeable about the technologies in the field of home appliances*, *Compared to most other employees in this organization, I know more about technologies in the field of home appliances*, and *Concerning technologies in home appliances, I know a lot* ($\alpha = 0.953$). Again, we gave our respondents cues about what we meant by need knowledge and solution knowledge.

To measure individual absorptive capacities, we used a measure based on Lowik et al. (2012) which, unlike other individual-level conceptualizations, has the advantage of being applicable across different contexts. We adapted this measure in two directions: First, our study necessitated the distinction between absorptive capacity for need knowledge and absorptive capacity for solution knowledge. This focus required us to drop items we could not adapt to capture our distinction, specifically *I intentionally search for knowledge in many different domains to look 'outside the box'* and *I am good at distinguishing between profitable opportunities and less profitable information or opportunities.* Second, we used a three-dimensional specification (recognition, assimilation, application) of absorptive capacity, pooling the items for knowledge assimilation and transformation from Lowik et al.'s scale in one dimension (assimilation). This is in line with much of the literature that regards absorptive capacity as a three-dimensional construct (e.g. Lane and Lubatkin, 1998, Todorova and Durisin, 2007). Following these adjustments, we retained six items, two each for recognizing, assimilating, and applying new knowledge: *I am always searching for new knowledge types in order to create new products*, *I identify the new knowledge types that are most valuable to us*, *I translate new knowledge types into a language my colleagues understand*, *I turn existing knowledge types into new ideas*, *I exploit new knowledge types so as to create new products*, and *I always consider how to apply new knowledge types so as to improve products*. To focus the constructs on need absorptive capacity and solution absorptive capacity, we replaced *knowledge type* with *application problems and needs* and *technological solutions*, respectively, and again offered the explanation of differences between need knowledge and solution knowledge. These scales for need absorptive capacity and solution absorptive capacity had α-values of 0.948 and 0.967, respectively.

3.2.3 Control variables

We controlled for cognitive characteristics (Good and Michel, 2013) (i.e. cognitive style and openness to experience) and motivational variables (Ambos et al., 2008) (i.e. job satisfaction and intrinsic motivation), since these personal factors may relate to individuals' explorative and exploitative activities at work (Raisch et al., 2009).

We measured cognitive style using the *associative cognitive style measure*, comprised of three items (Shalley et al. (2009): *I am consistent in the way I tackle problems*, *I pay attention to the order of the steps needed to complete a job*, and *I accept the usual way of doing things* (α = 0.657).

To measure *openness to experience*, we employed Rammstedt and John's (2007) two-item, positively coded short subscale of openness to experience: *I have many artistic interests* and *I have an active imagination* (α = 0.732).

We used a global measure of *job satisfaction* to ask employees how they generally felt about their jobs. Such one-item specifications are common for general job satisfaction (cf. Lee et al., 2008, Trevor, 2001).

We measured *intrinsic motivation*, following Shalley et al. (2009). The items for intrinsic motivation read: *I take pride in doing my job as well as I can*, *I feel personally satisfied when I do my job well*, and *I feel unhappy when my work is not up to my usual standard* (α = 0.752).

Further, we controlled for organizational tenure (in years), hierarchy (employee, lower management, middle management, top management) and demographic variables, specifically gender, age, and education level (less than high school, high school graduate or equivalent, technical or vocational school, college degree, university degree). In line with existing research into individual ambidexterity, we controlled for functional affiliation to marketing and R&D, with other functions as the baseline (MacCormack et al., Mom et al., 2009, Mom et al., 2007).

3.3 Common method variance

Self-ratings, which we used, are the most common source of data in social science (Malhotra et al., 2006), but may suffer from common method bias (CMB), which could inflate relationships and could reduce validity (Podsakoff and Organ, 1986).

We followed many of Podsakoff et al.'s (2003) suggestions for survey design, for instance by having the person responsible for disseminating the questionnaires check our questions' wordings regarding unequivocality and by assuring anonymity to all participants.

We also performed statistical tests on the constructs potentially affected by CMB, i.e. cognitive style, intrinsic motivation, job satisfaction, openness to experience, need knowledge, solution knowledge, need absorptive capacity, solution absorptive capacity, explorative behavior, and exploitative behavior. First, we used Harman's single-factor test, (Malhotra et al., 2006, Podsakoff et al., 2003) to check if more than 50% of the variance was explained by a single unrotated factor, which would be an indication of CMB; this was not the case. Second, we applied Lindell and Whitney's (2001) marker variable method. We included a marker variable (an adapted measure of a firm's perceived distinctness) (George and Chattopadhyay, 2005) and took the smallest correlation of the marker variable with any of our constructs (correlation with need absorptive capacity, $r = 0.004$), adjusting the correlation matrix by partialing out the correlation of the marker variable (cf. Lindell and Whitney, 2001). In the corrected correlation matrix, all significant correlations remained significant, which would not be the case in the presence of CMB. Based on these tests, we conclude that CMB was immaterial in our study.

4 Findings

We tested our hypotheses using stepwise regression analyses. We used the same strategy of analysis for all dependent variables. First, we entered control variables. We then entered the main predictors (i.e. need knowledge, solution knowledge, need absorptive capacity, and solution absorptive capacity), followed by the interaction terms and the quadratic terms for each predictor. For simplicity, we did not model the interaction of the quadratic term that would specify steepening or flattening of the curve (Haans et al., 2015)

4.1 Exploitative behavior

Table 2 shows our regression analysis' results. Figure 3 illustrates the interaction, Figure 4 illustrates our results via a response surface, incorporating all significant ($p < 0.10$) relationships for the main variables and higher-order interactions from the full model.

We found a significant and positive relationship between need knowledge and exploitation behavior ($\beta = 0.099$; $p = 0.030$). However, the quadratic term is only significant at the 10% significance level ($\beta = 0.089$; $p = 0.082$), i.e. we found only weak support that higher need knowledge will be disproportionally higher than exploitative behavior. This yields partial support for H1a. Supporting H1b, we found that solution knowledge relates positively to exploitative behavior ($\beta = 0.210$; $p = 0.00$); increasing levels of solution knowledge led to disproportionally high increases in exploitative behavior ($\beta = 0.095$; $p = 0.045$).

We also found support for H2, which states that need knowledge and solution knowledge are substitutes, such that increasing one will dampen the positive relationship between the other and exploitative behavior. This is supported by the negative interaction between knowledge types ($\beta = -0.197$; $p = 0.003$). Figure 3 illustrates the mechanism of this interaction. High and low knowledge levels are depicted at one standard deviation above and below the mean, respectively. The other variables were held constant at their means. The illustration shows that need knowledge has a stronger effect on exploitative behavior for individuals with a low solution knowledge level than for one with a high level of need knowledge, and vice versa. Combining the findings for need knowledge and solution knowledge, individuals benefit more concerning exploitative behavior from specializing in one knowledge type than from focusing on different knowledge types. Need knowledge and solution knowledge are substitutes rather than complements concerning exploitative behavior. Notably, in addition to employees' knowledge, both the need absorptive capacity and the solution absorptive capacity have a positive – and in the case of need absorptive capacity, also a significant – relationship to exploitative behavior.

Table 2: Regression analysis for precursors of exploitative behaviors

	B	SE	Beta	p-value	B	SE	Beta	p-value
Constant	4.629	.038		.000	4.596	.057		.000
Marketing	-.030	.040	-.022	.450	-.039	.040	-.028	.339
R&D	.017	.043	.012	.692	.016	.043	.011	.715
Cognitive style	.120	.044	.087	.007	.122	.044	.089	.006
Intrinsic motivation	.172	.047	.125	.000	.170	.047	.123	.000
Job satisfaction	.015	.043	.011	.728	.011	.043	.008	.800
Openness	.007	.043	.005	.879	-.003	.043	-.002	.948
Tenure	-.072	.060	-.052	.228	-.077	.060	-.056	.198
Hierarchy	.045	.044	.033	.305	.039	.044	.028	.379
Education	-.026	.046	-.019	.573	-.026	.046	-.019	.571
Age	-.066	.056	-.048	.240	-.060	.056	-.044	.287
Sex	.031	.043	.022	.478	.026	.043	.019	.553
Need knowledge	.136	.063	.099	.030	.110	.067	.080	.103
Solution knowledge	.289	.072	.210	.000	.308	.074	.223	.000
Need absorptive capacity	.296	.082	.215	.000	.324	.083	.236	.000
Solution absorptive capacity	.152	.086	.111	.077	.143	.087	.104	.100
Need knowledge x Solution knowledge					-.239	.079	-.197	.003
Need knowledge squared					.092	.053	.089	.082
Solution knowledge squared					.118	.059	.095	.045
F test	.000				.000			
R squared	.357				.362			

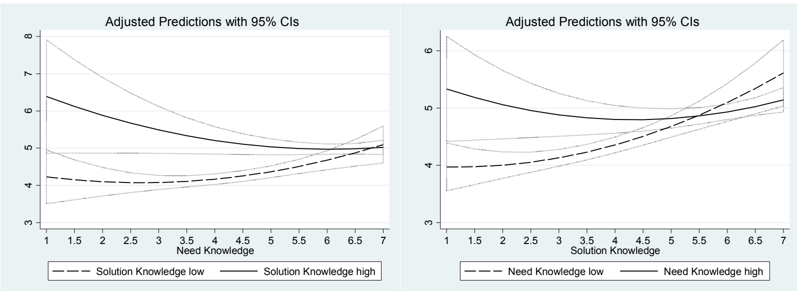

Figure 3: The Marginal effects of knowledge and exploitative behaviors

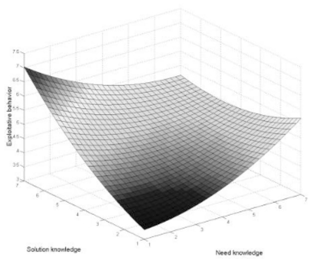

Figure 4: The Response surface for exploitative behavior

4.2 Explorative behavior

We found full support for all our hypothesized relationships for explorative behavior (see Table 3). Both need absorptive capacity (H3a) and solution absorptive capacity (H3b) relate positively and non-linearly to individuals' explorative behaviors ($\beta_{NACAP} = 0.313$; $p_{NACAP} = 0.000$; $\beta_{NACAP^2} = 0.118$; $p_{NACAP^2} = 0.004$; $\beta_{SACAP} = 0.445$; $p_{SACAP} = 0.000$; $\beta_{SACAP^2} = 0.079$; $p_{SACAP^2} = 0.039$). Further, the interaction between both absorptive capacities relates negatively to explorative behavior ($\beta = -0.181$; $p = 0.001$), supporting H4.

Using the same specifications as for knowledge above, Figure 5 illustrates absorptive capacity's marginal effects on explorative behavior. The illustration shows that NACAP has a stronger effect on explorative behavior for individuals with low SACAP than for individuals with high SACAP, and vice versa. Combining the findings, we see that individuals benefit more concerning explorative behavior from specializing in one knowledge absorption type than from focusing on both types. NACAP and SACAP are substitutes in their effect on explorative behavior. In the full model, neither need knowledge nor solution knowledge relate significantly to explorative behavior. The interactions are shown in Table 3, the response surface for explorative behavior is depicted in Figure 6.

Table 3: Regression analysis for the precursors of explorative behavior

	B	SE	Beta	p-value	B	SE	Beta	p-value
Constant	3.904	.035		.000	3.814	.061		.000
Marketing	.115	.037	.066	.002	.090	.038	.052	.017
R&D	.013	.040	.007	.745	.013	.040	.007	.751
Cognitive style	.016	.041	.009	.688	.010	.041	.006	.808
Intrinsic motivation	.027	.043	.016	.531	.020	.043	.011	.646
Job satisfaction	.013	.040	.007	.749	.014	.040	.008	.717
Openness	.005	.039	.003	.895	.002	.039	.001	.965
Tenure	-.016	.055	-.009	.773	-.016	.055	-.009	.776
Hierarchy	.021	.041	.012	.605	.018	.041	.010	.656
Education	.048	.043	.027	.263	.043	.042	.025	.310
Age	-.074	.052	-.043	.154	-.085	.052	-.049	.099
Sex	-.033	.040	-.019	.401	-.029	.040	-.017	.466
Need knowledge	.116	.058	.067	.044	.113	.058	.065	.051
Solution knowledge	.051	.066	.029	.438	.058	.067	.033	.386
Need absorptive capacity	.543	.075	.313	.000	.489	.077	.282	.000
Solution absorptive capacity	.771	.079	.445	.000	.822	.081	.474	.000
Need absorptive capacity x Solution absorptive capacity					-.350	.106	-.181	.001
Need absorptive capacity squared					.219	.076	.118	.004
Solution absorptive capacity squared					.168	.081	.079	.039
F test	.000				.009			
R squared	.657				.660			

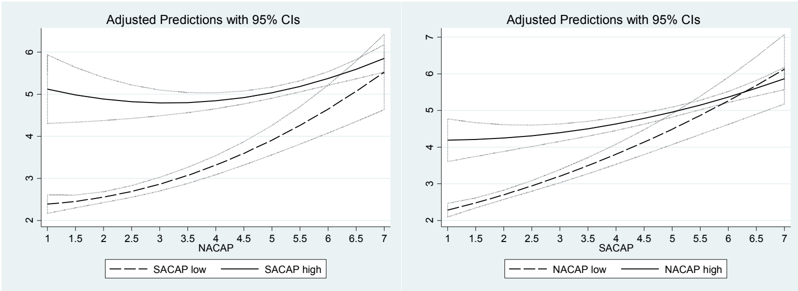

Figure 5: The marginal effects of absorptive capacity and explorative behavior

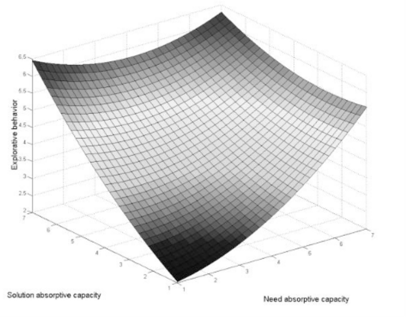

Figure 6: The response surface for explorative behavior

5 Discussion

5.1 Theoretical implications

We have investigated the effects of employees' knowledge domains and origins on explorative and exploitative behavior in organizations, and found that exploitation relates positively to solution knowledge (non-linear effect) and need knowledge (linear effect), but that there is a negative interaction between both knowledge domains and exploitation. Exploration relates positively and non-linearly to absorptive capacity for need knowledge and solution knowledge, but relates negatively to their interaction.

Our findings have contributed to the literature on individual ambidexterity and absorptive capacity, in at least three important ways. First, they have extended the understanding of the cognitive precursors of ambidexterity at the individual level (Good and Michel, 2013, Mom et al., 2007). We have introduced individuals' knowledge and absorptive capacities as precursors of exploration and exploitation and have shown that both relate to need knowledge and solution knowledge. This provides a better understanding of the distinct roles of knowledge and knowledge absorption in individual exploration and exploitation. The non-linear relationships showed that increasing knowledge in one domain can lead to excessive exploitation and that increasing absorptive capacity for one domain can lead to excessive exploration. This is a contribution to the literature on the potential downsides of knowledge in the form of knowledge traps (Levinthal and March, 1993, Liu, 2006).

Interestingly, need knowledge also relates to exploration, and the absorption of need knowledge also relates to exploitation. This is not the case for solution knowledge, which only relates positively to exploration if absorbed and to exploitation if it originates inside the organization. This difference could be grounded in the fact that solution knowledge is more structured than need knowledge (Autio et al., 2013, Clark, 1985), leaves less room for interpretation, and is therefore more closely coupled to exploitation (for existing solution knowledge) or exploration (for absorptive capacity of solutions).

Second, we have investigated the interactions between need knowledge and solution knowledge in relation to exploitative behavior and the interactions between absorptive capacity of needs and solutions in relation to explorative behavior; we found these interactions to be negative. Focusing on more than one knowledge domain, either internally or by absorbing external knowledge, has a marginally negative effect. Increases in exploitation will be higher if individuals invested additional knowledge into either need knowledge or solution knowledge, rather than splitting knowledge investments between the two. Analogically, increases in exploration will be higher if individuals specialize in either absorbing need knowledge or solution knowledge, rather than splitting their cognitive resources for absorption between the two.

Third, we have contributed to the small yet growing literature on individual absorptive capacity (e.g. Colombo et al., 2013, Jiménez-Castillo and Sánchez-Pérez, 2013, Lowik et al., 2012, Schweisfurth and Raasch, 2018). Individual absorptive capacity has been shown to relate to pro-organizational outcomes, such as task performance (Deng et al., 2008, Park et al., 2007), knowledge creation (Matusik and Heeley, 2005), and innovativeness (Lowik et al., 2012, Tortoriello, 2014). We have introduced individual absorptive capacity for need knowledge and solution knowledge as precursors of explorative behavior, extending the understanding of the micro-level outcomes of this capacity.

Our study has limitations. First, we only included cross-sectional data, which does not allow for causal claims. Thus, we could not assess whether explorative and exploitative behavior are caused by the knowledge precursors, or vice versa. Second, our data relied only on self-assessments. Although this data collection type is most common in social research (Malhotra et al., 2006), and although we utilized various measures to mitigate common method bias, it may still be present to some extent. Third, we did not force our respondents to make tradeoff decisions between an internal and an external knowledge focus and different knowledge types. Scholars have argued that individuals are limited in their attention and must balance internal and external search (Dahlander et al., 2016). Thus, we recommend that researchers explore the extent to which employees focus their attention on the absorption of new or the use of existing knowledge or different knowledge sets.

5.2 Managerial implications

Our findings have broad implications for managers. We have shown that there is a cumulative effect of knowledge types on exploration and exploitation. Employees with large amounts of one knowledge type are likely to increasingly learn from this knowledge, but also run the risk of excessive exploitation behavior based on this knowledge. Similarly, employees who focus on absorbing one type of external knowledge base increase explorative activities on this knowledge, but can get locked into a learning trap, where they only engage in single-domain exploration. In both cases, drawing on more than one knowledge domain has a dampening effect on excessive exploration and exploitation. These findings can help one to design jobs that must manage ambidexterity within an organization, using the knowledge dimensions presented in Figure 1 as parameters. To create more exploration in an organization, for instance, managers should encourage employees to engage in external knowledge absorption from one knowledge domain; to increase exploitation, managers should encourage employees to focus on their existing knowledge.

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Part III

Developments in Global and Sustainable Innovation Management

Chapter 13

Technology and innovation management in a global perspective

Alexander Gerybadze

Abstract

This chapter analyzes major trends and structural changes related to technology and innovation management (TIM) for the period 1995 to 2018. For quite a while, TIM was characterized by an emphasis on R&D, and biases in favor of technology-push, home-country and lead-countries. Most research was concentrated in a few academic institutions in Anglo-saxon countries that acted as centers of excelence. Technological parochialism dominated our thinking about global innovation. Until about 2005, innovation remained centered in large multinational corporations from a small group of advanced nations. And these large corporations concentrated most of their R&D investments in a small group of target countries. This pattern has somewhat changed during the last fifteen years, and particularly during the last decade. The footprint of innovation activities has become much more global and diversified. An increasing number of countries have followed ambitious innovation strategies. And our concepts of managing innovation had to be refined: towards more open, more user-oriented and more boundary-spanning concepts. We have seen a persistent increase in the globalization of the R&D function and a greater diversity of target countries for new R&D locations.

Even though it is hard to predict future courses in periods of growing political instability, the globalization of R&D will most probably go on during the period 2019 to 2030. Long-term megatrends like climate change, urbanization and new mobility must be addressed from a global perspective, and the appropriate technological and social solutions need to be developed and implemented in many countries simultaneously. The global footprint of innovation activities will be extended and we will see a proliferation of new uprising nations that play an increasingly important role. Sometime during the next decade, China will surpass the United States in terms of GDP as well as R&D spending. Other emerging nations like India, Brazil, Indonesia, Taiwan and Malaysia will follow high-tech development strategies. It will be interesting to monitor country-specific processes of linking science and technology, human capital formation and R&D growth. A key issue will be whether catch-up nations are able to grow beyond the so-called middle-income trap and whether these countries can implement a sustainable growth path.

Keywords: Global Innovation; Technology and Innovation Management; Lead-country Bias; Internationalization of R&D

1 Introduction

Technology and Innovation Management (TIM) has become an important subject taught at business schools as well as engineering schools around the world. Prominent universities have established global master programmes with a focus on technology management. Global corporations need to build global teams of specialists with diverse backgrounds, and have to

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R. Tiwari and S. Buse (eds.), *Managing Innovation in a Global and Digital World*, https://doi.org/10.1007/978-3-658-27241-8_14

manage effective global networks of R&D centers in order to exploit diverse sources of knowledge. In the following paper, we describe how the TIM practice has become globalized during the last 20 years. This process did not just involve an increasing number of R&D centers worldwide, but a much wider scope of search activities involving multiple disciplines, multiple functions as well as diverse institutional settings. It was Cornelius Herstatt's contribution to develop TIM further towards a truly global discipline, and to promote the user perspective and the role of demand in fostering innovation activities.

For quite a while, our discipline was characterized by an emphasis on R&D, a bias on technology-push, and a home-country bias resp. a lead-country bias. Most research was concentrated on a few academic institutions in Anglo-saxon countries. Technological parochialism dominated our thinking about global innovation. Until about 2005, innovation remained centered in large multinational corporations from a small group of advanced nations. And these large corporations concentrated most of their R&D investments in a small group of target countries.

This pattern has somewhat changed during the last fifteen years, and particularly during the last decade. The footprint of innovation activities has become much more global and diversified. An increasing number of countries have followed ambitious innovation strategies. And our concepts of managing innovation had to be refined: towards more open, more user-oriented and more boundary-spanning concepts. Three major changes in our thinking about the TIM practice will be highlighted in our paper: (1) the new role of demand and research on lead-users in driving innovation processes. (2) the greater global dispersion of innovation activities across many countries and, in particular, stronger innovation activities in emerging countries. Inasmuch as innovation is no longer limited to a small "club" of affluent countries and user groups, (3) less expensive types of innovation and concepts of frugal innovation become more and more important. Cornelius Herstatt and his team at the Hamburg Institute of Technology have addressed these three important changes in technology and innovation management. He and his team have published widely on lead users and the role of demand in innovation.[1] Herstatt has also studied innovation management practices in advanced as well as in emerging countries.[2] And during the last years, frugal design and engineering has become a major research focus within his team (Herstatt and Tiwari 2017).

The paper is structured as follows: in section 2 we provide an overview on recent trends in the literature on global R&D management. Section 3 analyzes the major investors and the largest source countries for trans-border R&D investment within multinational corporations. The level of concentration of investor countries is still quite high, while more and more of these investments flow to a growing number of target countries. In section 4, we describe this process of global dispersion and the new division of labour between countries operating at the technological frontier on one side, and an increasing number of emerging countries on the other side. Section 5 then highlights the new role of emerging nations in attracting offshore R&D centers within multinational corporations. In section 6, we analyze a new diagnostic

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1 Cornelius Herstatt has worked within the "customer-active paradigm" developed originally by Eric von Hippel at MIT (von Hippel 1988). Herstatt developed von Hippel's research methods further and has extensively published on user-driven product development and innovation marketing (Herstatt, von Hippel 1992, Herstatt, Verworn and Nagahira 2004, Lüthje and Herstatt 2004).

2 Two focus areas of his comparative international studies cover the Japanese innovation system, and more recently studies on frugal innovation in India. In addition, Cornelius Herstatt has completed empirical innovation research in many other countries.

toolkit for measuring distributed technological competences based on patent data. We conclude our paper with a summary of managerial challenges and with recommendations for further research.

2 The process of R&D globalization within multinational firms

In studying the process of R&D globalization and the sequence of developing the TIM practice into a truly global discipline, we may distinguish three major phases. During the early phase, i.e. between 1980 and 1995, multinational corporations followed a sequential process of international business expansion, while foreign R&D and innovation played still a minor role. Corporations from the U.S. and Europe typically started with export activities, which were followed by setting up offshore production units in foreign markets. During this early phase, however, the locus of innovation remained in their home base. New product development and R&D was most often concentrated near headquarter locations. At a rather low level, some adaptive work may have been dislocated to foreign production plants, if local customer preferences or regulation required some change.

This pattern of internationalization changed during the period 1995 to 2005, when R&D and innovation became of much greater concern for multinational firms. In this phase, we have observed a strong wave of globalization, the integration of former communist countries in the world economy, and the formation of complex and interconnected global supply chains. Large multinational corporations used to be the prime agents in this process, and they have continously extended their presence in foreign markets. And being active in foreign markets often implied to be present with foreign production as well as with foreign R&D. During this time, we have encountered a strong wave of foreign R&D investment within multinationals from Europe, the U.S. and Japan. In parallel, a growing number of scholars published books and articles on the globalization of R&D. Particularly during this phase 1995 to 2005, researchers in a growing number of countries including the U.S., Britain, Japan, Sweden, Germany and Switzerland became interested in this subject.[3]

The next wave of globalization and the new pattern of global R&D can be observed during the most recent period following 2005, and particularly after the financial crisis in 2008/09. While multinational corporations followed a sequential and evolutionary process of international expansion until then, the technological dynamism observed in several industries required to implement TIM in an integrated and global perspective. Very high fixed costs for product development in many industries together with the shortening of product life-cycles forced multinational firms to develop and launch products on a global scale. A typical example is the pharmaceutical industry, where high fixed costs amounting to more than a billion dollars for a major new drug led big pharma companies to organize multi-country clinical trials and to launch registered new drugs in several world markets simultaneously. Similar imperatives for global innovation are typical for many other industries, including automobiles, information technology and electronics.

This new technological dynamism coincided with a greater variety of innovation systems worldwide. More and more nations in the world wanted to participate in high-tech industries.

[3] Cornelius Herstatt became affiliated with research groups in St. Gallen and at the ETH Zurich, that were studying the R&D globalization process during his early academic and consulting work in Zurich.

Many governments in Asia, Latin America and Eastern Europe invested in their national innovation system as well as in science and engineering education. As their level of competence increased, multinational companies found it attractive to set up R&D centers in emerging countries, and to benefit from a globally-dispersed talent base.[4] Finally, the rapid development of advanced information and communication technology facilitated a greater degree of global dispersion of work and the decomposition of global value chains. The rapid diffusion of the internet, cellular mobile telephony, fiberoptics and satellite communication made it possible to distribute workgroups and R&D teams around the globe, and to effectively coordinate their work across distances. The generation and dissemination of knowledge and the communication between globally dispersed workgroups has since been facilitated.

As a result, we observe a continuous trend towards greater differentiation and globalization of the R&D function. In addition, advanced marketing and service concepts, joint problem-solving with customers, and simultaneous product and process engineering became as important as the R&D function. Multinational firms have thus established global networks and had to develop complex organizations with distributed sensory capabilities. We observe different patterns, however, if we analyze different industries, as well as source countries, and target countries for international R&D investment. In section 3, we will describe patterns of foreign R&D investment observed in major source countries. This is followed by an analysis of changes in the structure of target countries of foreign R&D investment in section 4.

3 Major source countries for foreign R&D investment

Major **drivers of outward foreign R&D** investment are (1) export and foreign production activities that need to be complemented by design and development; (2) expected stimuli and challenges from a dynamic innovations system in a lead country (3) access to technological assets and research competences available abroad; (4) search for skills and manpower due to limited resources at home and (5) a sequence of mergers and acquisitions that result in the need to integrate several pre-existing R&D units.

For a long time, foreign R&D investment was dominated by multinational corporations from the United States and from large Western European countries primarily active in selected R&D intensive industries. Between 1995 and 2005, Japanese corporations started to invest in foreign R&D centers in the U.S. and in Western Europe, while American as well as European corporations also stepped up their R&D investment abroad. Still today, the lion´s share of corporate R&D investment comes from multinational firms from the U.S., followed by corporations from Germany, Japan, Switzerland, France and Sweden. We will concentrate on the role R&D investors from the U.S., Germany and Japan, and will emphasize structural changes in foreign R&D investment within these three countries.

U.S. multinational corporations continue to dominate foreign R&D investment with approximately 36% of trans-border R&D investment worldwide. U.S. corporations have increased annual foreign R&D investment from 13.2 billion $ in 1995 to 54.8 billion $ in 2015. Their foreign R&D ratio, i.e their share of foreign R&D to the total worldwide R&D expenditures of U.S. corporations has increased from 12 % to 16 % during the same period (see table

[4] The UNCTAD published a major issue of the World Investment Report on the "Internationalization of R&D" and highlighted this trend to invest in R&D centers in emerging countries for the first time (UNCTAD 2005).

1). Major industries in which U.S. firms have strongly increased their foreign R&D investment are (1) pharmaceuticals, (2) aerospace, (3) software development (4) computer hardware and peripherals, followed by (5) motor vehicles and (6) IT services. Until about 2002, U.S. corporations used to invest about two third of their foreign R&D in Europe. Since then an increasing share of R&D is also being invested in Asian countries (26% in 2015). More recently, U.S. firms have strongly increased their R&D investment in China and India. Both countries have attracted more than 3 billion $ of R&D investment of U.S. MNC in 2015. Within Europe, U.S. firms have concentrated their R&D investment in Germany, the U.K., and more recently in Switzerland and Ireland.[5]

Table 1: Outward R&D investment of U.S. multinational corporations 1995 to 2015; Source: IMI Hohenheim University, based on data from BEA (2017), Mataloni (2007) and Mataloni (1997)

	R&D Expenditures in Billion €			CAGR in %
	1995	2005	2015	1995-2015
Foreign R&D Expenditures of U.S. Multinational Corporations	13.2	28.3	54.8	7.4
R&D Expenditures of U.S. Parents of MNC in the U.S	96.5	178.5	284.3	5.6
Total (Worldwide) R&D Expenditures of U.S. Multinational Corporations	109.7	206.9	339.1	5.8
Share of Foreign R&D to Total (Worldwide) R&D Expenditures of U.S. Corporations (in %)	12.0	13.6	16.2	

German multinational corporations represent the second largest group of investors setting up R&D centers abroad. They account for approximately 18% of trans-border R&D investment worldwide. German corporations have increased their annual foreign R&D investment from 5.1 billion € in 1995 to 24.1 billion € in 2015. The share of foreign R&D to the total worldwide R&D expenditures of German firms. has been increased from 23 % to 35 % during the same period (see table 2). Major industries with strong foreign R&D ratio are (1) pharmaceuticals, (2) motor vehicles, (3) electrical engineering and (4) machinery. German corporations. still concentrate about a third of their foreign R&D investment in the U.S, and another third in neighbouring European countries. During the last 10 years, German firms have increasingly also invested in R&D centers in China, India, Brazil, as well as in Eastern Europe.[6]

[5] This is mainly influenced by specific acquisitions of pharma and biotech companies in the case of Switzerland. The new role of Ireland as R&D center may be explained by tax-based relocation decisions of U.S. corporations.

[6] See the report on outward foreign R&D expenditures by German companies in EFI (2014, chapter A5) and in Gerybadze, Schnitzer and Czernich 2013).

Table 2: Outward R&D investment of German multinational corporations 1995 to 2015; Source: IMI Hohenheim University, based on data of the Stifterverband Science Statistics, Data Reports 1997, 2007, and 2017.

	R&D Expenditures in Billion € 1995	2005	2015	CAGR in % 1995-2015
Foreign R&D Expenditures of German Multinational Corporations	5.1	11.1	24.1	5.2
R&D Expenditures of Parents of German MNC in Germany	17.0	26.8	44.6	5.0
Total (Worldwide) R&D Expenditures of German Corporations	22.1	38.2	68.7	5.1
Share of Foreign R&D to Total (Worldwide) R&D Expenditures of German Corporations (in %)	23.1	29.9	35.0	

Multinational corporations from Japan started to invest in foreign R&D in the mid-1990s, and have continuously stepped up their technological competences abroad. They invest primarily in the United States, in large Western European countries, and more recently in China, Singapore and India. Their foreign R&D investment is closely linked to their global production network in export-oriented industries like electronics, pharmaceuticals, automobiles and machinery. Major R&D investors from other source countries include Switzerland, France, the U.K., Sweden, and South Korea. To summarize, outward foreign R&D investment is still strongly concentrated among large industrialized nations with a strong endowment of multinational corporations.

4 Major target countries for foreign R&D investment

While the structure of source countries for trans-border R&D investment has remained comparatively stable over time, we observe considerable changes with respect to the location decisions for new foreign R&D centers. An increasing number of emerging countries have developed their national innovation systems, and are trying to attract R&D-intensive multinational firms to their shore. As a result, the global R&D footprint has become much more diverse and colourful, particularly during the last 10 to 15 years.

What are the **drivers of inward R&D** investment? What are the major location factors for attracting foreign multinationals? And how did these locational factors change over the last 15 years? Here we need to distinguish between target countries that operate close to the technological frontier, and those countries that attempt to catch up. The group of “advanced countries” which continue to operate at a very high level of competence is still rather small, and even the very large industrial countries have become specialized on few industries and technological fields. Multinational firms go to these “high-end locations” in order to participate in the innovation game. Foreign R&D is basically home-base augmenting and feeds into the corporate knowledge base.[7] On the other side, we have an increasing number of catch-up countries, which attempt to strengthen their technological portfolio. They are most often the recipients of international technology transfer, and they offer business opportunities, a rich

[7] For the distinction between home-base augmenting and home-base-exploiting R&D see Kuemmerle (1997, 1999), Criscuolo (2009) and Criscuolo, Narula and Verspagen (2005).

talent base and other incentives for investing in R&D centers. Multinational firms operate R&D units in these countries, but these are not as sophisticated and often of a home-base-exploiting nature.

Major **drivers of inward R&D for advanced target countries** which are close to the technological frontier include (1) the attractive size and growth potential of the market in this particular country and (2) the characteristics of a lead market with strong inducements for advanced product development; (3) furthermore, this country influences standards and business models which have a high chance of later a becoming worldwide standard; (4) Several advanced corporations in this country serve as challengers as well as a source of spill-overs; (5) innovation is supported through a world-leading science and research infrastructure and, last-not-least, (6) companies get access to highly-skilled scientists and engineers.

In Table 3, we have summarized the ranking of the major target countries for foreign R&D investment, based on published OECD data (OECD MSTI 2018/2). Reliable statistics on inward R&D investment are available only for OECD countries, and we need to assess the role of countries like China, India or Brazil based on complementary data sources (see section 5 and 6). While the "classical" target countries like the U.S., Germany, the U.K. and Japan continue to play a strong role, we observe considerable strong growth in Israel, Ireland as well as in Eastern European countries. In some of these countries, foreign subsidiaries of represent the dominant source of business R&D spending, and this is the case for the U.K., Israel, Belgium, Ireland, Austria as well as for Eastern European countries. In some cases, foreign multinationals represent between 60 and 70 % of business R&D spending, and this may indicate an unfavourable dependence on investment decisions of foreign investors. As an example, foreign R&D centers represent more than half of business R&D in the U.K., and it may be expected that foreign multinationals will reduce their R&D spending as a result of BREXIT.

Table 3: The largest target countries for R&D investment of multinational corporations 2005 and 2015; Source: IMI Hohenheim University, based on OECD MSTI 2018/2 and MSTI 2009/2

Country	R&D Expenditures of Foreign Affiliates 2005 (Million $)	Share of Foreign Affiliates in BERD (%)	Country	R&D Expenditures of Foreign Affiliates 2015 (Million $)	Share of Foreign Affiliates in BERD (%)
1. USA	31 099	13.8	1. USA	56 743	15.9
2. Germany	12 160	27.8	2. Germany	16 806	21.5
3. United Kingdom	7 595	39.1	3. United Kingdom	15 411	51.1
4. France	5 767	23.5	4. Japan	8 987	6.7
5. Japan	5 038	5.1	5. France	8 025	20.6
6. Canada	4 235	32.6	6. Israel	7 732	70.8
7. Sweden	3 530	41.5	7. Canada	5 194*	35.1*
8. Austria	2 408*	44.6	8. Austria	4 635	49.4
9. Belgium	2 406	56.8	9. Sweden	4 496	42.1
10.Italy	2 315	25.2	10.Belgium	4 453****	66.0****
11.Australia	2 000E		11.Italy	4 355	25.1
12.Israel	2 000E		12.Australia	3 547**	27.2**
13.Spain	1 869	26.2	13.Spain	1 964	38.4
14.Czech Republic	962	51.5	14.Netherlands	1 797	32.4
15.Ireland	924	70.3	15.Ireland	1 752	63.7
16.Finland	638	16.1	16.Switzerland	1 633	12.9
17.Norway	395	28.5	17.Czech Republic	1 231	61.4
18.Hungary	299	59.7	18.Poland	978	44.7
19.Poland	288	30.4	19.Finland	750**	20.4**
20.Portugal	237	34.0	20.Norway	679***	31.6***
Total (20 Countries)	86 165		Total (20 Countries)	151 080	

For many other important target countries, foreign R&D investment as well as R&D investments of local corporations represent complementary strategies. The U.S. still attracts the lion´s share of R&D investment of foreign multinationals with 56.7 billion $ in 2015. The share of foreign firms in BERD has gone up from 13.6 % in 1995 to 16.7 % in 2015, and this process is heavily debated in U.S. science politics. Japan has always followed a cautious strategy of attracting foreign R&D primarily in areas which complement national R&D capabilities. The share of foreign R&D in BERD in Japan is still at a rather low level (6.7 % in 2015), but has been increased steadily (from less than 1 % in 1995 and 5.1 % in 2005). Germany is still a major target for R&D investment of foreign multinationals, even though the strong growth of inward R&D investment between 1995 and 2005 has not been continued during the last decade.

In Table 4 we analyze structural changes of inward R&D expenditures of foreign multinationals in the United States. From an annual level of 15.6 billion $ in 1995, foreign firms have increased their R&D investment more than threefold to a level of 56.7 billion $ in 2015 (BEA 2017b).[8] About 35 % of inward R&D investment comes from foreign pharmaceutical firms who still consider the U.S. as the leading research base for health research and biotechnology, as well as the leading market for health products and services. 13 % of inward R&D is contributed by foreign firms in electronics and information technology, where the U.S. is still a dynamic market as well as a leading technology base. Other industries that attract significant shares of inward R&D investment are motor vehicles (9 %), scientific and technical consulting (7 %), machinery (4 %) and chemicals (3 %).

Table 4: The role of inward foreign R&D investment in the United States / structural changes between 1995 and 2015; Source: IMI Hohenheim University, based on data from BEA (2017b), and BEA (1997), and Anderson (2007)

	R&D Expenditures in Billion €			CAGR 1995-2015
	1995	2005	2015	
R&D Expenditures of Foreign Corporations in the U.S.	4.3	10.6	13.1	5.7
Domestic R&D Expenditures of U.S. Corporations	22.4	27.6	47.5	3.8
Total Business R&D Expenditures in the United States	26.7	38.2	60.6	4.2
Share of Foreign Corporations in Business R&D Expenditures in the United States (in %)	16.1	27.8	21.6	

U.S. affiliates of foreign multinationals from seven countries still account for 80 % of inward R&D investment flows in the U.S. Foreign corporations from Switzerland and the U.K. together account for 31 %, the large majority of this includes pharmaceutical companies that have set up research centers in North America or that have acquired U.S. based pharma and biotech firms with advanced research capabilities. Japan and Germany still account for a considerable share of R&D investments in the U.S., and their R&D portfolio is somewhat more diversified, reflecting the trade and foreign investment structure of these two countries. Other significant R&D investors come from the Netherlands and Ireland, even though this may be

8 This represents an annual growth rate of 6 %. Inward R&D investments of foreign firms were growing at a much higher rate than R&D investments by U.S. corporations within the U.S.

somewhat misleading, since this includes holding companies which simply have chosen their headquarters here primarily for legal and tax purposes.[9] Other relevant R&D investors in the U.S. are corporations from South Korea, Israel, Canada and Sweden. Investors from emerging countries like China, India, Singapore are not yet very active with setting up R&D activities in the U.S., but they are nonetheless keeping a window on U.S. technology following other strategies.[10]

Table 5: The Role of inward foreign R&D investment in the Germany / structural changes between 1995 and 2015; source IMI Hohenheim University, based on data from SV-Wissenschaftsstatistik, data Reports 2003, 2007, and 2017

	R&D Expenditures in Billion € 1995	2005	2015	CAGR 1995-2015
R&D Expenditures of Foreign Corporations in Germany	4.3	10.6	13.1	5.7
Domestic R&D Expenditures of German Corporations	22.4	27.9	47.5	3.8
Total Business R&D Expenditures in Germany	26.7	35.5	60.7	4.2
Share of Foreign Corporations in Business R&D Expenditures in Germany (in %)	16.1	27.6	21.6	

Table 5 analyzes changes in the structure of inward R&D investment in Germany between 1995 and 2015. Foreign multinationals have increased their R&D spending in Germany at an average annual rate of 5.7 % between 1995 and 2015. Meanwhile, domestic firms have increased their R&D spending in Germany only at 3.8 % p.a. The share of foreign firms in business expenditures in Germany thus rose from 16.1% to 27.6% during this first ten-year interval. During the financial crisis in 2008-09, German firms kept their R&D spending rather stable, while foreign multinationals reduced their R&D spending in reaction to a sudden business downturn. When business picked up again, German corporations increased their spending on R&D, while foreign investors still remained rather hesitant. While German firms were increasing their R&D investment between 2011 and 2015 at an annual rate of 6.5%, foreign firms merely increased their R&D spending for German labs at a nominal rate of 0.6 %. In real terms this led to a reduction in R&D personnel within subsidiaries of foreign corporations. As can be seen in table 5, the share of foreign R&D expenditures was reduced from 27.6 % to 21.6 % between 2005 and 2015.

Major source countries for R&D investment of multinational firms in Germany are (1) the United States, (2) Switzerland, (3) France, (4) the Netherlands, (5) Japan as well as the Scandinavian countries. In several high-tech industries like IT, pharma and aerospace, Germany tends to be strongly dependent on R&D investment of foreign firms. By contrast, R&D ex-

9 In the case of Ireland, several U.S biomedical companies such as Allergan and medtronics have transferred their legal headquarters to this country primarily for tax purposes. These new legal Irish companies cannot reasonably be considered Irish corporations. As a result, the published figures for trans-border R&D investment are overestimated in the case of Ireland.

10 This includes strategies to attract returnees from U.S. universities and corporate R&D labs, as well as licensing and other modes of technology acquisition.

penditures of German corporations are still heavily concentrated on medium-tech manufacturing industries like automobiles, machinery, chemicals and metal-processing. This tends to replicate a "competence-trap": while foreign firms consider Germany as an attractive R&D location in traditional fields like motor vehicles, machinery and chemicals, the country does not seem to attract enough foreign R&D in digital technologies, biotechnology and other dynamic fields.[11]

Japan is still the fourth largest target country for trans-border R&D investments of global corporations. Even though the country has always been quite hesitant in opening up national markets and research systems to foreign firms, R&D labs of foreign high-tech firms were regarded as an important source for inward technology-transfer. Since the early 1990s, multinational corporations from the U.S. and from Europe opened up new R&D centers in Japan, in order to learn from advanced business practices. The Japanese market was considered to be an interesting lead market, especially for consumer electronics, display technologies and for semiconductors. Cornelius Herstatt became interested in Japanese management of technology through his Ph.D. advisor Prof. Hugo Tschirky at the ETH Zürich, and has since then studied Innovation and new business practices in Japan. He became especially interested in studying the role of the Japanese lead market in triggering off new products and business concepts for foreign multinational firms.[12] Foreign firms became particularly interested in learning from advanced management techniques such as simultaneous engineering, managing the fuzzy front-end, as well as the linkage between quality management and product innovation. The proficiency of Japanese innovation management practices was well documented in several publications of Herstatt and his team.[13]

Table 6: The role of inward foreign R&D investment in Japan / structural changes between 1995 and 2015; Source: own calculation based on data from OECD MSTI 2004/2 and OECD MSTI 2017/2

	R&D Expenditures in Million €			CAGR
	1996	2005	2015	1996-2015
R&D Expenditures of Foreign Corporations in Japan	548	5 038	8 987	15.9
Domestic R&D Expenditures of Japanese Corporations	51 164	93 346	124 191	4.8
Total Business R&D Expenditures in Japan	51 712	98 384	133 178	5.1
Share of Foreign Corporations in Business R&D Expenditures in Japan (in %)	0.9	5.1	6.7	

Due to this important role of the Japanese innovation system, foreign multinationals increased their R&D investment in Japan, particularly during the ten-year period following 1995. As can be seen in table 6, R&D expenditures of foreign corporations were growing at an annual average rate of 28% between 1996 and 2005. They continued to grow after 2005, even though

[11] For a discussion of this „competence trap", see EFI 2013, chapter B.1 and EFI 2014, chapter A.5.

[12] See Beise (2006), Reger (1997), Beise and Rennings (2004), Herstatt, Stockstrom et al. (2006) and Gerybadze (2006) for their studies of the Japanese innovation system, and their analysis of the functioning of lead markets in Japan.

[13] See Herstatt and Stockstrom (2006), Herstatt, Stockstrom et al. (2006), Verworn, Herstatt and Nagahira (2008) for detailed studies of Japanese innovation management practices.

at a lower pace, and have reached a level of 9 billion $ in 2015. A survey on trends in business activities of foreign affiliates published by the Ministry of Economics, Trade and Industry showed that 670 of the 3300 foreign multinationals in Japan operate their own R&D centers in the country (METI 2015). Even though this R&D investment of foreign affiliated companies still just represents 7% of total business expenditures of R&D in Japan, foreign multinationals still consider Japan as a major R&D hub in Asia.[14] For companies in optoelectronics, communication and advanced materials, Japanese innovation is still leading edge. In certain fields of automotive technology like hybrid engines and fuel cells, Japan is considered to be the "hot spot" and a major lead market. The same is true for robotics as well as for consumer product companies developing products for the so-called "silver market" in Japan.[15]

5 The new role of emerging countries in attracting foreign R&D centers

So far we have concentrated on foreign R&D locations mainly in advanced industrialized countries. The literature on Global R&D still underestimates the growing role of emerging countries as potential new target locations for R&D centers. During the last ten to fifteen years, we observe stronger R&D investments of multinational firms in emerging and uprising nations. The major drivers for the location of R&D centers in emerging countries, however, are different from the drivers of foreign R&D in lead countries that we have analyzed in the preceding chapter 4. The prime emphasis is not so much on knowledge sourcing at the frontier of technological change. Instead, foreign corporations that invest in new R&D centers in emerging nations want to benefit from a dynamic market and a resource-rich environment. Major **drivers of foreign R&D in emerging countries** are:

1) Foreign multinationals want to get access to a large and fast-growing national market where products need to be adapted to local conditions.
2) Companies often emphasize frugal innovation concepts, i.e. products and services that are well-adapted and tested for lower-income customer-groups.
3) Companies set up local production units and need to establish engineering centers in close proximity to manufacturing plants.
4) Companies want to get access to large talent pools, especially to science and engineering graduates with a still favourable wage-structure.
5) Target countries often follow ambitious policies for industrial development in high-tech industries combined with efforts to expand private as well as public R&D.
6) Often this goes hand in hand with strong national as well as regional incentives for localizing R&D.

An increasing number of emerging countries have thus followed a sequential process of competence-building, and have strongly emphasized R&D investment and the formation of knowledge-intensive industries. While they have often started with low-tech manufacturing, they tend to invest in research and development and in science and engineering education.

[14] A recent survey of JETRO (2016) asked 222 global corporations active in Asia about their assessment of R&D locations in different Asian countries. 43% of the companies mentioned Japan as the preferred R&D location, followed by Singapore (15%), India (15%) and China (10%).

[15] Japan with its ageing society is seen as a test ground for other markets in the world that will encounter similar demographic problems with a time lag. See Herstatt's studies on product development for the "silver market" in Japan in Kohlbacher and Herstatt (2011) and Kohlbacher, Herstatt and Schweisfurth (2010).

This allows them to move up into the formation of more advanced high-tech industries. These again build on home-grown national R&D capabilities as well as on inward technology transfer. Increasing strengths of a growing high-tech manufacturing and export sector then feed into the national R&D and university system and this creates an upward spiral.

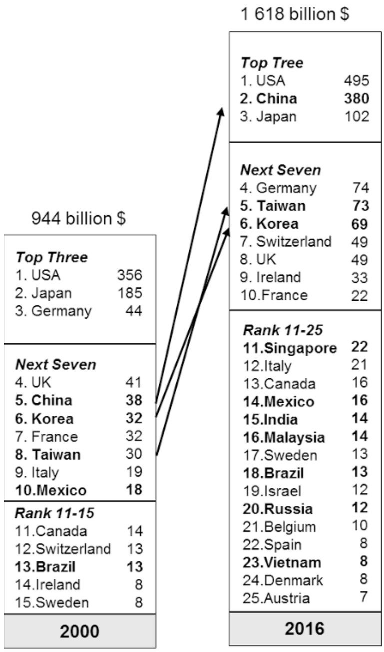

Figure 1: Structural changes in high-tech manufacturing / the new role of emerging nations in the periods 2000 and 2016; Source: Own illustration, based on data from NSF, science and engineering indicators 2018.

During the years 2000 and 2016, global spending on business R&D was growing from 465 billion $ to a level of 1 230 billion $. While BERD was still dominated by advanced industrialized countries in 2000, only two emerging nations were represented in the list of top 10 countries (China and South Korea). Fifteen years later, five emerging nations were represented in this list of the leading BERD investors. China has risen to second place closely following the U.S, South Korea attained rank 5, followed by Taiwan, Russia and India at positions 8 to 10. The group of emerging countries has realized much higher growth rates of business R&D spending than the former advanced nations, and this trend tends to continue. In figure 1, we analyze structural changes in the ranking of emerging countries and former industrialized countries. We use data on value-added in high-tech industries. Emerging nations have strongly invested in information and communication technology, electronics, pharmaceuticals, biotechnology and other R&D-intensive industries. In some specific high-tech industries, some countries have developed technological capabilities close to the technological frontier. Think of mobile communication from China and South Korea, IT services and software development from India, or security systems from Israel. In these specific fields, foreign multinational corporations have established world renowned competence centers in these countries.

A specific strategy that has become promoted through subsidiaries of multinational strategies in emerging countries involves frugal product design and **frugal innovation.** Multinational companies had to develop products particularly suited for the large potential markets in China and India. Products were characterized by modest technology levels ("just good enough"), by acceptable price-levels and by robustness. There are numerous case descriptions of successful frugal product development in China including computer tomography, automotive components and photovoltaics.[16] In most cases, these firms had to transfer product development capability to China, because their European engineers were just not prepared to develop products below certain performance standards and at the appropriate cost. Engineers in China were closer to the "voice of the customer" and ready to compromise with respect to technical performance. As it turned out later, frugal products developed for the Chinese market were then successfully launched to other parts of the world. Herstatt and Tiwari (2017) have studied similar projects in India, and have highlighted India's new role as a lead market for frugal innovations. In many cases, multinational companies from Europe and the U.S. have developed products in their R&D unit in India. Quite often, these robust products first introduced in the market in India have later become successful products in many other countries in the world. A typical example is Nokia with its development of affordable cellular mobiles, which later became successful in other Asian and African countries.[17]

6 Structural trends based on patent data

Patent data provide a reliable data source for studying the global distribution of innovation activities, since these are more widely published than data on R&D expenditures. Patent data published by the European Patent Office (EPO), and the Patstat database of the OECD distinguish between the location of patent applicants and the residence of individual inventors. Careful analysis of this information allows to assess the extent as well as the specific content of trans-border R&D flows within multinational corporations.[18] We compare patent filings and structural changes in inventor locations for two three-year periods (2011-2013 vs. 2000-2002). U.S. based multinational firms have stabilized their foreign inventor ratio at a level of 18% in both periods. During this period, however, foreign inventorship was moving to emerging countries, with a growing presence in China, India, Israel, Singapore and Russia. The share of foreign inventors from emerging nations in all foreign inventors went up from 14% in 2000-2002 to 36% in 2011-2013. During the same period, some former important inventor locations like Japan, the U.K. and France were becoming less relevant within U.S. firms. Meanwhile, China attained rank three of all foreign inventor locations within U.S. firms, and

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16 See the Ph.D. study of Schanz (2008) describing cases of product development Siemens' Chinese R&D lab, as well as the journal articles on low-cost innovations from R&D labs in emerging countries (Herstatt and von Zedtwitz 2014, Gerybadze and Merk 2014 and Schanz, Hüsig, Dowling, Gerybadze 2006).

17 See Tiwari and Herstatt (2013), Tiwari (2013) and Tiwari and Herstatt (2017)

18 This method of analyzing trans-border R&D activities based on patent data has originally been developed by Cantwell (1989) and Guellec and Pottelsberghe de la Potterie (2001). For a more recent development of this analytical tool see Gerybadze and Sommer (2017) and Dominguez Lacasa et al. (2013).

India attained fifth position. This corresponds to the new role of these two countries as R&D locations, as has been outlined in section 5.

For German corporations, the foreign inventorship ratio has gone up from 14% in 2000-2002 to 18% in 2011-2013. These figures are somewhat lower than the overall shares of foreign R&D spending. However, patent data allow for a more detailed analysis of inventor countries, and these provide data for a number of emerging countries in particular. While only 10% of foreign inventors in German firms came from emerging countries in the earlier period, their share has been increased to 20% in 2011-2013. Inventors from China and India played an increasingly strong role. We also observe quite a strong growth of inventor locations in the Czech Republic, in Hungary, Poland, Turkey and Romania, which corresponds to typical outsourcing locations for German manufacturing firms.

Japanese multinational firms have moderately increased their R&D spending, and this corresponds to a foreign inventorship ratio of 4.2% resp. 4.8% in the two consecutive periods. The former strong dominance of the U.S. as inventor location (with 57% of all foreign inventors in Japanese firms) has become somewhat reduced to 35% in 2011-13. Meanwhile, inventors from the EU have increased their share from 35% to 46% in 2011-13. Similar to trends observed for U.S. and European firms, Japanese multinationals have turned their attention to new inventor locations in emerging countries. The share of foreign inventor locations in emerging nations increased from 9% to 20%. China in particular has become very important as inventor location for Japanese firms. Other relevant inventor locations for patents filed by Japanese firms in 2011-13 are Singapore, South Korea, Thailand, Taiwan and India. These developments just describe overall structural changes, but this instrument of host-country patenting allows for much more detailed investigations of trans-border inventor activities for different patent classes, as well as for specific corporations.

7 Conclusions

Our paper has analyzed major trends and structural changes related to technology and innovation management for the period 1995 to 2018. We have seen a persistent increase in the globalization of the R&D function and a greater diversity of target countries for new R&D locations. Even though it is hard to predict future courses in periods of growing political instability, the globalization of R&D will most probably go on during the period 2019 to 2030. Long-term megatrends like climate change, urbanization and new mobility must be addressed from a global perspective, and the appropriate technological and social solutions need to be developed and implemented in many countries simultaneously. The global footprint of innovation activities will be extended and we will see a proliferation of new uprising nations that play an increasingly important role. Sometime during the next decade, China will surpass the United States in terms of GDP as well as R&D spending. Other emerging nations like India, Brazil, Indonesia, Taiwan and Malaysia will follow high-tech development strategies. It will be interesting to monitor country-specific processes of linking science and technology, human capital formation and R&D growth. A key issue will be whether catch-up nations are able to grow beyond the so-called middle-income trap and whether these countries can implement a sustainable growth path.

There are still some white spots in our studies on global R&D. We know quite a lot about multinational corporations active in advanced OECD countries. There are still not enough studies on business R&D and the role of multinationals in emerging nations. Published data on R&D expenditures are available for inward R&D investments, but rather sketchy for outward R&D investments, and particularly for R&D flows to emerging countries. And even though multinational firms from China, India, Taiwan and many other emerging nations are increasingly active in global markets, the role of foreign R&D within these firms is not well documented. Complementary data sources as outlined in section 6 could be used to monitor inventive activities and patenting within these newly emerging multinationals. And it would be interesting to combine different data sources linking R&D spending patterns with patent as well as publication data.

Innovation research also requires a combination of analytical and appreciative research. Publication imperatives and scientific ranking procedures may have led to an overemphasis on quantitative studies using large data sets. Technology and innovation management in a global perspective would certainly benefit from a mix of research methods combining different types of quantitative data, as well as field studies, expert interviews, and solid case research. Cornelius Herstatt and his fellow researchers at Hamburg Institute of Technology were always promoters of such comprehensive studies of innovation.

We also need more insightful studies on the role of foreign lead markets, the characteristics of lead customers as well as the influence of lead regulation. Through which practices are firms able to absorb relevant knowledge and how do they manage to transfer novel practices across countries? The examples of lead markets in Japan, India and South Korea were addressed in recent studies, but could certainly be enriched through intra-organizational studies of learning and innovation within firms. The concept of frugal innovation in driving markets like India and China is such a case. The effectiveness of frugal innovation would require that multinational companies are able to transfer design rules and engineering practices across different locations. How can firms in Europe effectively use their counterparts in India and China, and build powerful global development teams that launch products for growing world markets?

Effective cross-country learning strongly depends on the mobility of people and on shared understanding across cultures. This has been facilitated through the globalization of university education. More recently, we have many students that complete their bachelor studies in one country and then continue to study for a master's degree in another country. In some cases, Ph.D. studies and post-doctoral activities are later continued at a third location. Global master programmes like the one implemented at Hamburg Institute of Technology facilitate such multi-cultural and multi-disciplinary career-tracks. Many of these young scholars are interested in case studies and in experiences on the global management of technology. They are also important contributors, since students writing bachelor, master as well as Ph.D. theses will help to extend the repository of knowledge on global innovation projects. Novel case studies involving describing TIM practices in a wider sample of countries and in new dynamic fields of technology are necessary to widen the scope of business and engineering education. In this sense, the research programme developed at Hamburg Institute of Technology during the last two decades will have a bright future during the coming decade.

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Chapter 14

Communication and Knowledge Flows in Transnational R&D Projects

Maximilian Joachim von Zedtwitz

Abstract

Multinational companies exist in part because of their ability to tap into worldwide centers of expertise and disseminate this knowhow within the global firms. However, sharing knowledge efficiently is difficult even in highly networked organizations. Knowledge flows are hindered by spatial distance, costs of set-up and maintenance of communication structures, and lack of trust between distant sites. This chapter focuses on three key dimensions of virtual organizations: 1) knowledge transfer, 2) communication quality, and 3) coordination, and analyzes them in transnational R&D projects in industrial companies. Based on a cross-case comparison along the three dimensions, this chapter proposes inter-, intra- and multilocal aspects of virtual R&D teams, suggests three propositions, and concludes with managerial implications.

Keywords: Global Innovation; Transnational R&D; Virtual R&D Teams; Internationalization of R&D

1 Challenges of Managing Cross-Border Knowledge Flows

Multinational companies (MNCs) account for nearly one third of global production output (OECD 2018) but are estimated to be responsible for approximately 80% of global trade (UNCTAD 2011). MNCs also dominate international R&D: 70-80% of worldwide R&D investment is attributed to the 150 largest technology-intensive companies. As Iansiti (1998) noted, the organization of R&D must be designed to selectively retain information, process knowledge, and apply know-how. Although R&D is generally more centralized than other functions, it is often dispersed internationally to seek and transfer local know-how—as a consequence, knowledge flows increasingly across multiple locations worldwide.

R&D managers in technology and knowledge intensive companies have thus been increasingly confronted with the challenge to manage projects involving team members from different business units and R&D laboratories, often separated by thousands of kilometers and multiple time zones. Conventional innovation processes are traditionally designed with collocated project teams in mind, and it is only comparatively recently that spatial dispersion has become a determinant in managing R&D and innovation projects. Such projects have been labeled 'virtual' R&D projects, 'transnational innovation projects, or 'global' product development projects (Chiesa, 1996; Gassmann and Zedtwitz, 2003a).

What are virtual R&D teams? Based on Lipnack and Stamps (1997), we define virtual team as a group of people or entities who interact through interdependent tasks guided by common purpose, working across space, time, and organizational boundaries with links strengthened

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R. Tiwari and S. Buse (eds.), *Managing Innovation in a Global and Digital World*, https://doi.org/10.1007/978-3-658-27241-8_15

by information, communication, and transport technologies. Participation in such virtual teams may be temporary for individual members and their actual contribution may be undefined. We do not assume that members in virtual teams never meet face-to-face (e.g., Kristof et al., 1995), but are aware that a substantial part of the communication is mostly technology-supported (Maznevski and Chudoba, 2000).

But innovation projects with distributed R&D are difficult not only because of poor communication quality. The dominant orientation of decentralized organizations towards local markets and customer makes it difficult for local R&D units to adequately invest in and establish transnational cooperation. Not-invented-here syndromes, local fiefs, localized data standards, different languages, cultures and behavioral preferences as well as incompatible work routines impede efficient cooperation between teams. Individual R&D units are strongly based in the local environment, often with little integration—and little interest—in the worldwide organization. However, willingness to share information and constructive contributions to the overall project objective are necessary for virtual R&D teams to succeed.

To address the underlying questions, data was collected as part of a number of related research projects conducted over the last two decades, all of which were focused on international R&D management and virtual innovation teams. The unit of analysis for this research is the virtual team working on a project with decentralized resources. More than 150 research interviews with project managers, senior R&D staff, and other key people engaged in decentralized teams was analyzed for this research. Interview minutes were captured in writing and sent back for review and feedback. In addition, we were able to participate in project meetings or had access to communication protocols or documented communication. In alignment with Yin's (1994) requirement for data triangulation, we also collected secondary material on these teams and the organizations in which they were embedded. The researched teams had a strong focus on R&D, new product development (NPD) and innovation. In total, we surveyed teams in more than 40 companies, including firms in the pharmaceutical and chemical industry, engineering, consumer electronics, and IT/software.

As the goal was to identify also practical solutions to the problems incurred by spatial dispersion, most notably knowledge sharing and team coordination, we pursued our research in light of the following guiding questions:

Who do members of virtual teams communicate, i.e. formulate and transfer knowledge to other project members?

- How often and how much coordination and communication is necessary?
- How is control and communication executed via modern information technologies?

This chapter continues by identifying typical problems of virtual R&D and three critical factors for communication and coordination, and by illustrating practices of selected international R&D organizations. It then conducts a cross-case analysis of knowledge flows in different virtual R&D organization, and proposes a model that maps interdependence and spatial dispersion within virtual team organization. It concludes with the most important managerial implications for managing virtual R&D teams.

2 Reviewing Problems of Decentralized Innovation

2.1 An Example from Management Practice: Shell's Carilon Project

An example of a company with highly competent but dispersed R&D units is Royal Dutch/Shell. In 2018, Shell spent almost US$ 1 billion on R&D carried out by more than a dozen R&D centers worldwide. Shell's early experience with coordinating distributed R&D efforts is illustrated by its Carilon project, a multiple-application polymer developed between 1984 and 1997. This polymer was first developed in a Belgium R&D laboratory, but then the central laboratory in Amsterdam got involved and—as the United States was discovered to be the ideal target market—the Westhollow Research Center in Houston. For some time there was duplicate R&D activity and the presence of the Not-Invented-Here syndrome among researchers in various participating sites. Researchers were not communicating between different R&D sites, and political resistance grew. With the prospective polymer development not making significant progress, Shell eventually overcame some of the well-established 'laws' cherished in conventional R&D, and as a consequence gave one R&D center complete responsibility for the polymer's development. The additionally enforced focus on market development turned Carilon into a success story. What was initially known as "the most poorly managed project in the company's history" became the first successful multinational product development at Shell.

In retrospect Shell's multi-site configuration was considered more as an asset than as a problem, especially during the commercialization phase. Not all companies are this fortunate, and most struggle with seemingly insurmountable problems. Companies that have started to establish international R&D sites but have little experience in coordinating and integrating them towards coordinated platform development programs typically face the following issues:

- Poor coordination and exploitation of synergy between distributed R&D centers due to unclear technical and product responsibilities and poor collaboration and communication among R&D sites.
- Different standards and platforms of information and communication technologies.
- Difficulties to initiate and lead multinational/multicultural/cross-border teams as well as ineffective team management across long distances during long projects.
- Difficulties to share knowledge and experience across sites and ineffective knowledge transfer; as a consequence, low integration of decentralized technology and application knowledge.
- Optimization of local business with customers and suppliers at the expense of global partnerships.

In summary, these R&D organizations are struggling to align diverging objectives across multiple locations.

2.2 Review on Critical Factors in Virtual R&D Project Management

Despite substantial research in project management, many open questions remain with respect to the management of dispersed collaborative R&D projects (vom Brocke and Lippe, 2015). The literature either adapts conventional (i.e. non-dispersed) R&D project organization for transnational uses (e.g., Wheelwright and Clark, 1992; Gassmann and von Zedtwitz, 2003a), or develops novel conceptual schemes (e.g., Chiesa and Manzini, 1996). Most research stresses the importance of informal or soft coordination tools in addition to traditional project management methods (e.g., Reger, 1999), but often fails to spell out their integration in multi-site R&D project execution and organization.

Most research on R&D project management makes little distinction between global and local project execution. Handbooks and project manuals have been developed for conventional local projects. With the advent of the Internet and online communication, project management has been updated with respect to mobile IT solutions. When managers of international projects consult this literature, they are either applying conventional wisdom to a new environment and thus risking sup-optimal behavior, or they are forced to improvise and make intuitive decisions where established knowledge is lacking (Boutellier et al., 1998; Griffith et al, 2003). Conventional projects are not fundamentally different from virtual projects, but key elements long taken for granted are often applied to virtual project environments without adapting them to potentially new requirements.

One such key element is the role and *power of the project manager*. Burgelman (1984) describes the problems internal group and venture leaders are faced with, recommending additional support roles by corporate and middle-level managers. In a study on the locus of power between project and functional managers, Katz and Allen (1985) argue for considerable power in the hands of project managers in order to improve organizational support and coordination authority. Four types of team structures-from functional to heavyweight-were finally typified by Clark and Wheelwright (1992). Closely related to the degree of leadership authority in teams is the *significance of the project* and its success to the corporation (e.g. Burgelman, 1984; Thamhain and Wilemon, 1987; Roussel, Saad, and Erickson, 1991).

While much has been written about *funding* of R&D in general, the allocation criteria for funding specific R&D projects were intensively debated (e.g., Madauss, 1994, EIRMA, 1995). Different exposure and assessment to risk asks for different funding models. Based on comparative analysis of 300 companies, Szakonyi (1994) points at the poor relations of R&D with finance and accounting departments. Funding sources and costs of projects are disclosed in case studies and other accounts of R&D project management (e.g., Borgulya, 2008; Wyleczuk, 2008). Large-volume projects are categorized and reviewed differently from regular projects, and their project management is often given more autonomy and authority. Although *costs* are typically better accounted for in projects than in functional environments, hidden costs occur particularly in accelerated product development (Crawford, 1992).

Clear *project aims* seem to be a necessary condition for project success (e.g., Roussel, Saad, and Erickson, 1991: 151; Dimanescu and Dwenger, 1996: 82). However, innovation effectiveness depends on the initial diversity of project ideas and the appropriate and timely definition of product specifications. Two important determinants come into play. First, at the time of specification freezing, all *system interfaces* must have been negotiated and defined. Technical uncertainties (Madauss, 1994), organizational inertia and structures (Henderson and Clark, 1990), reciprocal interdependencies (Nadler and Tushman, 1990) as well as difficulties in knowledge mode conversions (Nonaka and Takeuchi, 1995) make this a less than trivial task. Second, the *project owner* as the main protagonist and champion of the product idea exerts significant influence over technology and market targets (see e.g. Rubenstein 1989). Project ownership and commitment creates direction, momentum and a common purpose (Katzenbach and Smith, 1993; Leavitt and Lipman-Blumen, 1995).

Besides content-specific integration, appropriate planning, reporting, control and information systems help to manage the R&D process (e.g., Roussel, Saad, and Erickson, 1991: 157). But special efforts in establishing team culture or align individual project objectives are needed to achieve *project coherence* (van de Ven, 1986; Thamhain and Wilemon, 1987). R&D groups that create their own dynamic orderliness have been referred to as 'self-organizing teams' (Burgelman, 1983; Imai, Nonaka, and Takeuchi, 1985). Self-organizing teams as well as project teams composed of members of diverse functional specializations are capable of cross-fertilization. In above-mentioned study, Szakonyi (1994) observes that the commitment towards establishing *cross-functional integration* is present but in general weakly supported. Such structural linking could be achieved by liaison officers, cross-unit groups, project integrators, or matrix organization (Nadler and Tushman, 1990).

During integrated problem-solving, communication between members of the team is particularly intensive (Wheelwright and Clark, 1992). *Communication tools* and communication facilitators have long been recognized to improve R&D quality and effectiveness. Based on Allen's (1977) seminal work, R&D managers lay-out R&D facilities to enhance and facilitate communication. Tushman (1979) observes, however, that communication patterns differ with function (research, development, technical service) and operational needs both within and outside the firm (operational, professional). As Dimanescu and Dwenger (1996) argue, it is important to maximize the opportunity for interaction and information exchange and not the actual information flow. This also extends to the project manager's ability to communicate directly with each team member (Hoegl et al., 2004). Frequent interaction may not lead to interpersonal *trust* automatically, but absence thereof certainly does not help either (Breu and Hemingway, 2004; Muethel et al., 2012).

With the ongoing trend towards empowerment and decentralization (see e.g. Albers and Eggers, 1991), communication tools have become a vital ingredient for effective *coordination*. Conventional R&D coordination tools (e.g., Cooper and Kleinschmidt, 1991; Madauss, 1994; O'Connor, 1994) are being complemented by new organizational structures (de Meyer, 1991), modern communication instruments (O'Hara-Devereaux and Johansen, 1994) and boundary-crossing individuals (de Meyer, 1991; Ancona and Caldwell, 1997). However, it is still unclear whether dispersed projects require disaggregation along task lines, or whether organic coordination mechanisms compensate for deliberate (or inadvertent) lack of formal coordination (Perea and von Zedtwitz, 2018).

Global R&D management literature has pointed to increased impediments of communication and coordination in international R&D (e.g., Rubenstein, 1989). De Meyer and Mizushima (1989) introduced "the half-life effect of electronic communication", pointing out that e-mail is at best complementary to face-to-face contact. Groupware and its usefulness in sharing know-how worldwide have been described by O'Hara-Devereaux and Johansen (1994), Campagna and Roeder (2008) provide an interesting example of its application. The early use of ICT in R&D has been studied by Howells (1995); in particular he summarizes some preconditions for cross-border R&D teamwork. With ICT a familiar tool for many engineers and scientists, its utilization for R&D management was just a matter of time. The adoption of global project coordination mechanisms has been somewhat slower. Nevertheless, our understanding about the value of ICT in virtual R&D management is improving (Boutelllier et al., 1998; Naman, Dahlin, and Krohn, 1998; Griffith et al., 2003).

2.3 Transnational, Interlocal, or Multilocal? – Aspects of Task Dependence

The guiding research questions thus is*: 'How to organize and control transnational R&D activities.'* 'Transnational' is defined as the quality of distance which makes regular convenient face-to-face contact impossible. In this sense, 'interlocal' may be a more suitable synonym than 'transnational'. The two R&D units of Endress+Hauser in Reinach (CH) and Maulburg (GER), both situated only a few kilometers away, would then have a large share of transnational projects, while research between UTC's East Hartford site and the one in California would not be considered as 'transnational' even though both sites are in different time zones.

The motivation behind measuring interlocality is that once the determinants of transnational R&D are identified, the quality of interlocal or multilocal activities may be measured and controlled, and this in turn allows to improve the planning and organization of transnational R&D activities. This is in line with one of the primary objectives of R&D controlling: Making the R&D process transparent in order to provide a sound base of information for future decisions and planning.

The prerequisite of multi-site research activities is that the work must be separable. The concept of transnationality can be further refined by taking into account that interaction between partners differs during the execution of the project.

If the workload of a project is spatially separable, two forms of transnational R&D can take place. Interlocal work is characterized by high interdependency of the work tasks. Frequent communication and strong coordination are required to take place during the entire project. Since communication and travel costs tend to be high, a strong reason for this form of transnational project execution must be present, such as time-critical projects, high uncertainty of the project outcome, the usability of information technologies, and a firmly defined spatial distribution of resources.

The clinical research phases of pharmaceutical innovation processes fall into this category. Time-to-market is extremely critical, as profits almost exclusively depend on early market penetration. Government regulation agencies often require local testing, and participating hospitals as well as R&D centers are globally distributed. Failure rates in drug testing are extremely high (up to 90 % in clinical phases alone), but test results can be easily communicated to the global project coordinator, who is in firm command of the entire process.

Multilocal work is suited to projects with little interdependent work tasks. Coordination takes place particularly in the beginning of the project, when workloads are defined and assigned to partners. Each partner carries out his part of the project. The results are collected at the end of the project. Communication and travel costs are much lower, as the need for coordination during the project is less intense. Multilocal project execution is called for when resources are: i) not relocatable, ii) work tasks can be carried out in parallel, iii) changes to a plan are quickly executable, iv) the outcome is well defined at the beginning, and v) the degree of modularity is high.

Some collaborative projects funded by international bodies can serve as examples. A project coordinator acts as a central information officer, but has no directive authority over participating partners. Work packages are defined and distributed among the participants, usually according to their individual interests and capabilities, and then carried out largely intramural.

In fact, work tasks are deliberately defined such that interpartner communication is minimized while combined output is maximized. The individual results are assembled to the final product. This is not to say that interaction between different participants is prohibited, but because of the high costs associated with highly interactive projects, these projects are more likely to be cut or dismissed by the central approval committee.

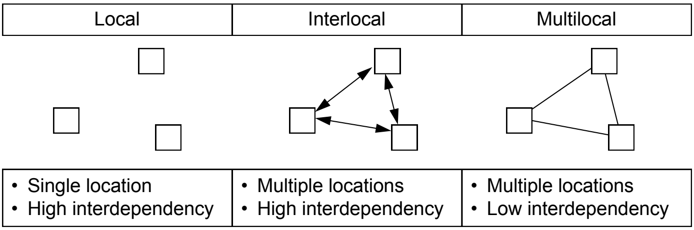

Figure 1: Degree of Interlocality and their Interdependency

As a means to track transnational R&D processes better, the following indicators can be considered:

- number of flights
- number of videoconferences
- number of telephone calls
- number of face-to-face meetings
- telephone costs
- travel costs
- number of e-mail contacts.

The number of co-authored paper and patents is not a useful indicator, as the project is usually long terminated before patents are granted or papers are published. Given they are not the primary objective of most R&D projects, papers and patents are unreliable indicators for the effectiveness of R&D. Man-years per project and per location are useful for distinguishing between local and multi-site projects, but this ratio does not capture the difference between interlocal and multilocal projects.

The quality of information exchange differs within transnational R&D projects. The traditional view holds that research requiring informal relations cannot be carried out internationally, because interpersonal trust and richness of communication suffers from the spatial distance of the communicators. Interlocal research is characterized by intense (and costly) communication and frequent travel - members in such projects repeatedly meet and can maintain close links that sustain a level of informality with the use of modern ICT. Due to the reduced amount of interlocal communication, communication and relations tend to be more formal in multilocal projects. Informality or formality is difficult to measure directly. Possible indicators for formality are the degree of meeting official deadlines, the involvement of senior executives, or the definition of timetables.

3 Knowledge-Intensive Transnational Innovation in Practice

This chapter presents several examples of virtual R&D teams, illustrating how these critical factors influence project management in real projects. In this retrospective description of especially successful virtual R&D projects, there are hints at solutions or 'best-practices' of coordinating and managing communication in dispersed R&D teams. We list five such examples:

1. Hitachi's Holonic management of dispersed research
2. Shared goals and managed communication flow in a European research project
3. Bridging trust and language barriers with Unisys's 24-hour laboratory
4. ABB's IT-enabled PIPE project management tool
5. International product development at IBM

3.1 Hitachi's Holonic Management of Dispersed Research

Hitachi had no significant manufacturing operations in Europe until the mid-1990s, but nevertheless aimed to pursue fundamental research in close connection with local universities and research institutes. Starting with research centers at the Universities of Cambridge (microelectronics) and Dublin (information science), Hitachi expanded to Munich and Milan, employing more than 80 research people in 1997. The administrative headquarters remained at the European research headquarters in Maidenhead, UK.

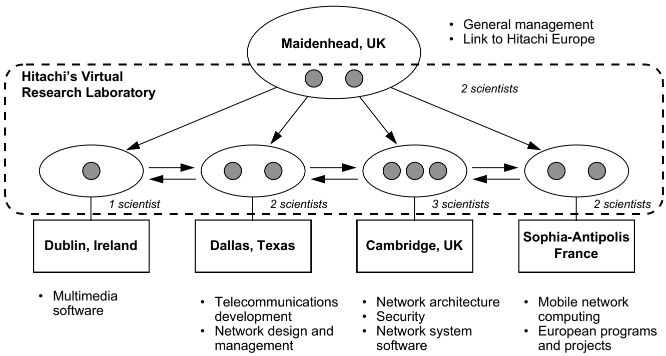

Figure 2: Hitachi's competence-based virtual R&D laboratory.

Based on these locations, Hitachi formed a virtual research laboratory called Hitachi European Telecommunications Lab in 1997. The goal was to pursue research in telecommunications systems and the development of network system software. Research was designated to four of the most suitable locations: Cambridge (UK), Dublin (Ireland), Sophia-Antipolis (France) and Dallas (US) dynamically group and operate collaboration projects that can change in location and partners (Fig. 1). The network includes Dublin because of its competence in multimedia related contents software, and Cambridge because of the Centre of Communications Systems Research at Cambridge University, which is engaged in security issues and future network architectures. The Dallas Laboratory provides network design and network management competence. Overall research administration remains in Maidenhead.

Access to standardization consortia was also important. At Sophia-Antipolis, a science city in the south of France, Hitachi found not only competence in mobile computing and communications but also local partners engaged in European framework programs and committees such as EURECOM, ESPRIT, and ETCI. Research is distributed among ten scientists in those five places. Individual scientists are given a lead by holonic management which yields a maximum of power and freedom to the individual while making sure that the research understands and pursues the overall goals of the research laboratory and how his work affects his own research and that of his colleagues. Although each scientist is a fully integrated researcher in his local community, he relies on the work of his virtual colleagues and shares his results with them.

3.2 Shared Goals and Managing Communication Flow: The European ESPRIT Project REWARD

R&D activity in European projects is extremely decentralized. Reward, a one-year project aimed at designing and implementing re-engineering methods in R&D, was formed by teams from Daimler-Benz, Philips, Nokia, SEC Electrocom, and Thomson-CSF, teams from smaller companies (GSM Software Management, ATM Computer, Planisware) that ensure exploitation of the project results for a wide range of companies in Europe. Teams from research and consulting service providers (KPMG Management Consulting, University of St. Gallen, and Fraunhofer Institute for Industrial Engineering) provided the required theoretical background.

A total of 25 researchers were involved. One of the partners (SEC Electrocom) assumed coordination responsibilities to organize and administer start-up workshops, regular face-to-face meetings, and intensive e-mail communication. His central location was important for frequent personal contact between contributing partners and the coordinator himself (Fig. 3). Apart from managing a highly dispersed research activity, the management of different cultural backgrounds, not only by ethnic, but also by professional standards posed a key challenge to the success of the project. Much patience and sensitivity were required to align the individual objectives of each partner team to agree on a shared understanding of what was to be achieved, and how each partner would contribute to this goal.

The entire project work was split into small work packages to be executed by each team. Three problems occurred. First, hand-over of preliminary and final work package results was often complicated by incompatible computer and information systems. Second, after a team had concluded its part of the work, the entire project was given a lesser priority, thus hindering the efficient project continuation for the rest of the teams. Third, the project coordination office responsible for coordination and control was given only weak influence and decision power, thus lacking the strong authority needed to keep decentralized activities on track. It was learned that decentralized project work involving several partners required a different mind-set from the efficiency-oriented work routines used in single-location projects. Every individual at each partner had to gain an understanding for his collaborators' needs and weaknesses. Communication between teams was essential; the change of intensity often provided a clue when a particular sub-task was delayed or the anticipated outcome could not be reached.

Due to the distances between the teams, initial workshops were designed to last at least two days. Time is required for future partners to build up a relationship of trust and respect. This can be best achieved during the time aside from the formal meeting. The project office must be aware of such needs and consequently arrange appropriate start-up meetings, face-to-face meetings, and regular events to strengthen team culture and team spirit.

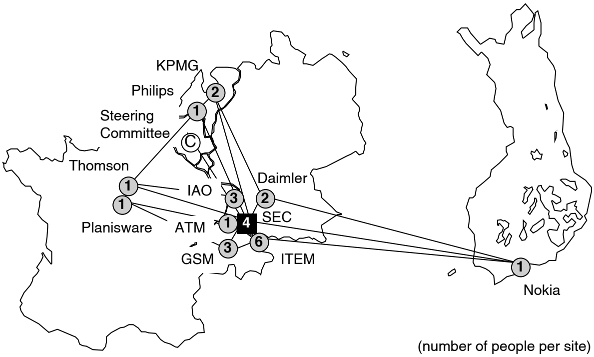

Figure 3: Decentralized R&D in a European project.

Since much of the effective communication takes place by modern information technologies, the access to shared databases and the error-free operation of e-mail and file transfer exchange must be ensured at the beginning of the project. Too often, project members are frustrated when communication breaks down during the critical ramp-up phase of a project. Personal friendships will last longer than the original project, spanning across corporate boundaries to form an informal network by which much of the know-how and technology transfer will take place for which European projects are initiated in the first place.

3.3 Bridging Trust and Language Barriers: The 24-hour Laboratory at Unisys

The exploitation of different time zones helps to circumvent labor laws concerning total work hours per week and the general aversion of R&D personnel towards working in shifts. Since around-the-clock research depends largely on the efficient transmission of information, the codability of the information and its rapid re-utilization at the recipient's location are crucial success factors. These preconditions are more likely to appear in the later stages of R&D, e.g. development, and in industries that work with highly codable data such as the software development industry.

Software development at the Unisys Personal Computer Division has been implemented in what is sometimes called the '24-hour laboratory' or 'Around-the-clock'-research in order to exploit different time zones of R&D units (see Winkler and Edgar, 2008). System software development is highly time-critical. Many companies have installed integrated information systems on which their businesses depend. When they approach Unisys with a service, update or development request, rapid delivery of the solution is crucial. Unisys has chosen around-the-clock R&D over night shift work. In commodity markets such as operating systems, software or microelectronics, the customer does not care where the product was developed, and neither does Unisys.

Unisys R&D units in San Jose, Tokyo and France participated in this project (Fig. 4). In one large software development project, consisting of many smaller software packages to be encoded, design of software modules was carried out in San Diego and sent to Tokyo where the specifications were programmed. Testing of parts of the software took place in France. The test results were analyzed in San Diego the next morning, prompting possible programming changes in the software or refinement of the specifications. After their day's work, these changes were in turn tested in Japan – the cycle continued.

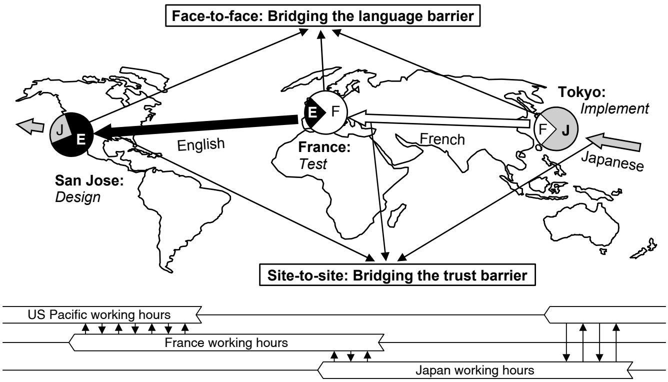

Figure 4: At Unisys, remote teams ensure efficient communication between R&D locations.

In transnational R&D processes, communication plays a central role. Soft factors determine the R&D process more significantly than the effective transmission of program code. The acceptance of the work done by the transferring team depends on the trust and confidence of the recipient team in the capabilities of their predecessors and a general understanding of the predecessors' working routines. Directions and explanations are well-meant but may offend the recipient when not formulated appropriately. Also, the means of communication affect the effi-cient transfer of information and acceptance of intermediary products. Speaking and communicating in the right language, as well as understanding cultural issues for and by the recipient, are part of the soft factors affecting the efficient transfer of information between geographically separated R&D groups.

Hence, Unisys complemented the utilization of ICT with the placement of members from the recipient team to the transferring site. For instance, Japanese engineers are seconded from the Tokyo office to the San Jose group. By being involved in the product conception in San Jose, they guarantee the consideration of efficiency in subsequent programming stages. They also learn hands-on and face-to-face about the requirements and expectations of the San Jose team for the implementation group. But local Japanese engineers can communicate these requirements back to the Tokyo team better than their American co-workers. They speak the same language and understand well the peculiar problems of misunderstanding and cultural noise at the receiving side. While the problem of information sharing and language difference is solved by face-to-face communication, the trust and culture problem is taken care of by the communication of team members of the same cultural and interpersonal background. Unless the other person behind the computer is known, teamwork is unlikely to harness its full potential. The familiarity between members of the same team tends to decrease after some time. Frequent e-mail communication may prolong this time period, but the half-life period of trust cannot be overcome without face-to-face communication. Unisys therefore replaces the seconded engineers after three months with other members of the recipient group. This prevents a loss of trust by the recipients, as well as potential misunderstandings due to assimilation or alienation of the remote engineers.

Intertemporal cooperation across geographic distances as in around-the-clock research requires standardization in reporting, project management tools and problem-solving in general. The routinization of such transnational development activities greatly enhances the exploitation of interlocal R&D.

3.4 ABB's PIPE: Project Idea, Planning and Execution

During ABB's reorganization towards greater integrated R&D management, ABB introduced a work flow application to support the research organization's core processes. This tool is called PIPE – Project Idea, Planning and Execution. PIPE is based on Lotus Notes: Since all scientists in ABB Corporate Research have Lotus Notes on their desks, they can communicate, share knowledge and access relevant databases independently of the PC platform The same applies to many ABB employees in the businesses, Lotus Notes being the ABB standard tool for communication.

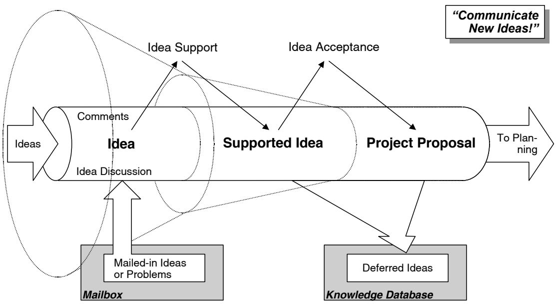

Figure 5: ABB's PIPE system module 1: Communicate new ideas!

PIPE consists basically of three main applications. It supports the creation and communication of ideas and projects, portfolio planning and assessing their value, and project execution and decision making. It is consistent with project portfolio management including resource allocation and project ranking.

A scientist can create an idea any time, test it, i.e. discuss it with suitable, selected colleagues around the globe. He then seeks support either from business area colleagues or from corporate research management, e.g. the program manager. Upon positive feedback a project is generated and it flows into the portfolio planning stage. After a ranking process it flows into the execution phase, if resources are available. Otherwise it is put into a "project storage" data base. In March 1997, the average user activity in the PIPE system were 36 entries or 11.7

Mbytes for idea creation, 203 entries or 49.8 Mbytes for reporting, and 171 entries or 44.5 Mbytes for planning (Tedmon, 1997).

At idea creation, the principal motivation was to keep track of all ideas and make them available throughout ABB. The idea creation module (see Fig. 5) also supports the formation of virtual teams. It was learned that most ideas were 'public,' meaning that they were not limited in visibility to restricted user groups. Software-related R&D was quick to accept PIPE as an R&D tool; quicker than researchers in traditional R&D fields.

PIPE supports the creation and planning of new projects with the second module (Fig. 6). This includes the selection of the project leader, preparation of project cost estimates, access to local accounting systems, and easy project tracking. Data consistency is ensured because there is only one point of entry for each kind of data. PIPE is accessed by the main project leader, local project leaders, department managers, program managers, and financial controllers. Several databases for process control, support manuals, knowledge and soft data repositories, fund requests and accounting enhance visibility and process-orientation in research.

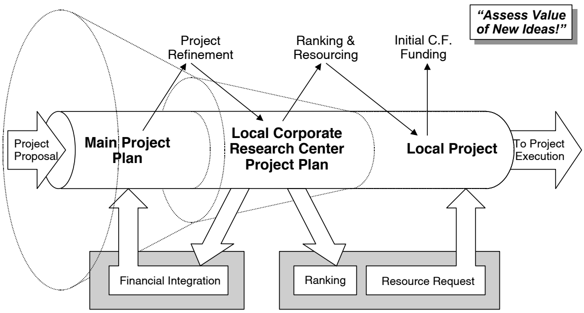

Figure 6: ABB's PIPE system module 2: Assess value of new ideas!

The project reporting module (see Fig. 7) does not only keep track of projects, it also ensures common notations and reporting standards. It presents different financial and budgetary summaries, project statistics, and business area consolidations. All information is condensed, updated and saved online. Since the introduction of PIPE, several duplicate projects were terminated and many local projects were coordinated. Often, a local project becomes part of a global project. This is the case when resources for execution are not exclusively available in one lab. In such a case colleagues are working as members of a global virtual team on various aspects of a main problem.

The process dramatically supports:

1. Forming cross-border project teams;
2. Overcoming multicultural barriers;
3. Improving transparency and trust in collaborations.

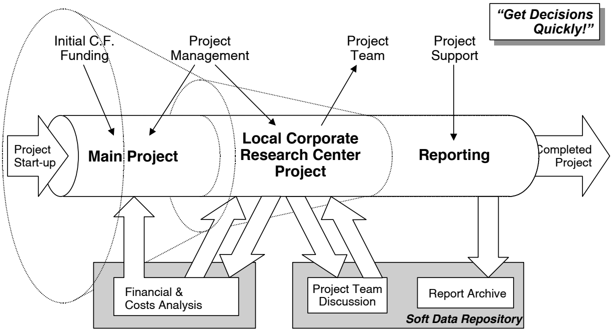

Figure 7: ABB's PIPE system module 3: Get decisions quickly!

With the help of advanced IT tools the world-wide R&D activities and resource allocations are completely visible and transparent to the management team. Shared information is available to an international team. Many new ideas are transferred to ongoing projects – processes are faster and simpler. Redundant efforts in the projects within the corporate research organization can more easily be avoided because the program managers have control over the funds.

PIPE also has a strong educational aspect, as now all ABB employees are used to think and consider in the ABB core processes. In a multinational-multicultural company like ABB the most important coordination tools - besides control of funds - in international R&D is openness and transparency of all R&D activities and resource allocation through one common database and groupware applications.

3.5 International Product Development at IBM

The significance of multi-site R&D activities is exemplified in the following study on the development of a new operating system involving three IBM R&D sites in the US, and one each in Australia, the UK, Germany, Belorussia, Canada, and Austria. This description is based on the IBM case study in Boutellier et al. (1998).

Traditionally, large-scale commercial software development projects such as the development of the VSE/ESA operating system for IBM's S/390 Enterprise Server Family has always been conducted across national boundaries. The gathering of requirements, the product planning and design phase play an essential role in the development of products: the aim is to collect the customer requirements, to develop adequate responses to these requirements, and to validate the solutions with the customers.

In system software development at IBM, requirements are brought to the attention of the development organization via a variety of channels:

- World-wide operating user organizations such as GUIDE, COMMON, or SHARE.[1] collect requirements and pass them on to IBM. At IBM the requirements are gathered

[1] GUIDE, COMMON, and SHARE are world-wide operating organizations for users of the IBM operating systems. E.g. GUIDE represents primarily the users of the VME/ESA and the OS/390 operating systems.

in databases, distributed to the development organizations, where they are analyzed and addressed.

- The service organization is another important channel for customer requests: employees in this function have daily contact with customers who experience problems with current products. These problems are entered into a database (RETAIN) which can be accessed world-wide.

The development teams operating world-wide access the available data and define the necessary small product improvements in close cooperation with the system house. More extensive improvements, especially when there are dependencies between products, are only introduced in close cooperation between all affected development locations. For extensive new developments, customers are involved in the validation process after the conceptual design has been created: One or more concepts are presented to the customers and their feedback is requested and analyzed. This process is used to reduce the number of implementation alternatives. For the subsequent coordination and planning processes both IT-based and traditional methods (travel and meetings) are employed.

- First approaches are often defined in face-to-face meetings and conferences. More recently, video conferencing (fixed image and more recently full-motion video) is also being used. This medium allows frequent, effective discussions lasting several hours without stress (no waiting periods, travel time, jetlag) and costs of long business trips.
- For later stages of coordination in which details are settled, the possibilities of electronic mail (e-mail) and telephone contacts are sufficient. At IBM, e-mail is preferred over the telephone: It is less expensive, and it has been observed that many German IBM workers dislike talking to answering machines and therefore avoid the use of the available voice mail systems.
- For final planning coordination personal meetings are used.

These early activities and the close cooperation between the different functions involved lead to a common understanding of the requirements and the content of what is eventually produced. At the same time the close cooperation promotes team building in the virtual team. The development engineer views the design process as a creative activity independent of whether the job is a new product development or extensions to an existing product. In this phase intensive team work is necessary. In the initial phase, all organizations are involved in the definition of system structures and interfaces between components and products. In the second phase of the design process, interfaces between modules are defined and component and module structures are developed locally in small teams. This staging is possible because interfaces between components and products can generally be described comprehensively and completely. The description takes a written form and is published in the team: The design document describes the layout of interfaces, all inputs, and outputs. Checking the design for completeness and correctness is labor-intensive and error-prone and requires careful coordination with others.

- Coordination takes place initially in face-to-face discussions lasting several days. Technical alternatives and implementation suggestions must be discussed and weighed against one another. The discussions serve to develop a common understanding among the various local teams about the functionality and the implementation.
- In the second phase of design, as the definition process progresses, documents are exchanged via the e-mail system of the IBM Global Network. This phase establishes

the normal communication flow between decentralized teams: a common understanding among the teams about the progress of the work is guaranteed.

The component and module design process take place in the local team. It is completed with a series of inspections of the overall design. During these inspections the correct implementation of the user requirements, consistency of interfaces, and the clear separation of functions is checked. The inspections take the form of highly interactive face-to-face discussions. Project leaders and those responsible for the design are included. By the end of the design phase all members of the team have a common understanding of the objectives and the project scope. This understanding is supported by intensive daily contacts between all team members via the internal e-mail system of IBM Global Network.

4 Interdependency and Informal Communication: Coordination in Transnational Projects

Within the last two decades, cooperation of internationally dispersed R&D units has increased, and the pressure on performing global R&D as efficiently as possible has become very intense. This puts extra emphasis on de Meyer’s (1989) prediction that individual face-to-face communication were to improve the productivity of an R&D organization, and that geographically decentralized R&D were not an efficient organization for such communication.

While new information and communication technologies have helped to bridge often great distances between R&D teams, they are limited in their applicability in creative brainstorming sessions, start-up meetings and trust building between project members. Research findings from this thesis support Reger's (1999) conclusions that, unlike many European companies, "Japanese companies make much more intensive use ... of informal mechanisms such as conferences, workshops and especially the transfer of scientists to the business units and job rotation systems, in order to create a cross-company culture."

The extent to which an R&D project can be carried out simultaneously in separate locations is determined by the degree of interdependency of the project work tasks (Gassmann and von Zedtwitz, 2003a). Fig. 8 illustrates a possible typology for international R&D projects, arranged by interdependency of work tasks and physical separation between individual R&D project groups. For example, 'individual projects' denote projects carried out by individual researchers with relatively little need of mutual coordination or communication. These projects may be short in duration, or they are undertaken by a research specialist who does not need or does not want to work with other scientists.

'Intralocal projects' are characterized by a strong interdependency of the project work tasks undertaken in one location. Because of the complexity of the project task, strong coordination and hence communication between the researchers is required. An example is the development of the ABB GT24/26 turbine or the Necar advanced development project house at Daimler-Benz. If a project is characterized by high interdependency but R&D sub-teams are forced to be located away from each other (because of, e.g., immobility of resources and facilities such as heavy testing equipment, customers, or qualified personnel), it must be carried out as an 'interlocal project.' Continuous coordination and management of diverging interests are crucial for the success of such projects.

Because international projects require significant management attention and coordination costs are high, project coordinators try to break down international projects into work packages as independent of each other as possible, thus creating a 'multilocal project.' In the ideal multilocal project, a work plan is defined centrally. The resulting tasks are grouped in independent work packages, meaning that interfaces between work packages are predefined and transparent. Each work package is assigned to the location most suited for its execution. At completion of the work package, the result (e.g., a feasibility analysis or a product component) is returned to the central project coordinator who is in charge of system integration.

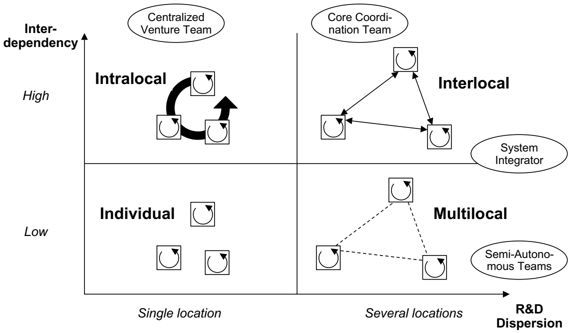

Figure 8: In interlocal R&D projects, prearranged communication is a critical success factor. The Gassmann and von Zedtwitz (2003a) classifications are given for reference.

From a cost-driven point of view the multilocal project form is to be preferred because the costs of coordination and communication are small and there is no costly relocation of resources. Although supposedly most international R&D projects are designed that way, most of them are later characterized as coordination, communication and travel intensive. Apparently, these projects assume less favorable organizational forms. How can this be explained?

We must look at international R&D project management from several angles. First of all, complete independence between work packages can never be achieved. At one time or another, system reviews must be conducted and the whole project structure and workload may require adaptation. As long as the project team is small and not dispersed physically, and the technology is still in its formative stage, there is nothing wrong with making the technology or product development project more effective. However, once the team has grown, several R&D sites are involved in the project, and a substantial amount of the targeted technology has already been created, changes in the product structure are extremely costly. In order to reduce the risk of costly and time-consuming project rework, it has been suggested to split international R&D work into two phases: a first intralocal phase focusing on the effectiveness of the resulting product, and a second multilocal phase concentrating on efficient execution of the project (Gassmann and von Zedtwitz, 2003b). The definition of the product or system architecture marks the transition from the first into the second phase.

The second notion is that communication in projects with dispersed teams is different from communication in a collocated team. Project-internal communication is a necessary prerequisite for project coordination and management. Formal communication mechanisms include technical reports, standardized project reviews, task descriptions, shared databases, presentations and meetings. The critical role of informal communication is still largely underestimated in project success. Shared coffee-corners, open work and office space and team mixing are directly job-related approaches, but joint weekend trips and the company gym extend the reach of facilitating informal communication. However, the project-internal informal communication is hampered if project members are dispersed across several remote locations. While formal mechanisms remain to fulfil their role as a bi-directional information provider, informal communication effectively breaks down. Communication then cannot happen on the spur of the moment – no spontaneous brainstorming with a colleague next door, no discussions over a hand-written sketch at the coffee table.[2]

Therefore, even informal communication (as a basis for project coordination) in international R&D must be prearranged (see earlier case examples). Among the most important approaches are international personnel rotation in order to establish a worldwide network of contacts (e.g. Hitachi's HIVIPS), liaison officers and gatekeepers, temporary assignments with the remote project team (e.g. Unisys's 24-hour project scheme), and the education of people to exploit new communication technologies to their fullest potential (e.g. ABB's PIPE). All of these approaches involve a fundamental cultural shift: Employees must think multinationally and they must be highly computer-literate.

In anticipating such difficulties in international R&D work, some companies initiate transnational R&D projects with the not explicitly stated yet equally important motivation to foster the creation of an international network of R&D individuals. These R&D employees will be experienced in executing transnational R&D projects, and they will know their counterparts in future collaborative projects. Such experimental transnational R&D projects are often research-oriented, not time-critical, and of small scale, hence reducing economic risks. The creation of a transnational R&D workforce with strong networking and communication capabilities is more important than substantial advances in R&D. These individuals become also important in strategic cooperation between the parent company and another firm. They are the nuclei for future transnational R&D projects.

5 Theory Take-Aways

For the purpose of this chapter, the focus was on three problems of communication and coordination in virtual R&D teams. The first problem area was concerned with the formulation of knowledge and its transfer. Nonaka and Takeuchi (1995) proposed a model of knowledge conversion between tacit and explicit knowledge. It has been often noted that tacit knowledge is best transferred face-to-face and in demonstration/practice settings. The transfer of tacit knowledge has remained a problem for virtual teams even when one resorts to simple communication techniques such as emailing snapshots of whiteboards and sketches. On the other hand, the Internet and other global communication means provide convenient means for the

[2] Allen (1977) found a logarithmic relationship between the probability of communication and physical distance, pointing out that the likelihood of communication among scientists approaches zero after only a few meters away from their immediate office or work space.

transfer or large data amounts, but still lack the human touch. Video-conferencing and virtual reality communication, which promise to introduce communication richness at great distances, are still in their infancy. We summarize this research in the following proposition:

Proposition 1: Virtual teams find it more difficult to transfer tacit knowledge, which introduces a tendency to exchange explicit rather than tacit information in virtual communication.

The second proposition is concerned with communication quality. Virtual teams are ICT based, i.e. heavily interconnected by email, telephone and shared databases. The platforms for frequent communication are present. However, De Meyer and Mizushima (1989) used the concept of half-time of trust to describe decreasing familiarity and trust relationships between remote team members. The more time passes without face-to-face contact, the greater the alienation within the team, the lower the likelihood to share critical information, and the lower the frequency of knowledge exchange taking place. We thus formulate:

Proposition 2: Knowledge exchange in virtual teams takes place less frequently than in collocated teams.

The third proposition deals with coordination issues in virtual R&D teams. Unlike in physically collocated teams, where the design of office space and functional as well as hierarchical separation delimits and defines communication boundaries, email is a truly 'democratic' communication media cutting across all such boundaries. Communication lines are added exponentially in unrestricted networks, and logarithmically only in hierarchical networks. In order to avoid information chaos, such as inundation or inconsistency, channels and platforms of communication emerge or are introduced that are specific to virtual teams and extend beyond established communication traditions. At the same time, because of the highly decentralized character of virtual teamwork, these new channels of communication are integral to the coordination of virtual teams.

Proposition 3: Virtual teams establish new forms of communication channels that are integral for virtual coordination.

6 Lessons Learned

The application of IT is absolutely vital in large-scale international projects where there is a high degree of division of labor. Although the application of IT is a prerequisite for virtual R&D teams, it is not by itself a sufficient guarantee of a project's success. Rather, the technical aids must be complemented by organizational and human-relations components.

For the application of IT in virtual R&D teams, various conditions must be fulfilled. In summary, the following recommendations can be made:

1. The spatial and organizational shape of virtual teams must be specifically tailored to the project. This means that certain situations may necessitate bringing together a virtual team in one place (e.g. for radical innovations, when there is a large proportion of implicit knowledge at the start of a difficult project), even when sufficient IT-facilities are available.
2. IT cannot act as a substitute for traditional project management in virtual teams. Replacing travel and face-to-face communication in transnational R&D projects by IT-

based communication places particularly high demands on the project leader. Cultural tolerance and empathy between the project leader and the team prove to be a basic condition for the communicative openness required.

3. A large part of the team should know one another before the start of the project. If this is not the case, intensive measures for developing team spirit are necessary at the start. For this purpose the team must be assembled in one place. Once an atmosphere of trust has been built up among the team members, this must be continually revived, as it drops off in the course of decentralized cooperation ("half-life of trust").
4. The use of e-mail, common databases, and remote login is usually crucial if the virtual team is to be able to work efficiently. Video conferences can be a useful complement to face-to-face meetings.
5. Despite the enormous progress made in IT, face-to-face contact is still essential in transnational R&D projects. The degree of virtuality of R&D teams is determined by the degree of trust required, the proportion of implicit knowledge and the complexity of the project. Integrated problem-solving strategies often still require interpersonal communication within traditional teams. The longer the duration of an R&D project and the greater the continuity of the team, the easier it is for face-to-face communication to be replaced by IT-based communication.
6. Brief project summaries are often better than long status reports, and they offer fewer opportunities for misunderstandings, especially when backed up with a video summary.
7. In larger projects is seems especially useful to manage communication with a dedicated infrastructure, a project communication office, and a schedule when and what information to be exchanged.
8. As prearranged communication is in conflict with spontaneous creativity, it is necessary to provide a sufficient platform for the latter to take place efficiently.

7 Concluding Observations for Management

Although the drivers for and against transnational project execution are far from complete, and the set of potential indicators of interlocality and multilocality require further discussion, it is possible to apply the principle of controlling as outlined above as a means of providing a tool for the improvement of management and organization. Figure X depicts a simple chart of what conclusions can be drawn if the observed transnationality of a project does not match the planned one.

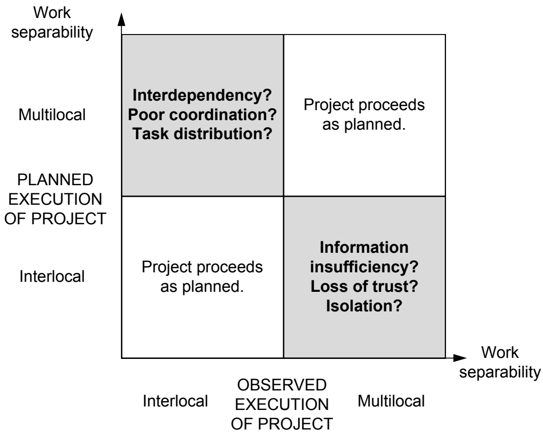

Figure 9: Mismatch between planned and observed virtual R&D projects.

If an R&D project has been conceived and designed for interlocal execution, and the observed characteristics of the transnational R&D process does indicate its interlocality, then the project behaves as planned. No interference with its project management is needed. The same logic applies to multilocal projects.

A mismatch between planned and observed transnationality occurs if a designated multilocal project is executed in an interlocal way. More communication and interaction takes place than originally planned, serving as an indication that actual interdependency of the project work tasks is much higher than anticipated. Possible other causes may be insufficient coordination or unfavorable distribution of work tasks. If an interlocal project is carried out as a multilocal project, i.e. if project members interact below the planned extent, then this can serve as an indication for too little communication and information exchange, loss of trust, and isolation. Important results may be lost; the project is prone to be delayed or may be even canceled because critical milestones are not reached in time.

In conclusion, this chapter presented some of the challenges and opportunities of virtual R&D projects and their team-internal communication and coordination. It proposes three degrees of virtuality of R&D projects—intralocal, interlocal, and multilocal—and advances three theoretical propositions. The literature review provided a quick summary of key dimensions to be considered in virtual / international R&D projects, illustrated by five mini-case studies (six, if including Shell's Carilon). While the technological underpinnings of ICT are constantly improving, the managerial tools seem to follow more slowly. Despite conceptual advances, the gap between technological potential and managerial practice in transnational R&D and innovation processes seems to be widening.

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Chapter 15

What enables frugal innovation? An examination of innovation pathways in India's auto component industry

Rajnish Tiwari and Katharina Kalogerakis

Abstract

Recent research suggests that emerging economies can act as lead markets for innovations aiming at achieving affordable excellence. On the other hand, the overall R&D intensity of, and the number of patents filed by most firms in the developing world remain low. Only little published research exists so far – going beyond anecdotal evidence based on a limited number of cross-industry cases – about how successful emerging economy firms from a given industry actually are in a long-term perspective and what innovation pathways they take. This paper examines innovation capabilities in India's auto component sector, which has acted as a key enabler of frugal, extremely cost-effective solutions in the vehicle industry. Results of our multi-layered study, based on sectoral and firm-level data, suggest that firms often engage in open innovation to reduce development costs; but also that they have accumulated significant product development capabilities. Leapfrogging to latest (manufacturing) technologies allows firms to engage in process innovations, lightweighting of components and significant reduction of waste. Very high efficiency levels are found to be central to balancing economic, environmental and technological considerations. The study discovers a remarkable set of frugal innovation pathways that make use of collaborative development, avoid over-engineering and are often driven by economies of scale.

Keywords: Frugal Innovation; Innovation Pathways; Automotive; India; Frugal Innovation Pathways

1 Introduction

Building innovation capabilities usually depends on business and technological strategies pursued by firms (Dosi, Freeman, Nelson, Silverberg, & Soete, 1988) and the incentives set by the state and its institutions (North, 2008). In most emerging economies, firms are, however, faced to varying degrees with weak institutional infrastructure, little government support, and low levels of disposable incomes that make it difficult for firms to engage in high-risk technological projects (Gupta & Subramanian, 2016; Lall & Pietrobelli, 2002; Nair, Tiwari, & Buse, 2017). And yet, recent research has shown that emerging economies are catching up in terms of innovation (Gerybadze & Merk, 2014) and that "lead markets" can also emerge in countries of the developing world, especially if they are endowed with a large demand base and significant technological capabilities (Tiwari & Herstatt, 2014). India's "small car" industry has been cited as one such example of lead markets in the developing world.

It has been also suggested that resource-constrained settings in emerging economies, such as India and China, are especially conducive for creating affordable solutions with "good

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R. Tiwari and S. Buse (eds.), *Managing Innovation in a Global and Digital World*, https://doi.org/10.1007/978-3-658-27241-8_16

enough" quality, also known as "frugal innovations" (Radjou & Prabhu, 2015; Sharma & Iyer, 2012; Tiwari & Herstatt, 2012). Frugal innovations can be defined as those innovative products, services or processes that "seek to create attractive value propositions for their targeted customer groups by focusing on core functionalities and thus minimizing the use of material and financial resources in the complete value chain. They substantially reduce the cost of usage and/or ownership while fulfilling or even exceeding prescribed quality standards" (Tiwari, Fischer, & Kalogerakis, 2017: 24).

Product development pathways, in general, are determined by factors under control of the innovating company as well as by factors belonging to the ecosystem in which the company is embedded, such as economic, regulatory, societal and political contexts (Mittra et al., 2015; Schmitz and Altenburg, 2016). What, however, remains unclear is how appropriate innovation pathways are created for developing frugal solutions, what influence they have on innovation capability of the firm, and how they help firms to overcome the operational constraints mentioned above (see, e.g., Altenburg et al, 2016).

The aim of this paper is to assess innovation capabilities in India's auto component industry in order to identify innovation pathways leading to success and expansion of this industry in India. Key insights of this paper indicate that frugal innovation is an important element for successful innovation pathways in the Indian automotive industry.

The paper is structured as follows: after this brief introduction, section 2 familiarizes the reader with the research design employed for this study. Section 3 provides an overview of India's auto-component industry and the sectoral innovation activities. Section 3 contains four firm-level case studies and a cross-case comparison. Results and their limitations are discussed in section 4, while section 5 contains a concluding summary.

2 Research design

Insights about innovation capabilities of the Indian auto component industry were derived in a four-step process. First, a thorough literature review and scanning of available industry-level statistical data was conducted to generate understanding of the macro-level developments in the industry. In a second step, a database was constructed to collect firm-level information available in public domain regarding ownership structure, firm age, presence of formal R&D, and the generic financial performance for all company-members of the Automotive Component Manufacturers Association of India (ACMA).

As next, we conducted a study of annual reports of 123 publically-listed companies from the auto-component sector (ACMA members), whose annual reports were available for a consecutive period of 6 years between fiscal years (FY) 2009-10 to FY 2014-15..[1] Analysis of annual reports enabled us to track formal expenditures on R&D and of innovations that the firms announced to their (potential) investors in a legally-binding document. With this step some general insights about innovation capabilities in this industry could be derived.

[1] Indian fiscal years (FY), unless specified otherwise, pertain to the period from April of a given calendar year to March of the following year. All monetary values originally available in Indian rupees (INR) have been converted to international currencies (euros and USD) using the average annual exchange rate in the applicable FY or calendar year, as published by Reserve Bank of India (RBI, 2016).

Finally, we conducted 4 case studies to investigate the innovation profiles of selected companies in detail covering 16 years' period from FY 2000-01 to 2015-16 in order to observe different innovation pathways. We selected cases representing Indian and German auto component suppliers operating in India's auto component industry. For each country of origin, we analysed 2 large firms as well 2 SMEs allowing us to generate some preliminary ideas about the eventual correlation of firm size or nationality on the innovation pathways taken.

3 Indian auto-component industry

3.1 Brief history

After Independence in 1947 India started on the path of a "mixed economy" in which substantial parts of the economy were reserved for state-owned enterprises (Kumaraswamy, Mudambi, Saranga, & Tripathy, 2012). A complex policy of industrial licences and permits was introduced to protect the nascent domestic industry and to ensure economies of scale for firms. However, the policy effectively also ended up reducing competition, putting barriers on demand and creating quasi-monopolies leading to relatively high prices and low-quality of products. In this period, "innovation in India", according to Kumar and Puranam (2012: xi), "contorted itself mainly into an ingenuity to overcome import, licensing, and other bureaucratic controls."

In the early 1980s, the government initiated a modernization program with relaxations for the automotive industry. Passenger car segment was "identified as a core industry of national importance" (Tiwari & Herstatt, 2014: 109), and the government entered a joint venture (JV) with Suzuki Motor Corporation of Japan, leading to introduction of some Japanese standards and technologies to the Indian automotive industry. However, all JVs with foreign companies were required to "achieve 95% indigenization within 5 years of start of production" (Tiwari & Herstatt, 2014: 109) and, in hindsight, these local content requirements may have been a boon for domestic component suppliers incentivizing them to improve their competences, even as this policy "forced" OEMs to help their domestic suppliers raise standards and in some cases to collaborate with global technology leaders (Bhargava & Seetha, 2010; Diebolt, Mishra, & Parhi, 2016).

After a severe economic crisis in 1990-1991, a new phase of industry liberalization was initiated (cf. Ahluwalia, 2002). Since then, the Indian automotive industry has been developing dynamically. In a phased process import restrictions were removed by 2002 and customs duties were cut substantially (Diebolt et al., 2016).[2] In the post-liberalization phase, global firms entered the Indian market creating another competition-induced incentive for domestic firms to upgrade their technological base as well as new avenues to collaborate with their global counterparts.

3.2 Current profile

Today, the auto component industry in India can be divided into an organized and an unorganized sector. More than 800 companies were registered with the Automotive Component Manufacturers Association of India (ACMA) at the end of May 2018 (ACMA, 2018a). While

[2] Detailed accounts of the historical development of the automotive industry in India can be found in, for example, Kathuria (1987), Narayana (1989), D'Costa (1995), and Narayanan (1998).

the organized sector companies represented in the ACMA account for over 85% of the turnover of the auto component industry in India, the rest (~15%) is generated by about 10.000 small companies active in the so-called unorganized sector often catering to the aftermarket category (IBEF, 2017). An analysis of the ownership pattern in our database shows more than three-fourths (77%) are wholly-owned domestic firms, while 15% are wholly-owned affiliates of foreign firms. Among the rest, 4% have a mixed form of ownership and for the rest no clear form of ownership could be ascertained. More detailed results of this analysis have been reported in Tiwari and Kalogerakis (2017). The industry has registered an enormous growth since the turn of the millennium, see Table 1.

Table 1: Key financial data for India's auto-component industry (in billion USD)[3]

Fiscal Year	Turnover	Exports	Imports
2000-01	4.4	0.6	0.7
2001-02	5.2	0.6	0.7
2002-03	5.9	0.8	0.7
2003-04	8.1	1.3	1.4
2004-05	10.6	1.8	2.0
2005-06	14.8	2.5	2.7
2006-07	23.0	3.6	4.8
2007-08	27.2	4.5	7.1
2008-09	24.1	5.1	8.2
2009-10	30.8	4.2	8.0
2010-11	41.3	6.7	10.9
2011-12	42.2	8.8	13.8
2012-13	39.7	9.7	13.7
2013-14	35.1	10.2	12.8
2014-15	38.5	11.2	13.6
2015-16	39.0	10.8	13.8
2016-17	43.5	10.9	13.5
2017-18	51.2	13.5	15.9
CAGR	15.5%	20.2%	20.5%

Top-5 sources of imports in FY 2017-18 were China (27%), Germany (14%), Japan (11%), South Korea (10%) and USA (7%), while top-5 export destinations were USA (23%), Germany (7%), Turkey (5%), UK (5%) and Italy (4%), as the ACMA (2018b) data show. A very large number of auto component suppliers in India have secured international quality certifications, such as ISO 14001, TS 16949, and ISO 9001 indicating high process efficiency and quality control (Tiwari & Herstatt, 2014).

3.3 Innovation activities

While in 1991 only two auto component sector companies out of 99 in the Prowess Database of the Centre for Monitoring Indian Economy (CMIE) were reported to have had a formal R&D budget (Nath et al., 2006), a study by Ramamoorthy and Tiwari (2009) found that 174 out of 425 member companies of ACMA (41%), whose R&D activities could be assessed, had established formal, in-house R&D activities by 2009.[4] The analysis of own database shows that altogether 302 firms (~42%) report some form of formal R&D activities in their annual reports and/or on their Internet pages. An increasing number of companies in a simultaneously growing set of players are thus engaging in formal R&D activities.

[3] Source: own construction based on ACMA/SIAM data

[4] Also see Pradhan and Singh (2008) for an in-depth analysis of R&D activities between 1991-2007 based on the Prowess database. The study, however, is based on a varying sample size limiting its generalizability.

Generally speaking, the propensity to engage in R&D seems to be significantly higher when domestic and foreign firms hold a joint stake in the firm (shared ownership) than when they are wholly-owned domestically or otherwise (Tiwari & Kalogerakis, 2017). A probable explanation could be that R&D related activities are a key motivation for such joint investments. Our analysis of annual reports of 123 publically-listed companies in this sector for FY 2009-10 to FY 2014-15 provides deeper firm-level insights into innovation activities of auto component suppliers in India. We conducted a study of firms whose official data was available in public domain for a consistent period of 6 fiscal years.

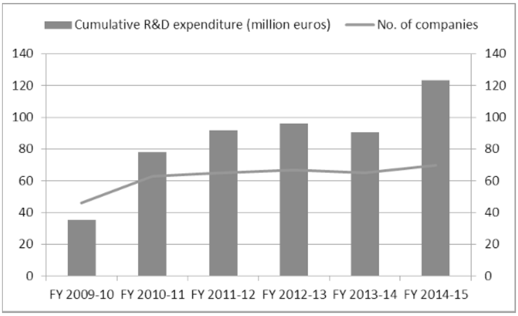

Figure 1: Cumulative R&D expenditure by publically-listed component suppliers[5]

Altogether 70 firms out of 123 reported a cumulative R&D expenditure worth €123.5 million in FY 2014-15, while just 6 years ago only 46 firms had formally reported R&D expenditure to the tune of €35.5 million (Figure 1). Average annual expenditure per firm has continuously increased in this period from €0.77 million to €1.76 million signifying increasing R&D engagement of certain firms. However, compared to developed countries the R&D intensity is still quite low and averaged only 0.52%; the median value languished even lower at 0.17%.

4 Case study analysis

As a next step, we analysed promising cases of four firms listed at the stock market which ensured data availability. The selected cases represent 2 Indian (IN) and 2 German (DE) firms. The sample also represents 2 large and 2 small firms (see Table 2). All monetary values are in million euros in FY 2015-16.

[5] Source: own illustration

Table 2: Overview of investigated cases[6]

Case	Firm Origin	Size	Turno-ver	Exports' Share
Bharat Forge Ltd. (BFL)	IN	Large	595.6	57.1%
Menon Bearings Ltd. (MBL)	IN	SME	15.5	6.9%
Bosch India Ltd. (BIL)	DE	Large	1412.9	10.7%
Hella India Lighting Ltd. (HILL)	DE	SME	19.7	11.1%

4.1 Bharat Forge Ltd.

Bharat Forge Ltd. (BFL) is a leading powertrain and chassis component manufacturer headquartered in Pune, India. It was incorporated in 1961 and is a part of the Kalyani Group, which is a conglomerate with a reported annual turnover of $2.5 billion and a global workforce of about 10,000 (Kalyani Group, n.d.). The Kalyani Group is the largest forging company in the world, holding the No. 1 position in Engineering Steel as well as in Axle Aggregates in India (Kalyani Group, n.d.).

BFL, the daughter concern, has successfully established itself as a tier-1 supplier in the global automotive market (Kumaraswamy et al, 2012). It has 10 manufacturing locations spread across India, Germany, France and Sweden and employed 4,766 permanent employees in March 2016. In FY 2015-16, BFL, as a standalone company, i.e. excluding the business of its subsidiary and affiliates, generated a turnover of €596 million, with exports accounting for over 57% of the revenues.

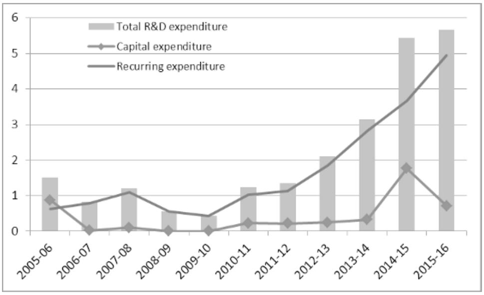

Figure 2: Development in R&D expenditure of BF (in million euros)

The company's revenues have more than quadrupled since FY 2000-01 and the share of exports has risen in this period from less than 16% to over 57%. The firm supplies to all major Indian and global OEMs and tier-1 suppliers and its net worth has grown from €24 million in

[6] All information, unless specified otherwise, are taken from the respective company's annual reports for FY 2000-01 thru FY 2015-16, except for BIL. In case of BIL, the data from 2000 to 2013 pertain to calendar years, for 2014 to a 15 months' period from Jan. 2014 to March 2015; after that the company shifted to Indian fiscal years (2015-16).

FY 2001-02 to €504 million in FY 2015-16. BFL has emerged as an innovation-oriented company that has managed to reverse its employee ratio of 85% blue-collar workforce into 85% engineering workforce (Kumar & Puranam, 2012; Ramachandran & Mukherji, 2005).

In FY 2015-16, the company spent €5.7 million on R&D efforts, registering an R&D intensity of 0.95%. Truly interesting, however, is the development in the expenditure on recurring R&D costs. The company has increased its expenditure on recurring R&D costs from €0.43 million in FY 2009-10 to €4.95 million in FY 2015-16, while capital expenditure on R&D has been more variable (see Figure 2). The company also reported royalty payments worth €0.07 million in FY 2015-16, while it also regularly – though not every year – reports payments for technical service and technology license fees, pointing towards the role of external knowledge in its innovation strategy. Company's overseas subsidiaries also engage in R&D.

As benefits derived by the company from its technology absorption, adaptation and innovation efforts, BFL annual reports regularly report product improvements by implementing lightweighting and ensuring better fatigue strength. It also stated to have developed new operational processes enabling it to minimize errors and to achieve first-time quality, as well as reducing development cycle time for new part development. It also reported improved die life. (BFL, 2001-2016). Ramachandran and Mukherji (2005: 2) quote Baba Kalyani, Chairman and Managing Director of BFL, as saying, "Today our manufacturing side is on par with [the] best anywhere in the world and at a cost that is lower by almost 20-25%!"

BFL filed 12 patent applications in FY 2015-16 and 7 in the FY before that, bringing the total number of patents filed till then to 22. Beginning with 2010, BFL started reporting presentation of technical papers by its staff at various national and international conferences. Baba Kalyani has stated that the company is committed to developing technologies that help reduce carbon footprint, enable manufacturing of lightweight products and lead to lower energy consumption. For this the company is encouraging its employees to take up basic research. (Annual Report 2015-16, p. 9).

In short, BFL presents the example of a large Indian firm that has grown consistently and has been taking efforts to turn towards focused, customer-centric innovations that combine qualitative excellence with affordability by integrating modern technologies. For this purpose, the company also actively seeks modes of open global innovation networks both within and outside firm boundaries. It seems that BFL is following a strategy which has the potential to transform its manufacturing and logistic processes radically.

4.2 Menon Bearings Ltd.

Menon Bearings Ltd. (MBL) is based at Kolhapur in Western India and is engaged since 1991 in producing "bi-metal Engine bearings, Bushes & Thrust Washers for light & heavy automobile engines, two wheeler engines as well as compressors for refrigerators, air conditioners etc." (MBL, 2017). MBL reportedly belongs to those few companies in India that have "fully integrated manufacturing facilities under one roof, to produce a wide range of critical auto components" and its engineering capabilities enjoy "strong brand equity among leading OEMs all over the world" (NDTV Profit, 2017). MBL's customers, as per company statement, include Indian and global OEMs such as General Motors, Tata and Volvo, and tier-1 suppliers, such as Honeywell and Knorr-Bremse. Its business activities reportedly span across 24 countries. The company's net revenues in FY 2015-16 stood at €15.5 million, while the share of (direct) exports stood at 6.9%. Main export destinations included Brazil, China, France, Italy, Mexico, UK and USA. The company revenues have grown almost four-times since FY 2000-01 (MBL, 2001-2016). It was around ten years ago that MBL decided to ramp up its facilities to be able to cater to demands of the low price segment by providing quality solutions in a high volume market with lower margins (Annual Report for 2007-08).

By and large, the company reports do not mention any regular and significant amounts of R&D expenditures, royalty payments or filing of patents. In FY 2015-16, MBL spent €0.03 million on R&D efforts, reaching an R&D intensity of 0.21%. Nevertheless, the company reports several innovations. For example, in FY 2015-16, it reported development of "Copper base Sintered Lead free material" and special bi-metallic bushes. These innovations, as per firm's statement, lead to reduction in pollution, cater to specific requirements of customers and increase cost competitiveness. In FY 2012-13, MBL reported developing a new planting technology which enabled doubling of production with unchanged manpower and electricity consumption. The company has also cited reduced lead time, less scrap generation, low inventory, and enhanced productivity as benefits generated by its innovation efforts (e.g. in FY 2007-08). Technology imports from countries such as China, Israel, Lithuania and Taiwan are reported regularly. Benefits derived from technology absorption, adaptation and innovation are improved productivity, saving of manpower costs, reusability of material and reduction in material costs.

Overall, the innovation pathway of the company points to "new for firm" solutions with a proactive integration of global technological solutions. The company actively seeks to engage in the path to ecological sustainability by reusing material and waste. Development of new, environment-friendly materials and production processes points towards efforts to achieve high efficiency with modern technologies. An analysis of characteristics of reported innovation reveals high emphasis on increasing product robustness and longevity ("service life") as well as environment-friendliness. In a nutshell, the company strives to develop "cost-effective products of high quality and standard", as stated in its Annual Report 2011-12.

4.3 Bosch India Ltd.

Bosch India Ltd. (BIL), earlier known as Motor Industries Company (MICO) Ltd., is a majority-owned affiliate of Germany's Bosch Group. Its business operations in India go back over 95 years, and its first manufacturing unit in India was established in 1953 (Tiwari, 2014). Robert Bosch GmbH holds a 71.18% stake in BIL. The Bosch Group in India, however, apart from BIL consists of five more wholly-owned companies (BIL, 2015). BIL has entered joint ventures with other organizations in India. For example, it has set-up a JV with Mann and Hummel Filter Pvt. Ltd., to deliver filters for automotive as well as industrial applications for the Asian market (Mann-Hummel, 2016).

The company reported total (standalone) sales worth €1,413 million in FY 2015-16, nearly four times more than in 2001 (€343 million). Its export revenues also grew from €46 million to €151 million in this period, leading to an export share of 10.7% (BIL, 2001-2016). This growth has been enabled by continuous investments. In the three years preceding FY 2015-16, the company has reportedly invested €242 million in India and its net worth has increased from €150 million in 2001 to €1.2 billion in FY 2015-16.

BIL is also the single largest spender on R&D in India's auto component sector. In FY 2015-16 it spent €24 million on R&D (intensity 1.7%). Its recurring expenditure on R&D doubled from €11 million in 2010 to €22 million in FY 2015-16. Another prominent feature of BIL's innovation activity is characterized by its relatively large expenditure on royalty and technical service fee. This expenditure has grown from €8 million in 2009 to €22 million in FY 2015-16 (see Figure 3). Including this expenditure, the innovation intensity reaches the mark of 3.3% of revenues. BIL takes recourse to knowledge and technologies being developed in the global Bosch Group, which employs close to 56,000 associates in R&D at 118 locations worldwide. In India alone, the Bosch Group employs nearly 14,000 associates for R&D related work (Annual Report 2015-16).

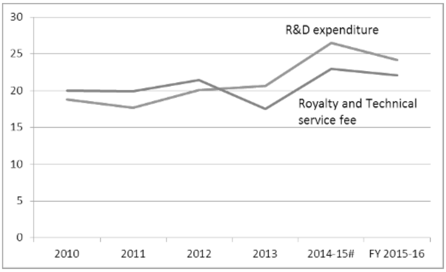

Figure 3: Development in innovation expenses of BI (in million euros)

BIL and the Bosch Group are known to have contributed significantly to creation of several frugal vehicles (Tiwari & Kalogerakis, 2017). Especially, its role in the creation of the Tata Nano, the world's most inexpensive car, has been very well documented (Chacko, Noronha, & Agrawal, 2010; Freiberg, Freiberg, & Dunston, 2011; Schuster & Holtbrügge, 2011). Process efficiency has been high on BIL's agenda. Around 2004 it introduced a tool called the Bosch Production System (BPS), "for eliminating waste in production and associated business processes" in all plants leading to reduction in raw materials inventory, in set-up time and improving "first pass yield thereby increasing flexibility towards changes in customer demands and reducing costs".

Improving fuel economy, increasing resource efficiency, catering to the rising emission standards and developing robust solutions for the low cost/price segment seem to be the common thread that can be discerned from the technology absorption, adaptation and innovation activities described in the annual reports of BIL in the period of study. The firm itself cites providing "optimum cost/benefit ratio for system solutions" and solutions specific to the market needs in India ("localization") as core benefits derived by its R&D activities in the country.

4.4 Hella India Lighting Ltd.

Hella India Lighting Ltd. (HILL) is a majority-owned affiliate of Germany's Hella Group engaged in the business of producing horns and lamps for the automotive industry, which accounted for 17% and 59% of the business respectively in FY 2015-16. The company, in its own words, seeks to bring "Technology of Tomorrow for the Life of Today" and became active in India at first in collaboration with J.M.A. Industries Ltd. in 1959. The JV was dissolved in 2005 (HILL, 2017). Its revenues in FY 2015-16 stood at €19.7 million, with an export share of 11.1%. The business has grown very significantly, growing over four-times from €2.5 million in FY 2000-01.

The company does not report any significant formal R&D expenditure or filing of any patents in its annual reports between FY 2000-01 and FY 2015-16. But remarkably, it regularly reports innovations such as design and development of LED interior lamps, car segment fog lamps (FY 2013-14), low-cost Rocker Switches and sheet metal reflectors (FY 2014-15), low-cost electronics for LED rear lamps (FY 2015-16). Also several new technologies have been introduced. In FY 2009-10 the company reported that it "has its own Design & Development Department (D&D) and they were continuously making efforts towards technology, absorption, adaptation and innovation".

As its future plan of action the company regularly states objectives such as coming up with more competitive products with reduced costs and higher economies of scale. Such innovations have helped HILL, as per its own statement, to enter new market segments, increase sales/profit, enhance product portfolio, optimize processes and increase productivity (FY 2013-14). The "discrepancy" of the reported nil R&D expenditures and a simultaneously intensive innovation activity points towards limitations of using (declared) R&D spend as a core measure of innovation activity. A possibly better (partial) indicator for innovation here lies in the royalty payments reported by the firm. In FY 2015-16, HILL reported royalty payments worth €0.13 million, which was almost 3 times higher than 4 years ago. Furthermore, the company seems to place a lot of emphasis on having design and development capabilities for "complete in-house product development" sourcing technologies from within its Group firms.

It seems as if HILL follows the objective of developing and producing reliable products that fit the cost targets of its customers, for which it uses the term "Value fit products". Furthermore, it mentions time ("critical fast track development") as a critical success factor in competition. Overall, the company seems to follow a strategy of acquiring latest technologies from its mother concern and then develop solutions specific to the local market needs.

4.5 Cross Case Analysis

Comparing the cases on indicators such as establishment of formal R&D, payments of royalties for securing access to technologies, taking recourse to open global innovation networks (OGINs) and the propensity to file patents, an interesting picture emerges (see Table 3).

The two large companies (BFL and BIL) have established formal R&D processes, whose size has been growing significantly even if their R&D intensity is still rather low. The two small companies in the sample do not seem to place a similarly high importance on formal R&D. While MBL occasionally reports R&D activities, HILL continuously reports them as being *nil*. Nevertheless, all firms in the sample, judging from the innovation activities mentioned in their annual reports, are fairly innovative.

Looking at the nationality angle, it seems that the two German firms are more often engaged in technology adaptation for the cost-sensitive, local market. This is corroborated by their regular and substantial royalty payments in foreign currency to their holding concerns (BIL: 1.56% of the turnover; HILL: 0.64% of the turnover; both in FY 2015-16). Both Indian firms engage occasionally in acquiring technologies abroad and royalty payments are not reported every year.

All 4 firms engage in open global innovation networks (OGINs), even though there are differences in approach. While the two large companies interact with a variety of actors within and outside their own global firm boundaries, for HILL it is basically about a global engagement within firm boundaries of its parent concern; and MBL's engagement is focused on technology imports. No information was available to indicate joint product development efforts at MBL. The two small firms, therefore, appear to engage only partially in open innovation.

Table 3: Comparison of cases on selected indicators

Case	Formal R&D	Royalty Payments	OGINs	Patents
BFL	Regular	Occasional	Yes	Increasing
MBL	Occasional	No	Partially	No
BIL	Regular	Regular	Yes	Increasing
HILL	No	Regular	Partially	No

In terms of patents both large firms were starting to file a growing number of patents, or even otherwise engaged in active creation of intellectual property (IP) for example by publishing technical papers. It seems that the two smaller firms primarily focused on application development specific to their concrete business needs.

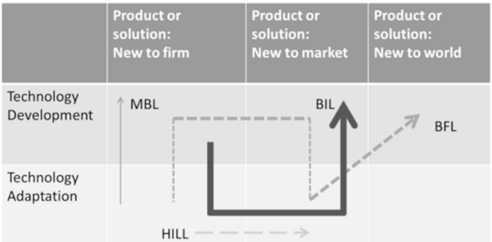

Figure 4: Identified innovation pathways for investigated firms in India.

It seems that BFL was more likely to bring out "new to market" and even "new to world" products as it starts engaging in basic research and collaborates with external research institutions. BIL is also engaged in anticipatory development, for example by creating solutions for next generation emission norms in India, and is likely to bring out "new to market" products. Bosch, however, appears less likely to create "new to world" products in India as a considerable part of its work is focused on adaptation of its global technology for the local market conditions in India. While all four companies bring out products that are "new to firm" in India, the focus of the two small companies seem to be stronger on this segment. In case of HILL, products can be also "new to market" but are mostly a result of technology adaptation. MBL is focused on efficiency gain and creating quality solutions targeted at volume markets with affordable prices. The typical product development and innovation pathways that could be identified for the 4 firms, based on publically available information, are depicted in Figure 4, where thickness of the arrow indicates the intensity of financial investments in innovation efforts (not to scale).

Similarities in respect of firm nationality appear to lie in the fact that both German companies are more focused on technology adaptation and target solutions that are new to firm and new to market. Both Indian firms investigated here seem to put greater emphasis on technology development, albeit with a strong difference in the innovation target. While BFL, in its India operations, also targets solutions new to world, MBL is rather focused on solutions new to firm. The role of firm size can be seen in the fact that both smaller firms make use of technology adaptation and have a strong focus on products that are new to firm, even when HILL partly also targets at products, which are new to market.

5 Discussion of results

As the previous sections have shown, justified high growth expectations exist concerning the auto component industry in India and the size of the Indian auto market sets a strong incentive for companies aiming for profits based on economies of scale. Within the last years, quality and production capabilities of the Indian automotive component industry have advanced and thereby enabled more and more companies to participate in the global automotive market. This trend is also reflected in the rising exports of the auto component industry.

The level of formal R&D is still low but has been continuously rising. Moreover, R&D expenditures alone, very clearly, do not give sufficient information on the level of innovation activities, as the case studies have revealed. One must also take into account additional indicators such as technology imports and royalty payments. As we discovered, there are many innovations in this industry, which take place despite low levels of formal R&D.

Looking at special characteristics of the innovations developed by investigated firms, two important aspects could be identified. Improving the environmental friendliness of solutions and implementation of new, efficient production techniques was found to be very common. In addition, companies also focused on offering robust products which offer a longer operating life and reduced maintenance costs. Cooperation with foreign companies seems to be an important source of innovation, especially as the Indian auto component industry still needs improvements to reach a better position in global competition. Companies seem to realize that they need to cooperate in order to add missing competences in terms of availability of advanced technology and the expensive and risk-prone nature of formal R&D, thereby showing an appreciation of open innovation practices.

Innovation pathways within this industry also seem to be strongly influenced by the role of the government. The state plays a key role in setting regulatory standards. More stringent safety norms and rising emission standards found often mention as a key driver of innovation.

6 Conclusion

Our findings indicate that the Indian auto component industry has developed unique frugal innovation pathways that manage to circumvent the various shortcomings of India's innovation ecosystem, by building on the strengths of that very ecosystem. The firms often engage in designing and developing products making use of modern technologies, leapfrogging certain stages and reach very high levels of process and resource efficiency while catering to market-specific demand aspects. The huge domestic market and the rising global demand for affordable, high quality products provide an incentive for investments. Cooperation between Indian and global companies as well as mergers and acquisitions have accelerated the development of innovation capabilities in India.

Furthermore, a trend to frugality, as defined by "affordable excellence", can be observed within the Indian auto component industry. Innovations are aiming to achieve a specific, desired and/or required quality level with robust features and to improve process efficiency. The focus on concrete application within requisite parameters gives rise to "appropriate solutions" that balance economic, ecological and technological performance. Altogether, the study discovered a remarkable set of innovation paths that make use of collaborative development, avoid over-engineering, are often driven by economies of scale and in which the state acts as a key promoter as well as inhibitor of innovations.

Acknowledgements

An earlier version of this paper was presented at the R&D Management Conference 2017 (Leuven, Belgium) under the title "Assessing Innovation Capabilities in India's Auto Component Industry". The study was originally conducted as a part of the project "PotFrugInno" supported by Germany's Federal Ministry for Education and Research (BMBF) under its ITA programme (Grant no. 16/1670). The authors would like to thank Dr. Luise Fischer at project partner Fraunhofer Center for International Management and Knowledge Economy (Leipzig, Germany) for constructive feedback during research design. Sebastian Cremer, Mithun Kumaar Jayavarthanavelu, Bhimsen Dattatraya Phadnis, Siddharth Poornachandran and Jakob Scheitza helped with desk research as well as in collecting and analysing data. Rajnish Tiwari would like to thank Claussen Simon Foundation for supporting his research at TUHH with a generous grant in the corresponding period.

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Chapter 16

Potential role of frugal innovation for diffusing energy management systems in Japan

Fumikazu Morimura, Rajnish Tiwari and Stephan Buse

Abstract

Increasing energy consumption is associated with major negative impacts on the climate. The Japanese government has sought to promote home energy management systems (HEMS) in private households as a measure to enhance energy security in the country. Reports suggest that while potential users appreciate the need for using HEMS, the actual adoption of HEMS in the country has remained low, suggesting a gap in consumer intention and its actual implementation. High upfront investment, high switching/operating costs and the perceived technological complexity are reported as inhibiting the adoption of HEMS in Japan. The objective of this chapter is to investigate whether and in what respects frugal innovations might help in overcoming barriers for the adoption of HEMS. Frugal innovations offer affordable excellence for significantly lowered prices, are focused on core functionalities, and enable optimized performance levels. Frugal solutions may enhance the consumer perception of benefits of HEMS, while reducing negative perceptions regarding high technological complexity or expensiveness. Although frugal innovation could help in solving the attitude-behaviour gap, to date, there is little research to argue the effect of frugal innovation on consumers' decision making process. This research contributes to the innovation adoption or resistance literatures by applying frugal innovation, which allows innovation researchers and managers to understand the mechanism of the innovation diffusion more effectively.

Keywords: Frugal Innovation; Attitude-Behavior Gap; Home Energy Management Systems; Smart Homes, Japan, Consumer Behavior

1 Introduction

Increasing energy consumption especially that of fossil fuel intensifies environmental pollution and is associated with major negative impacts on the climate (Alireaei et al., 2017; International Energy Agency, 2016). After the earthquake disaster of 2011, the Japanese government decided to stop using nuclear energy. This decision, however, also increased the country's dependence on thermal power and the resultant emission of greenhouse gases. In addition, the government initiated a policy to support installation of solar power that includes a purchasing scheme for excess household-generated electricity by solar power (Institute for Sustainable Energy Policies, 2017). As a side effect of these measures, energy costs for households have risen, negatively affecting the disposable household incomes. Innovations in energy management aimed at reducing energy consumption and greenhouse gas emission are, therefore, increasingly important for environmental sustainability in the country.

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R. Tiwari and S. Buse (eds.), *Managing Innovation in a Global and Digital World*, https://doi.org/10.1007/978-3-658-27241-8_17

Home Energy Management Systems (HEMS) provide a potential solution to the above-mentioned challenges. HEMS can be understood as systems that allow households to "efficiently monitor and manage electricity generation, storage, and consumption" (Zhou et al., 2016, p. 31). HEMS collect, visualise and monitor data, and automatically optimise energy consumption in the concerned household. They generally use smart meters with embedded sensors connected to electric appliances in the household, e.g. television, air conditioner or refrigerator, and eventually to energy generation and storage systems, such as solar power (Wunderlich et al., 2013; Zhou et al., 2016).

Energy consumption in households is prone to fluctuation and the range of the peak and bottom levels may depend on various factors such as outside temperature, climatic conditions, and the economic situation of a given household. Electric power companies generate electricity through multiple sources, for example thermal, hydro, wind, natural gas, or nuclear power. HEMS can potentially enable power generation companies to observe real-time energy consumption in individual households. Observation of the aggregated demand in real-time could allow them to maximize the use of renewable sources and better cope with the demand fluctuation and situational change. Firms and society can increase the efficiency of resources, while households can reduce energy costs

through visualising the amount of energy consumption or by optimising usage of electric appliances (Daneshvar et al., 2018; Hemmati, 2017).

Since HEMS can enable social as well as individual benefits, the Japanese government seeks to promote them as a matter of strategic policy and has set itself an ambitious objective to install such systems in all 51 million Japanese households by 2030 (GOJ, 2012). Consumers too are seen as understanding the importance of sustainable energy management (National Institute for Environmental Studies, 2017), and over 70% of them state to have intention to use this system in future (SBI Sumishin Net Bank, 2013). However, there has been very slow progress on this front: the diffusion of HEMS languished at a dismal 0.5% of all private households in 2013 and is estimated to grow to only 3% by 2020 (Fuji Keizai, 2015). Therefore, there seems to be a gap in the stated intention to use and the actual installation of HEMS. The gap between positive consumer evaluation and the low diffusion rate is an issue that requires scholarly attention.

Some innovation studies have shed light on the consumer attitude-behaviour gap toward using an innovative solution (e.g. Aschemann-Witzel and Aagaard, 2014; Papaoikonomou, 2011). These have investigated the mechanisms of consumer acceptance of innovation by identifying factors affecting customer attitude and purchase intention. For example, if a consumer anticipates benefits from an innovative solution, it would likely increase his/her positive attitude and intention to use that product, service, or technology (Venkatesh et al., 2003, 2012; Nikou and Economides, 2017; Wunderlich et al., 2013). Conversely, if a consumer perceives functional and/or psychological barriers in the usage of an innovative solutions, it would negatively affect his/her attitude towards that innovation and the intention to use would decrease (Heidenreich and Handrich, 2014; Mani and Chouk, 2017; Talke and Heidenreich, 2014). Perceived benefits in terms of financial and environmental advantages increase the positive *attitude*. In contrast, anticipated complexity of usage, ambiguous value, or perceived financial, technical and social risks decrease the *intention* to actually use those innovations (Claudy et al., 2013). Attitude-behaviour gap can explain slow diffusion and provide an important instrument to ensure customer adoption of environmentally and socially responsible products and services aimed at ensuring green consumption (Carrington et al., 2010; Claudy, et al., 2015; Hassan et al., 2016).

Previous research on the attitude-behaviour gap has explored factors or mechanisms to minimize the gap. The consistency between attitude and intention to use innovation, and intended behaviour are enacted by consumers' past experiences or knowledge to use related products or services and situation that affects consumer involvement (Carrington et al., 2010; Lane and Potter, 2007). In addition, attitude-behaviour gap is solved by information seeking capability that contribute to consumer preferences for responsible consuming behaviour (Perera et al., 2016). These are internal and cognitive factors that affect consumer decision making process. Claudy et al. (2015) suggest that firms can complement these internal factors by the design of innovation. As a result, attitude-behaviour gap would be solved. However, so far, little is known about the direct relationship between attitude-behaviour gap and the design of innovation.

The objective of this research is to address this research question: *how frugal innovations might help in overcoming barriers for using innovations*. Frugal innovations as one of the strategical design of innovations, which offer affordable excellence for significantly lowered prices, are focused on core functionalities, at requisite performance levels may offer a solution to the problems of high upfront investment, switching and operating costs as well as to overcome usage complexity (Herstatt and Tiwari, 2017, Weyrauch and Herstatt, 2016). This type of innovations would potentially contribute to enhancing the perception of benefits of innovation, and to reducing perceptions related to technological complexity, price, and uncertainties. Although frugal innovation would solve attitude-behaviour gap, to date, there is little study to argue the effect of frugal innovation on consumers' decision making process for using innovations. This research contributes to the innovation adoption or resistance literatures by applying frugal innovation, which allows innovation researchers and managers to understand the mechanism of the innovation diffusion more effectively.

In this paper, we firstly demarcate HEMS as innovation in energy management and its functions in Japan in section 2. Then we briefly discuss literatures on attitude-behaviour gap toward using innovations and frugal innovations in the section 3. In the section 4, the identified factors for the customer resistance are then matched against dimensions of frugal innovation to assess what impact, if any, availability of frugal innovations could possibly have on the diffusion of innovations. Then, we discuss implication in the section 5 and draw conclusions for attitude-behaviour gap and frugal innovations in the section 6.

2 Overview of Home Energy Management System in Japan

Japanese government set a strategic policy to increase the number of housing manufacturers and builders to install HEMS in newly built houses (GOJ, 2018). Market size of HEMS was 370 million € in 2016 but will become 1.2 billion € in 2025 (Fuji Keizai, 2017). Current progress of energy management system as represented by smart home is remarkable in Japan. The number of the kinds of household appliance that can be connected through internet exceed 100 (ASMAG, 2018). Current HEMS offers many functions based on the Internet-of-Things. Basic functions are visualising and analysing energy consumption. Each electric appliance is connected by internet and sensors, and consumers can confirm their degree of consumption. HEMS analyses the fluctuations of consumptions of each appliance, controls energy supply from solar power and battery systems, and offering improvements for consumers. Regarding the most advanced function, HEMS can automatically optimise energy consumptions based on the artificial intelligence learning from the energy consumption data, meteorological information, and weather prediction in the cloud (GOJ, 2016a). Furthermore, since 2016, because electric market was liberalised and many firms enter into market and offer various contract plans to consumers, HEMS offers the optimum contract plans to consumers. HEMS also offers peripheral functions. For example, consumers control electric appliances such as managing room temperature, cooking, laundering, and supplying the hot-water into a bathtub with voice operation, and HEMS informs them when the task is completed. In addition, regarding security, HEMS offers the functions to lock window and doors, pull down a shutter, watch the image of crime-preventing camera by remote control, and detect the inflections of electricity consumption in the nursery and notify it to parents. Furthermore, after great earthquake in 2011, countermeasures against disaster become one of upmost concern in Japan. HEMS automatically start storing electricity in battery and prepare for an interruption of the power supply when meteorological agency issue the weather warnings.

However, consumers did not perceive obvious benefit from HEMS. HEMS offers not only functions to optimise energy consumption but many functions to support users' daily life. HEMS collect various usage data from each appliance and other external information, and analyse data on the cloud by artificial intelligence. Nevertheless, the results are utilised only for reducing electricity consumption and do not contribute to the needs of consumers in their lives. Besides, HEMS shows the amount of the reduction of CO2 and its goals. However, the contribution of HEMS is ambiguous for consumers and the method to evaluate the contributions of consumers to reduce CO2 has not been established. Therefore, it is still difficult to give counsel of improvements. For these reasons, consumers hardly evaluate the benefit of HEMS compared to the install and usage costs (GOJ, 2014). The upfront price of HEMS itself is not expensive. For example, the cost of installing basic system including connecting, visualising, controlling several appliances is about 2,000 euro. However, HEMS generally assume to install and connect with solar power and battery systems and include all peripheral functions. It takes 7,700-16,000 euro for solar power and 7,000-12,000 euro for battery system and consumers must use appliances in accordance with specific communication standards (GOJ, 2018). Even though there are financial supports from local governments for solar power and battery systems, upfront cost still high.

3 Theoretical Background

3.1 Attitude-behaviour gap in consumer decision making process

Fishbein & Ajzen (1975)'s theory of reasons action explains that individuals' attitude guide their intention to behave, and intention immediately determine their action. For example, technology acceptance model (TAM) explain consumers' attitude and behavioural intention to use technologies and technology-mediated products and services (Davis et al., 2003), which is the robust and valid model to predict behavioural intention from attitude (King and He, 2006). Thus, in order to make potential consumers adopt an innovation, the simplest and efficient approach is to enhance positive attitude toward using innovation.

However, an consumers' attitude, behavioural intention, and behaviour are not always consistent. In the cognitive process, a belief that the object achieves performance and an attitude as the favourability toward the object become positive in the hypothetical and socially desirable situations. In contrast, a behavioural intention is formed in the consideration of true preference and thus tend to be negative, which cause the gap between the attitude and the behaviour (Ajzen et al., 2004; Wong and Sheth, 1985). The gap between the hypothetical and actual situation happens in consideration of public goods, ethical, responsible, and sustainable consumptions because the gap is a form of social desirability bias and consumers cover their true preferences (Auger and Devinney, 2007; Carrington and Attalla, 2001; Grimmer and Miles, 2017; Hassan et al., 2016; Juvan and Dolnicar, 2014; Perera et al., 2016). In addition, intentions created in the hypothetical situation is regarded to distal behaviour and change over time, which yield a weak association with actual behaviour in different context (Carrington et al., 2010; Sutton, 1998).

3.2 The model of attitude-behaviour gap toward using innovation

Some innovation studies try to understand attitude-behaviour gap from the viewpoint of innovation resistance. The mechanism of innovation resistance is traditionally primarily concerned in innovation management because innovations always involve change and a threat to the existing behaviour, which provoke resistance (Heidenreich and Handrich, 2015). Innovation resistance can be defined as the resistance offered by consumers against the changes that are imposed by an innovation (Ram and Sheth, 1989).

The process of innovation diffusion contains five stages: knowledge, persuasion, decisions, implementation, and confirmation (Rogers, 1995). Innovation resistance may originate from negative evaluations of products and services in or after the persuasion stage (Talke and Heidenreich, 2014) when consumers develop their attitude or intention, and behave based on their evaluations (Bettman, 1979). Innovation resistance is frequently rooted in functional and psychological barriers (Ram and Sheth, 1989). Functional barriers are perceived when potential consumers consider the attributes of products and services as inappropriate or insufficient for their expectations. Functional barriers are classified into value barrier and risk barrier. Value barrier refers to the lack of monetary and performance value, and relative advantageousness of an innovation, whereas risk barrier arises when consumers perceive the security risk and performance uncertainties associated with newness (Laukkanen et al., 2008). Psychological barriers arise when an innovation is inconsistent with the consumers' past experiences, values, acceptance requirements, or existing usage patterns (Talke and Heidenreich, 2014); see Table 1.

Innovation barriers explain reasons why consumers avoid using innovations and reveals the mechanism of attitude-behaviour inconsistency. The model of attitude-behaviour gap toward using innovation is based on behavioural reason theory that explains consumers' evaluations both for and against when they decide about the adoption of an innovative product or service. These dichotomous drivers are conceptualized as facilitators and barriers (Westaby, 2005). Positive reasons for behaviour increase both attitude and behavioural intention, whereas negative ones hamper both of them.

Table 1. Barriers of using an innovation

Barrier categories	Description of barrier	Second-order factors (Effects on barrier)	Definition of second order factors
Usage barrier	If the use of the new service is inconsistent with the consumer's past experiences, values, and acceptance requirements, the consumer then needs a long time to accept the innovation (Lian & Yi, 2013)	Perceived ease of use (-)	Degree to which the prospective user expects the target system to be free of effort (Davis et al., 1989)
		Complexity (+)	Degree to which an innovation is perceived as difficult to understand and use (Roggers, 1995)
		Compatibility (-)	Degree in which the use of an innovation is perceived as consistent with socio cultural values and believes, past and present experiences, and the needs of potential adopters (Rogers, 1995)
Value barrier	The value barrier refers to the lack of monetary and performance value of an innovation. Laukkanen et al. (2008)	Perceived usefulness (-)	Degree to which the prospective user expects the target system will increase his or her performance (Davis et al., 1989)
		Relative advantage (-)	Degree to which an innovation is perceived as being better than the idea/product it supersedes (Arts et al., 2011; Rogers, 1995)
		Perceived price (cost) (+)	Price is what is given up or sacrificed to obtain a product (Zeithaml, 1988)
Risk barrier	The risk barrier arises when the user cannot assess the risks and uncertainties associated with the new service. Laukkanen et al. (2008)	Physical, performance, and social risk (+)	Degree to which the functional, social, and/or financial consequences of purchasing and using an innovation cannot be established (Hoeffler, 2003)

Consumers have very specific reasons toward using innovations, which depend on the specific context. Related to using social innovations such as micro wind energy generation turbines, reasons for adoption such as energy cost savings, environmental benefit, and independent from conventional sources of energy such as oil or gas increase only attitude. In contrast, reasons against adoption such as usage, value, and risk barriers are operationalised as upfront costs, incompatibility with existing infrastructure, and uncertainty in regards to the performance decrease behavioural intention (Claudy et al., 2015). As attitude-behaviour gap toward ethical and responsible consumptions, evaluation of benefits increases positive attitude toward innovation. However, this evaluation is based on the hypothetical situation. Potential consumers better focus on the negative aspect of innovation in the situation close to actual usage, which cause the low diffusion rate.

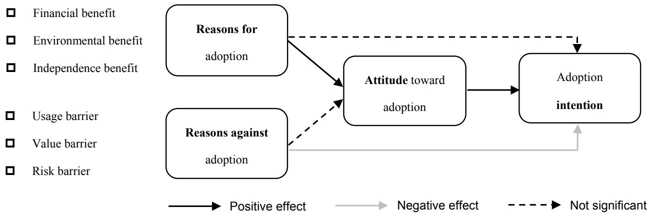

Figure 1. Attitude-behaviour gap model toward using innovation and the result regarding the innovation of energy system from Claudy et al. (2015)

3.3 The concept of frugal innovation

Frugal innovation originated in the context of developing countries and focuses on developing products and services that fits special needs and requirements and that are cheap enough for non-wealthy consumers (Hart and Christensen, 2002). However, this innovation is also necessary in developed countries where ongoing economic crisis compels frugality both in the public and private sectors (George et al., 2012; Goldsmith et al., 2014).

To define frugal innovation, three criteria simultaneously must be filled. The primary criterion is cost reduction, which includes aspects of "considerably lower initial cost or purchase price", "reducing the total cost of owner ship,", and "minimising the use of material and financial resources" (Weyrauch and Herstatt, 2016, p.6). The important point is that the price must be low from a consumer perspective, not from manufacturers and service providers. Cost reductions related only to manufacturers or service providers are insufficient because frugal innovation avoid needless costs and the affordability for consumers (Barclay, 2014; Sharma and Iyer, 2012). Weytauch and Herstatt (2016) concludes that frugal innovation should be one third or more lower purchase and total cost of ownership compared to current solutions available on the market.

Second criterion of frugal innovation is concentration on core functionalities, which contains aspects as "functional and focussed on essentials", "minimising the use of material and financial resources", and "user-friendly and easy to use" (Weyraucha and Herstatt, p.7). Compared to current solutions available in the market, frugal innovation focus on core benefits and essential functions, and reduce complexity, which generate the highest customer benefits and directly fulfill user requirements. In other words, frugal innovation aims to respond to essential needs efficiently (Cunha et al., 2014). Focusing on core functions save resources and reduce initial costs (Barclay, 2014; Tiwari and Herstatt, 2012), and make products and services simple and easy to use (Wooldridge, 2010).

Third criterion is performance level of innovation. In case to capture the meanings of frugal innovation, it is not enough to focus on core functionalities. Product and service innovation in developed markets are often over-engineered. Products and services with high technologies exceed the requirements of consumers and thus high-priced. Frugal innovation offers the right level of performance to meet the desired objective with a good enough and economical means (Soni and Krishnan, 2014) and to fulfil the acceptable quality with minimal costs (Tiwari and Herstatt, 2012).

4 The potential role of frugal innovation and overcoming attitude-behaviour gap

Reducing the evaluation of reasons against innovation is the key to overcome the attitude-behaviour gap and increase diffusion rate of an innovation. Claudy et al. (2015) suggest that the innovation design is one direction to solve the gap. Frugal innovation is strategic design of innovation and defined as the innovation that "simultaneously meets the criteria such as substantial cost reduction, concentration on core functionalities, and optimised performance level" (Weyrauch and Herstatt, 2016, p.12).

Frugal innovation could solve the gap between attitude toward innovation and behavioural intention to adopt through reducing the effect of reasons against innovation such as switching cost, incompatibility, and uncertainty. First, frugal innovation has considerably lower initial cost or purchase price from a consumer perspective because the functions and performances of frugal innovation focus on essentials of consumer needs. The perceived price is associated by the consumer with a monetary sacrifice (Kim et al., 2007) and their perception what is given up to obtain a products and services (Zeithaml, 1988). Consumer perception of the high price is the most frequently obstacle mentioned by consumers preventing the usage of innovation (Claudy et al., 2015; Laukkanen, 2016). Frugal innovation can avoid needless costs and achieve cost effective (Brem and Wolfram, 2014; Tiwari and Herstatt, 2010). Thus, frugal innovation can reduce the effect of the perception of switching cost as value barrier on behavioural intention.

P1: frugal innovation reduces the perception of value barrier toward innovation, which increase the behavioural intention to adopt innovation.

Second, frugal innovation has simple but focused and specific function and reasonable performance to fulfil specific consumer needs (Herstatt and Tiwari, 2017; Weyrauch and Herstatt, 2016). In the case that consumers evaluate innovations, it requires them of much cognitive effort regarding understanding and usage of innovation, which cause consumer resistance (Ram, 1989). Regarding the consistency of attitude and behaviour, consumers should have ability to manage the information about their needs, available situational cues and understand themselves (Snyder, 1979). Gap between attitude and behaviour can be solved if consumers could assume actual behavioural situations when they evaluate objective products and services, and create belief about usage and performance (Ajzen et al., 2004).

Especially, consistency of attitude and behaviour toward responsible consumptions is enhanced by consumers' behavioural control that reflects individual belief for the ability to use and achieve performance (Carrington et al., 2010). Similarly, consumers' actual responsible behaviour depend on their credibility that the products and services are designed for achieving social and environmental benefits, and depend on their knowledge to judge whether these are credible or not (Perera et al., 2016). Robustness of attitude and behavioural intention to adopt innovation depend on an individual capability related to information seeking (Gregn-Paxton and John, 1997) and available categorical knowledge related to the innovation (Kuhl and Beckman, 1985; Olshavsky and Spreng, 1996). Compared to the innovation which has many functions and more technological, frugal innovation requires consumers of less cognitive resources and potential consumers can easily evoke the category to which frugal innovation belongs (Weyrauch and Herstatt, 2016). Causalities between the functions of frugal innovation and consumer specific needs are distinct. Thus, broad knowledge and complex information seeking would not be necessary for potential consumers to evaluate frugal innovations because frugal innovation has limited function, user friendly but simple to use frugal innovations.

P2: frugal innovation reduces the perception of usage barrier toward innovation, which increase the behavioural intention to adopt innovation.

Not only high price but consumers' knowledge and experiences of services push the desirable services level up, whereas these consumers have high level of adequate services because they have high expectation for services (Zeithaml et al., 1993). Consumers reject services when they evaluate that services would offer lower performance than the adequate services level to satisfy their needs. In the case that consumers confront with innovation without alternatives and have less related knowledge, the level of adequate services does not become high. The performance of frugal innovation is limited but optimised just for the level to satisfy consumers' needs. Services can increase consumer satisfaction when they offer the performance above adequate services level of consumers. Because frugal innovation is originally planned to satisfy good-enough and acceptable quality standards that are in fact required, this offers performance meeting or even exceeding the adequate level (Tiwari and Herstatt, 2012). In addition, frugal innovation offers consumers innovations at low price, and simplified functions so that consumers can understand with less cognitive resources. Therefore, adequate level would not become high and consumers can evaluate that this innovation is better to satisfy their needs based on the cost effectiveness.

P3: frugal innovation reduces the perception of risk barrier toward innovation, which increase the behavioural intention to adopt innovation.

5 Discussions and strategic implications

Sustainability has become theoretically and practically important concept (Huang and Rust, 2011). It is necessary for firms to develop and promote products and services to minimise wasted consumptions and solve environmental problems (Achrol and Kotler, 2012). In the sustainable society, firms must develop products and services that offer not only benefits for consumers but benefits for society as a group of consumers, firms, and environments. Products and services with technological infrastructures such as information communication and sensing technology enable to connect information between individual and social level, and offer the optimal solutions for society without restricting benefits for individual consumers (Ostrom et al., 2010; Schumann et al., 2012). Current innovation researches have emphasised the strategic importance of sustainability and technology infusion for innovations. Especially, researchers highlighted the innovation for changing improvements in the well-being of both individuals and society (Anderson et al., 2015; Anderson & Ostrom, 2015).

HEMS in Japan is one of the most advanced energy systems in the world. Over 100 products can be connected to HEMS and HEMS offers many functions. Although government strategically promote to diffuse this system to reduce CO2 and consumers evaluate benefits of HEMS, it is hardly diffused. This research identifies factors of innovation resistance that affect the attitude and the intention towards using an innovation and conceptually argue to what extent frugal innovations can help decrease the gap between attitude and behaviour. This supports to discuss the design of HEMS in alignment with environmental and policy objectives in Japan. First, Japanese HEMS supposes connecting to solar power and battery systems. It costs totally over 20,000 euro to install most advantageous system, which crucially cause value barrier of potential consumers especially in current economically depressed situation. As mentioned above, upfront cost drops in case that HEMS offer basic functions or functions which cannot be replaced by consumers as well as fulfil consumers specific needs, and optimised performance for achieving reasonable goals. Thereby frugal innovation of HEMS can reduce value barrier of potential consumers.

Second, as illustrate above, current HEMS have many functions including not only main functions but peripheral functions. Japanese traditionally see better services as important (Melville, 1999) and are sensitive to added-values that are attentive in every detail as important (GOJ, 2016b). For these reasons, HEMS has become much sophisticated with stronger technological context. The system can offer much functions but becomes complicated, and thus it becomes difficult for potential consumers to evaluate whether these functions are necessary for them or not. Individuals in Japan traditionally have much experiences to achieve efficiency (Anderson and Wadkins, 1991). Thus, potential consumers can understand potential usefulness based on basic but necessary functions related to saving energy such as connecting and controlling each appliance, visualising energy consumptions, which contribute to reducing perceptions of usage barrier and diffusing this system.

Third, the performance of HEMS is obscure for potential consumers because they must evaluate many items of HEMS. Much knowledge and information processing capability are necessary for consumers to evaluate performance that each function achieves. In addition, CO2 emission related to electric consumption is calculated by "amount of electric consumption × emission factor" and a unit is "t-CO2/KWh". It is difficult for potential consumers to evaluate current amount of CO2 emission and their contribution for reducing CO2 emission (Leiserowitz, et al., 2015). Thus, it is also difficult to understand the contribution of HEMS for reducing CO2 emission. In conclusion, HEMS should be designed to reduce cognitive effort to make consumers understand performance and to set clear and reasonable goals for energy saving. Frugal HEMS focuses on main functions for consumers' specific needs, which directs their cognition adequately and makes them evaluate HEMS efficiently. This would solve attitude-behaviour gap arisen from risk barrier based on the performance uncertainty.

This research has implications for studies of attitude-behaviour gap toward using innovation and frugal innovation. Previous studies of attitude-behaviour gap have revealed that resistance factors hamper the consistency of consumer attitude and behaviour toward using innovation (Claudy et al., 2015). These resistance factors arise from the categorical knowledge (Olshavsky and Spreng, 1996; Rogers, 1995) and lack of capability to evaluate products and services to develop beliefs about their performance and contributions (Ajzen et al., 2004). Although the design of innovation might reduce attitude-behaviour gap, the mechanism what kind of design can reduce the gap and how design of innovation reduce the gap has not become clear. In addition, previous study of frugal innovation highlighted that frugal innovation reduces cognitive resources to understand and use innovation (Weyrauch and Herstatt, 2016). This suggests that frugal innovation affect consumer decision making process. However, little research has been conducted from the viewpoint of cognition. Therefore, focusing on the energy management system, this study conceptually shows the contribution of frugal innovation on consumer decision making process toward using innovation.

Table 2. The effect of frugal innovation toward innovation resistance barriers

Current HEMS	Characteristics of frugal innovation	Weaken the impact of "reasons against adoption" by frugal innovation
Initial cost of full system is high.	Considerably low initial cost or purchase price.	Reduce value barrier. ▫ Upfront cost drops.
Many functions with high technological context. ▫ High capability is required to understand benefits and to command all functions.	Simple and specific functions to fulfil specific needs. ▫ Minimising the use of resources ▫ User friendly and ease of use	Reduce usage barrier. ▫ They get simple solutions. ▫ They can understand the system is not "complex" or "difficult to use/replace".
Consumers doubt the performance of HEMS. ▫ They have to put much cognitive effort to evaluate high performance and contributions of each functions whether each performance is necessary for them or not. ▫ CO_2 emission is evaluated by "t-CO_2/KWh".	Optimal performance just enough to satisfy needs	Reduce risk and value barrier. ▫ Consumers can focus on their certain needs and have reasonable goals. ▫ They can assess the possibility of reducing utility charge and CO_2 emission clearly.

6 Conclusions

Innovative products and services are often withdrawn from market because of low diffusion rate although consumers evaluate benefits of innovations. Attitude-behaviour gap theory can explain that innovation resistance factors decrease consumers' intention to use innovation even if they evaluate benefits and have positive attitude toward using innovation. This research extends the knowledge of attitude-behaviour gap and frugal innovation. This research theoretically shows that frugal innovation decreases the perceptions of innovation resistance factors and solve the attitude-behaviour gap toward using innovation, which would result in actual using. This research has also implications for firms and policymakers. It shows that frugal solutions can help reduce the consumer resistance to technological innovations by focusing on core functions, substantial reduction in the cost of ownership and by minimizing avoidable complexity. Second, it helps firm in devising strategies for faster diffusion of their cutting-edge products. Especially for manufacturers of HEMS, this research identifies market segments that are receptive to frugal solutions. The study provides useful leads on how the government can develop effective strategies to promote the installation of HEMS for meeting its environmental objectives.

This research shows the future research directions. First, as this research shows, frugal innovation can solve the attitude-behaviour gap theoretically. Future research should verify that frugal innovation solves attitude-behaviour gap. Previous studies of frugal innovation has tried to understand the effect of frugality on the product development, competition, and supply chain management (Sharma and Iyer, 2012; Tiwari and Herstatt, 2012) and elaborate the definition of frugal innovation (Weyrauch and Herstatt, 2016). To investigate the effect of frugal innovation on decision making process expand the theory of frugal innovation into consumer psychology. Second, consumers' prior knowledge affects the first stage of decision making process or positive evaluation toward using innovation (Roggers, 1995; Olshavsky and Spreng, 1999) and the expectation level of new services (Zeithaml et al., 1993). In addition, Perera et al. (2016) shows that consumer learning and knowledge can solve the attitude-behaviour gap toward responsible behaviour. Frugal innovation focuses on core functions and thus it would not require consumers of much knowledge compared to general innovations. Future research should investigate the effect of knowledge on the mechanism that frugal innovation solves the attitude-behaviour gap toward using innovation.

Acknowledgements

This chapter is based on collaborative research by Fumikazu Morimura during his visiting fellowship at the Institute for Technology and Innovation Management of Hamburg University of Technology (TUHH). The paper represents work in progress. The authors would like to acknowledge the financial support provided to the principal author of this paper, Fumikazu Morimura, by Grants-in-Aid for Scientific Research (Grant No. 19K01938) from the Japan Society for the Promotion of Science. Sections of this paper draw on the authors' paper "Potential Role of Frugal Innovation in Home Energy Management Systems", presented at the ISPIM Connects Fukuoka conference in Dec. 2018.

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Chapter 17

Determinants of willingness to pay when purchasing sustainable products: a study from the shoe industry

Dominik Walcher and Christoph Ihl

Abstract

The manufacturing and disposal of shoes is a widely underestimated environmental problem. A regular shoe consists of up to thirty parts of different materials, such as leather, synthetics, rubber and textile, which are inseparably stitched or glued together and treated most often with hazardous chemicals to achieve the desired physical quali-ties. More and more companies start to produce and sell eco-friendly shoes. In this paper consumer behaviour in the field of eco-friendly shoes is analyzed. The results of the study demonstrate that there is a direct impact of Social Responsibility, Perceived Per-sonal Relevance, Lack of Trust and Lack of Product Benefit on the Willingness to Pay as well as a moderating effect of Product Information Demand.

Keywords: Shoes, sustainability, ecology, consumer behaviour, willingness to pay

1 Introduction

Analyzing sustainable consumer behaviour is crucial for companies marketing environmentally friendly products. Many studies have been conducted trying to explain how and why consumers do or do not incorporate sustainability issues into their purchasing behavior (Jackson, 2004; Verbeke & Vackier, 2004; Shepherd et al., 2009). In practice, these results help marketers to understand the general motivations of consumers and to determine the size of green consumer groups within the population. Though, they do not provide much information about consumers' specific attitudes towards a product category, a certain product or brand, which is substantial to develop marketing strategies. Peattie (2001), therefore suggests focusing research on the purchase decision to gain more insights on how, why and when people are actually choosing a sustainable product or not. Thus, the focus of this paper is to analyze the drivers of willingness to pay when purchasing eco-friendly shoes.

During the last century, the shoe market has undergone a huge transformation. Enhanced by global trade and the fashion industry the worldwide shoe consumption has risen from 2.5 billion pairs of shoes sold in 1950 to more than 20 billion pairs in 2005 (World Footwear, 2007). As a result, the worldwide per capita consumption of footwear has also increased considerably, from one pair of shoes per year and person in 1950 to almost 2.6 pairs of shoes in 2005 (SATRA, 2003). What may sound like pleasant facts in times of an economic downturn, is alarming taking into consideration the environmental problems linked with the manufacturing and disposal of shoes. Materials used for shoe manufacturing such as leather, synthetic materials, rubber and textile are treated with hazardous chemicals to achieve the desired physical qualities. While other industries already offer recycling and recovery options at the end

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R. Tiwari and S. Buse (eds.), *Managing Innovation in a Global and Digital World*, https://doi.org/10.1007/978-3-658-27241-8_18

of their products' life-cycle, the shoe industry is limping. Actually, scientific studies addressing the ecological impact of shoes are rare and studies focusing on sustainable consumer behaviour within the shoe industry lack completely. It is a common practise in shoe production to stitch or glue different types of materials together in a way that no part of the shoe can be used after they have been thrown away. Braungart and McDonough (2002) have invented the term "monstrous hybrids" for this kind of products and explicitly mention shoes as "Frankenstein products". In addition, the life-cycle of shoes decreases progressively due to rapidly changing fashion trends. This creates a steady waste stream of worn shoes that are dumped in landfills. Estimations state that the waste caused by shoes amounts to 1.2 million tons per year within the European Union only (Staikos, Rahimifard & Coates, 2007). Scientists have given evidence that the waste dumped in landfills can result in serious pollution of groundwater and rivers as well as in harmful emissions of greenhouse gases like methane (Staikos et al., 2006). In the last years, more and more eco-friendly shoe models have been offered by traditional companies as well as by new (start-up) companies (Allwood et al., 2006; Metcalf & Burger 2007). Basically, these offers can be classified into four groups.

The objective of the (1) first group is to predominately apply environmentally friendly materials, such as vegetably tanned leather, natural rubber, and latex as well as contaminant-free adhesives. In this group, traditional companies (e.g. *Timberland, Camper, Birkenstock* etc.) as well as newcomers (e.g. *Arche, El Naturalista, Trippen*) can be found. Companies belonging to the (2) second group typically use recycled materials combined with natural ones, such as hemp, organic cotton or coconut fibre. Companies like *WornAgain, Simple* or *Terra Plana* strive to market their products by means of comprehensive information campaigns as well as other activities in the eco-social sector in order to stress their positioning. The (3) third group can be described as "vegan group". Members of this group put their focus on the implementation of natural or synthetic (bio-polymers) materials that are biodegradable as the main resource for their shoe production. The ethical aspect and the avoidance of animal materials are stressed. Start-ups like *Beyond Skin, Bourgeoise Boheme* and *Vegetarian Shoes* figure as examples. The (4) last group entirely focuses on the application of natural and renewable materials, such as coconut and banana fibre, hemp or organic cotton – the use of synthetic materials is avoided. Products made for vegans are explicitly signed. Companies, such as *PoZu*, *Komodo* or *GrandStep,* can be mentioned here. Figure 1 depicts the four different groups with exemplary companies according to the dimensions of avoidance of virgin/animal materials and ecological/social rigor.

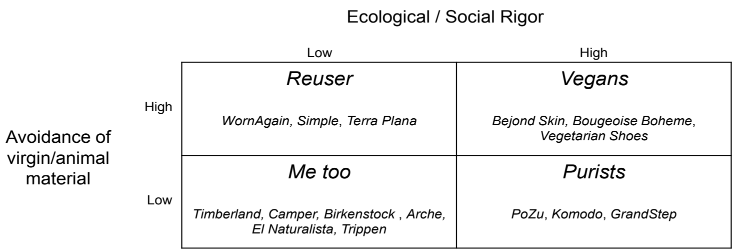


Figure 1: Classification of eco-shoe offers

Price politics as a marketing tool provides various functions, such as being a reflection of the production costs, a signal of quality, a basis for market segmentation, an indication of demand and supply, an important basis for competition and a key variable to achieve a wide variety of other marketing objectives (Kotler & Armstrong, 2004). Customers usually expect sustainable products to be higher-priced than conventional products (Peattie, 1995). It is argued that this is also true for eco-friendly shoes. Research shows that sustainable products are sometimes perceived as too expensive or that the consumers do not understand the justification for the price premium (IGD, 2002; Verbeke & Vackier, 2006). Marketing managers are therefore faced with the question, what price premium customers are willing to pay for the environmental benefit of a product.

But the elevated price of eco-friendly products is not only a marketing tool; it often results from higher production costs due to the implementation of environmentally friendly production methods or materials. Nevertheless, taking into consideration the total customer costs, which consist of product price, purchase costs, use costs and post-use costs, sustainable products are sometimes even more reasonable than conventional ones. However, the *product price* is most often dominant compared to the other customer cost factors when faced with a purchase decision (Belz & Peattie, 2009). Besides the cost-based aspect, price-setting for sustainable products is dominated by value-based factors. These factors, which can be considered as the main drivers for willingness to pay, are depicted in detail in the next chapter

2 Theoretical framework and hypotheses

Research on sustainable consumer behaviour focuses on consumers' attitudes and beliefs about sustainability issues (Wagner, 1997; Beckmann, 1998; Straughan & Roberts, 1999; Jackson, 2004). Three important sets of attitudes that influence consumers' willingness to engage with sustainability issues (and thereof willingness to pay for sustainable products) are *Social Responsibility (SR)*, *Perceived Personal Relevance (PPR)* and (Lack of) *Trust (LOT)* (Belz & Peattie, 2009). These determinants, which are assumed to have a direct influence on *Willingness to Pay (WTP),* are completed by *Lack of Product Benefit (LPB)* (Verbeke & Vackier, 2006) being a direct factor as well as *Environmental Locus of Control (ELC)* (Straughan & Roberts, 1999) and *Product Information Demand (PID)* (Ottman, Stafford & Hartman, 2006) being moderating factors.

2.1 Social responsibility

Social responsibility concerns the sense of shared responsibility for particular social and environmental issues and the willingness to take part in collective responses to them. An important driver for change and sustainable consumption in particular is the tendency towards reflexivity within post-modern society. People increasingly think and reflect about current cultural norms that influence them. By reflecting their role in society, consumers often get a feeling of responsibility regarding the protection of the environment and express this feeling through their purchase behavior (De Pelsmacker et al., 2003). Reflexive consumers evaluate ethical issues by their own standards (Dupuis, 2000) and consciously decide to buy certain products instead of others. This kind of demonstrative consumption especially incorporates environmental concerns, but is also connected with issues like human rights, animal welfare, and labor working conditions in the Third World (Tallontire et al., 2001). Buying sustainable products means helping the environment and the entire society. Social responsibility is determined by the values of individuals. Research on the influence of values suggests that several value shifts will have to occur within society to allow progress towards a more sustainable society and economy, including (Gilg, Barr & Ford, 2005; Belz & Peattie, 2009):

Table 1: Value shifts

From	To
Egocentric	Altruistic
Conservative	Open to change
Indulgent	Frugal
Materialist	Post-materialist
Technocentric (technology rules)	Ecocentric (nature knows best)
Anthropocentric (human centred)	Biocentric (all species matter)

The closer the product category is linked to environmental issues, the more likely a customer perceives its purchase as relevant to environmental protection. Thus, sustainability marketing has the opportunity to take advantage of consumers' willingness to purchase products that provide environmental benefits at a premium price (Belz & Peattie, 2009). Within the context of eco-friendly shoes, the perception of the ecological product impact can be considered as indicator for social responsibility. Following the rationale for positive effects of *Social Responsibility* on willingness to pay, it is hypothesized:

> *H1: Increased Social Responsibility has a direct positive impact on Willingness to Pay.*

2.2 Perceived personal relevance

Perceived personal relevance concerns the extent to which consumers see their lives being affected by ecological and social issues. According to results from environmental research, ecological benefits of products are the basis of competitive advantages for companies, assumed that the benefit can be internalized by the individual customer. Quite often, ecological products are designed to convey solely a collective benefit (see *social responsibility*), therefore, the individual internalization effect is missing. In this case, customers may find it hard to reason, why they should be the only ones buying the product (and possibly pay a price premium), whereas "others" benefitting from this purchase as well (e.g. in the form of a less polluted environment). Free-riders profit from the effort of others without contributing anything themselves. They do not directly perform any harmful action regarding the environment, but their attitude affects the motivation of others' willing to act eco-friendly. This means that eco-friendliness as the main selling argument only appeals to a small group of consumers. In order to reach a larger audience, it is necessary to combine eco-benefits with traditional product benefits. This way, the advantage of the product can be experienced directly and personally by the consumer (Belz & Peattie, 2009). Basically, *personal relevance* of individuals can be conceptualized with the help of *rational, psychological* and *sociological* explanations (Jackson, 2004).

Some of the earlier research into consumer behaviour and sustainability relied on *rational / utilarian* explanations. This perspective emphasizes the economics of sustainable consumption, and how consumers balance the functional benefits. Behavioural models based on economic rationality tend to assume a high degree of self-interest on the part of the consumer. The idea of the *homo oeconomicus* leads to the wide spread concept of *perceived costs and benefits*, which includes non-economic costs such as time, inconvenience, social unacceptability or psychological efforts. Consumers weigh out *perceived benefits* with *perceived costs* and opt for the solution with the highest *perceived net benefit* (Belz & Peattie, 2009). In studies about green customer behaviour, the balance between perceived costs and benefits is often mentioned as one of the most significant factors (Straughan & Roberst 1999). Based on these results, the implication for management can be seen as the objective to increase the perceived net benefits of sustainable solutions compared to conventional offers. Rational explanations also emphasize the role of information and knowledge in moving consumers towards sustainable choices. This assumes that increasing knowledge about sustainable issues will lead consumers to buy more sustainable goods (Belz & Peattie, 2009).

As a complement to rational explanations for consumer behaviour, there has been research into *psychological explanations* of sustainable consumption and more emotional or irrational reasons of consumer behaviour. Many of these focus on consumers' *traits, motives, attitudes* and *beliefs* about sustainability issues, such as experience, knowledge, variety seeking, risk affinity, lifestyle etc. Researchers trying to understand the psychological dimensions of consumer behaviour have relied on psychographics as a means of categorizing consumers as an alternative to demographics (Wagner, 1997; Straughan & Roberts, 1999; McDonald & Oates, 2006).

Another set of theories suggests that consumer behaviour is not simply a reflection of the rational cost benefit calculation nor is it fully explained by psychological explanations. It states that a main determinant for ecological buying behaviour is the way consumers think their consumption activities will be perceived by others and what kind of influence this has on their position in *society* (Wagner, 1997; Rose & Scott, 2007). In a consumer society, the act of consumption is no longer solely determined by meeting basic individual wants and needs. It rather became a primary mechanism through which relationships within society are structured and an accepted way to find individual happiness, expression, meaning and status. Harnessing social norms will be important for pro-sustainability behaviours, which are influenced by the behaviour of peers and neighbours. Consumers' willingness to change is influenced by their belief in whether or not others will do likewise (Thogersen, 2005). In the context of a consumer society, many purchases become important beyond the functional benefits they provide because they contribute to the construction of an identity (Schmalen & Xander, 2005). Wearing an eco-friendly shoe, for instance, reveals a lot about individuals (or how a person would like to be perceived by others). The normative influence of peers within a group can foster ecological consumption, but has also the potential to be a considerable obstacle, if it is associated with a negative image (i.e. "hippie"). Group norms are likely to be resistant to change and take time to transform. Nevertheless, social pressure is regarded as a very useful strategy for the diffusion of eco-friendly products on a larger scale (Verbeke & Vackier, 2006). Even though norms pose a significant barrier to market these products, comprehensive communication activities of companies, institutions or governments can contribute to a change in attitudes (FSA 2000).

Sociological theories generally hold a person's value orientation responsible for buying products with certain attributes. The perceived ecological value of the sustainable product compared to its conventional alternative is a crucial factor as well as the level of interest in sustainability issues related to the product and the ability of the product to differentiate on the market, which is generally lower for convenience products than for shopping goods or specialty goods. This is why a company should carefully choose its main target group before it can analyse people's willingness to accept a higher price (Kotler & Armstrong, 2004).

The construct of "lifestyle" is an important element of social theory. Many individual purchases and behaviours create the particular lifestyle of an individual. Progress towards more sustainable consumption is therefore not simply a question of which products and services are purchased; it is also about adoption of a lifestyle in which sustainability is reflected in all aspects of consumer behaviour (Belz & Peattie, 2009). Following the rationale on positive effects of perceived personal relevance on willingness to pay, it is hypothesized:

H2: Increased Perceived Personal Relevance has a direct positive impact on Willingness to Pay.

2.3 Trust

Besides social responsibility and perceived personal relevance, *trust* can be considered a crucial factor influencing consumers' willingness to engage with sustainability issues and therefore influencing consumers' willingness to pay for according products. Most often, the ecological attributes of a product are not visible and cannot be tested by the consumer prior to its use. In these cases, customers have to rely on the information provided by the companies. Extensive use of dubious ecological claims has raised consumer skepticism and created confusion (Gason & Gangadharan, 2002). An international survey revealed that only 10% of participants trust in what companies say about climate change, 25% in trust corporate claims about energy-efficient products and services, and 70% want third-party verification of climate change claims (AccountAbility and Consumers International, 2007). Another major barrier to sustainable consumption is the fact that consumers tend to perceive sustainable products of minor quality or less functional compared to conventional ones. A survey performed by the Roper Organization (2002) revealed that 41% of consumers did not buy green products because they did not trust the quality. It is argued that lack of trust affects the *Willingness to Pay* of consumers when purchasing eco-friendly shoes.

H3: Increased Lack of Trust has a direct negative impact on Willingness to Pay.

2.4 Lack of product bBenefit

A lack of trust towards the manufacturer or product quality can be regarded as an important sacrifice for the individual consumer. In the case of sustainable products, various lacks concerning product attributes exist, which also interfere with consumers' decision processes. Verbeke and Vackier (2006) mention consumers' perception of minor taste, appearance and conservation within the organic food branch, while Meyer (2001) discusses the important role and "sad" reality of *design impression* when buying eco-friendly fashion products. Low *perceived availability* of sustainable products may be another explanation, why intentions to buy remain low, although attitudes might be positive (Robinson & Smith, 2002). Some environmentally friendly products can only be bought in specialist shops and the effort one has to undergo in order to find and get the products is most often inconvenient. Thus, minor *design* *impression* and bad *perceived availability* can be interpreted as a lack of direct customer benefit when buying eco-friendly shoes. It is argued that these lacks have a negative effect on the willingness to pay

H4: Increased Lack of Product Benefit has a direct negative impact on Willingness to Pay.

2.5 Environmental locus of control

Locus of control refers to the extent to which individuals believe that they can control events that affect them (Rotter, 1990). A high level of internal control means that individuals believe that they are able to control life and its driving forces themselves to a high degree, whereas people with a high conviction of external locus of control think that everything is ruled by someone else (powerful others, fate, chance etc.), which makes them believe a person himself has no possibility to intervene at all. The concept of *locus of control* relates to the concepts of *perceived consumer effectiveness* (Straughan & Roberts 1999), which explains the belief of individuals that their actions can have a meaningful impact on others, and the concept of *self efficacy* (Sherer & Maddux, 1982; Smith, 1989, Sparks & Shepherd, 1992), which deals with the belief that one is able to engage in a particular behaviour effectively. Across a range of sustainable consumer behaviour studies, *perceived consumer effectiveness* is one of the factors that most consistently feature as a statistically significant influence (Straughan & Roberts, 1999).

According to these findings, consumers are most likely to engage in activities that they believe will have an effect (McDonald & Oates, 2006). Individuals with a high internal locus of control are more active in seeking information and knowledge concerning their situation, have better control of their behavior, tend to exhibit more resolute behaviors (socially, ecologically etc.), and are more likely to attempt to influence other people than those with a high external locus of control (Rotter, 1990). In the environmental context, people with a high external *locus of control* perceive a weak ability to affect environment positively via consumption behaviour, whereas they are convinced that existing or future technology will save the world (McDonald & Oates, 2006).

It is argued that environmental *locus of control* moderates *social responsibility* as well as *perceived personal relevance.* Regarding *social responsibility*, it is assumed that consumers with a high level of internal *locus of control* think they themselves are able to contribute to help society and environment and therefore are willing to engage more in sustainable issues as well as are willing to pay a price premium for sustainable products. Concerning *perceived personal relevance* it is assumed that - for instance - people with a high level of internal *locus of control* are more interested in buying and wearing eco-friendly shoes to show their lifestyle and ecological attitude and therefore are willing to pay a price premium.

H5a: Increased internal Environmental Locus of Control has an enforcing and moderating effect on Social Responsibility.

H5b: Increased internal Environmental Locus of Control has an enforcing moderating effect on Perceived Personal Relevance.

Knowledge about environmental harms can be considered a precondition that ecological product attributes are perceived as value adding (Junaedi, 2007). Although a person's value of a "clean environment" usually refers to all product groups, the awareness of an environmental issue among these groups differs greatly. The information deficit of consumers makes it harder for producers to successfully highlight the ecological benefit of their products, which may seem irrelevant compared to other environmental issues.

Messages in marketing communication have to be well chosen to be relevant to consumers and appeal to their personal needs and desires. In general, consumers' values influence the way they perceive and respond to information referring to ecological aspects of a product. Thus, performance claims for environmentally oriented products are more likely to be believed by consumers with strong environmental values (Picket-Baker & Ozaki, 2008). If such a product, though, is intended to attract a larger audience and not only a niche segment, marketing communication has to put the right information into the center of its communication efforts. Ottman, Stafford and Hartman (2006) propose to connect the socio-economic attributes of an eco-friendly product with the values that are desired by consumers. These can include safety issues, performance, health aspects, cost effectiveness, convenience, design, durability or symbolism. The personal benefits for the consumer have to be complementary with the relevant sustainability issues, which are promoted.

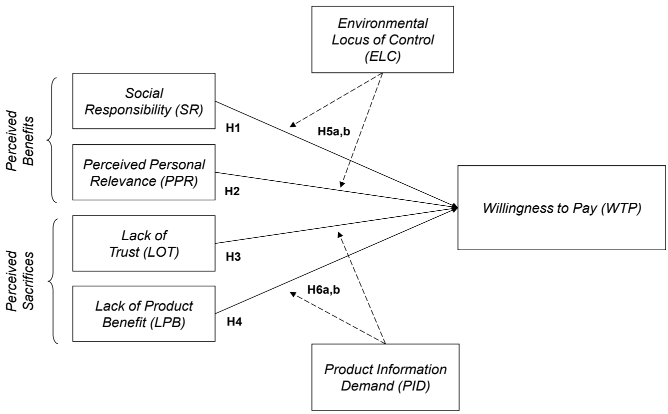


Figure 2: Model structure

A study conducted by the Alliance for Environmental Innovation and the consumer product company SC Johnson supports the theoretical finding by concluding that consumers are most likely to act on sustainability messages that are associated with their personal environment. It states that benefits of household products like 'not toxic ingredients' and 'safe to use around children' are preferred to 'not tested on animals' or 'packaging can be recycled' (Alston & Roberts, 1999). The chosen information can then be transported by marketing methods in a rational, emotional or moral way, depending e.g. on the audience and the communication channel. Marketing managers are faced with the challenge of balancing the amount of factual *product information* without overwhelming consumers and at the same time entertaining them without delivering a superficial impression (Belz & Peattie, 2009). It is argued that *lack of* *trust* and *lack of product benefit* is influenced by the availability of comprehensive and transparent *product information.* If *lack of trust* respectively *lack of product benefit* goes along with consumers' high *product information demand* the effects on *willingness to pay* are enforced and vice versa.

> *H6a: Increased Product Information Demand has an enforcing moderating effect on Lack of Trust.*

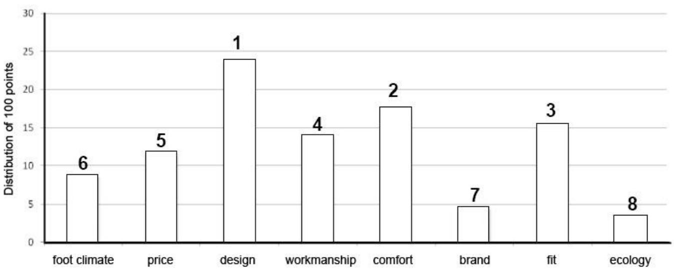
> *H6b: Increased Product Information Demand has an enforcing moderating effect on Lack of Product Benefit.*

The structure of the assumed relations is summarized in Figure 2.

3 Method

3.1 Sample

To analyse the determinants of willingness to pay when purchasing eco-friendly shoes, an online survey was conducted. The invitation to take part in the poll was posted in online shoe community forums and on sites for ecological (fashion) products. Altogether 147 valid answers were gathered. 52% of all respondents were female, 48% were male. The average age amounted to 31.6 years (min. 18, max, 66 years, StD. 7.9 years). The participants of the survey were mainly residing in Germany (47.7% of all respondents) and Austria (43.8%), while 3.1% were living in Switzerland and 5.4% in other countries. 55% of the respondents were living in cities with more than 50.000 inhabitants; about 85% whether had a university entrance diploma or already graduated from university. In order to get an impression of the relevance of ecology when evaluating the appeal of shoes, participants were asked about the importance of the following attributes and their influence on the purchasing decision: *(1) foot climate, (2) price, (3) design, (4) workmanship, (5) comfort, (6) brand, (7) fit* and *(8) ecology* are. The respondents were asked to distribute 100 points among the different dimensions. Figure 3 shows that *design, comfort* and *fit* were given the most importance whereas *ecology* currently does not play a significant role when buying shoes.



	foot climate	price	design	workmanship	comfort	brand	fit	ecology
Means	8,83	11,9	23,89	14,09	17,73	4,64	15,47	3,45
StD	9,253	10,754	15,315	9,093	10,248	6,231	11,84	5,335

Figure 3: Relevance of attributes when buying shoes

3.2 Measures

3.2.1 Social responsibility and perceived personal relevance

Social Responsibility was operationalized by five items addressing the perception of shoes as environmental problem. An exploratory factor analysis showed one *Social Responsibility* factor, which consists of two items ("Shoes cause environmental harm, but no real solution was found yet" and "Shoe production is a widely underestimated ecological issue"). The *Perceived Personal Relevance* factor consists of four items: One item addressing health as *rational* component ("Eco-friendly shoes are healthier"), one item addressing the *psychological* component concerning a feeling of guilt about the environmental damage ("Buying eco-friendly shoes salve my conscience") and two items addressing the *social* and lifestyle component ("Eco-friendly shoes contribute to express my ecological attitude" and "Eco-friendly shoes fit well to my lifestyle").

3.2.2 Lack of trust and lack of product benefit

The factor *Lack of Trust* consists of the two items "Information provided by eco-friendly shoes manufacturers is not very trustworthy" and "Eco-friendly shoes are of minor quality". *Lack of Product Benefit* was initially operationalized by four items, but the final factor consists of the two items "Eco-friendly shoes that correspond with my preferences are difficult to find" and "The design of eco-friendly shoes is most often not appealing". To judge the approach the Kaiser Meyer Olkin criterion with a threshold of 0.7, factor loadings with a minimum of 0.5 and Cronbach's Alpha with a limit of 0.6 (Malhotra, 2007; Nunnally, 1967) were used as quality measures and were met in all cases. To confirm discriminant validity, the square root of each average variable expected with the correlations of all constructs was compared. It turned out that the square root of each average variable expected was larger than all other correlations. See table 3 and table 4 in appendix for results from exploratory factor analysis and statistics of the model construct.

3.2.3 Environmental locus of control and product information demand

Environmental Locus of Control was operationalized based on the German study "Determinanten des Umweltverhaltens (determinants of environmental behaviour)" (Kuckartz, Rheingans-Heintze & Rädiker, 2007) with five items addressing (1) technology as solution for ecological problems, (2) resistance against ecological instructions, (3) exaggeration of ecological issues, (4) ability to contribute via consumption behaviour and (5) disability of customers to save energy compared to industry. A factor analysis extracted one factor (Varimax rotation, main component extraction, Kaiser Meyer Olkin > 0.7, factor loadings > 0.5, Cronbach's Alpha > 0.7). Regarding the *Product Information Demand* it was asked what pieces of information would be helpful to better assess the eco-friendliness when buying shoes. Thirteen attributes were offered, which had to be judged on a 5-point Likert-scale: (1) Type of packaging material, (2) length of shipping distance, (3) biodegradability of materials, (4) use of chemicals, (5) the ecological engagement of the producer, (6) the carbon footprint of the shoes, (7) work conditions at production site, (8) amount of waste at production, (9) origin of materials, (10) used materials, (11) production country, (12) official eco certificate and (13) water consumption at production. High judgements (4 & 5) on each attribute were counted as 1 and added building a *product information demand* index. People with a high index therefore have a high demand on product information and vice versa.

3.2.4 Willingness to pay

Regarding *Willingness to Pay* for ecological shoes following question was asked: "Guess a regular pair of shoes costs €100 (about $150 / Jan. 2010), how much are you willing to spend on an ecological version of this pair of shoes?" On average people are willing to pay about €15 (about $22) more, i.e. 15%.

3.2.5 Analysis and results

The analysis was conducted with an ordinary least square regression (OLS) comprising the estimations of direct and moderated effects. Table 2 shows the results from OLS regressions.

Table 2: Results from OLS regressions

	Model 1		Model 2		Model 3	
Variable	**Coeff.**	**t-stat.**	**Coeff.**	**t-stat.**	**Coeff.**	**t-stat.**
Constant - mean	14.762 ***	11.71	14.668 ***	10.80	14.995 ***	11.82
Direct effects						
Social Responsibility (SR)	4.548 ***	3.02	4.411 ***	3.88	4.975 ***	3.35
Perceived Personal Relevance (PPR)	3.225 **	2.06	2.957 *	1.79	3.283 **	2.07
Lack of Trust (LOT)	-4.124 ***	-2.75	-3.825 ***	-2.32	-3.095 **	-2.05
Lack of Product Benefit (LPB)	-3.206 **	-2.24	-3.278 **	-2.28	-3.393 **	-2.343
Environment. Locus of Control (ELC)			1.069 ns	0.57		
Product Information Demand (PID)					0.193 ns	0.37
Moderated effects						
SR * ELC			-0.380 ns	-0.24		
PPR * ELC			0.542 ns	0.32		
LOT * PID					-0.876 *	-1.71
LPB * PID					-1.076 **	-2.33
Model fit						
Sample size	147		147		147	
Adjusted-R^2	0.184		0.169		0.209	

Notes: two-tailed tests; ***: p<.01; **: p<.05; *p<.1; (ns): not significant; t-statistics based on robust standard errors

Before estimation all variables were mean centered. The regression model is significant (F=12.371, p<0.001) and explains 20.9% of variance (Adjusted-R^2) for the final model 3. Collinearity and autocorrelation can be neglected (all values of tolerance > 0.1; Durbin-Watson value of 1.9). H1 and H2 suggested positive effects of *Social Responsibility* and *Perceived Personal Relevance* on *Willingness to Pay*. The results of the estimations give strong support for H1 (β_1=4.975, p<0.01) and H2 (β_2=3.283, p<0.5). H3 and H4 suggested negative effects of *Lack of Trust* and *Lack of Product Benefit* on *Willingness to Pay*. These assumptions are also supported with (β_3=-3.095, p<0.05) for H3 and (β_4=-3.393, p<0.05) for H4. The moderating effect of *Product Information Demand* on *Lack of Trust* is significant (β_{6a}=-

0.876, $p<0.1$) as well as the effect on *Lack of Product Benefit* (β_{6b}=-1.076, $p<0.05$). The directions of direct and moderating effects are equal (negative) which supports the hypotheses of enforcing the direct effect of H6a,b. *Environmental Locus of Control* has no significant influence on *Social Responsibility* nor on *Perceived Personal Relevance.* Therefore H5a,b has to be rejected.

4 Discussion

The results of the study demonstrate that there is a direct positive impact of *Social Responsibility* and *Perceived Personal Relevance* on *Willingness to Pay* for eco-friendly shoes. Thus, the more there is an understanding of the threat shoes represent to the environment and society, the more people are willing to pay for eco-friendly shoes. In the same manner, the more people think eco-friendly shoes may have an advantage for them in a rational (health), psychological (conscience) or social (lifestyle, attitude) way, the more they are willing to pay. Regarding *Lack of Trust* and *Lack of Product Benefit* it was found that the willingness to pay a price premium for eco-friendly shoes decreases according to the level people start doubting about the trustworthiness of manufactures and about quality, design and availability of the shoes. The influence of *Lack of Trust* and *Lack of Product Benefit* on *Willingness to Pay* is enforced by the level of *Product Information* people demand. People who strongly doubt about trust and product quality and at the same time have a high *Product Information Demand* show the lowest level of *Willingness to Pay*. Though, the enforcing influence of *Product Information* on *Lack of Product Benefit* is stronger than on *Lack of Trust* (β_{6b}=-1.076 vs. β_{6a}=-0.876). Altogether, *Social Responsibility* has the strongest direct influence on *Willingness to Pay,* followed by *Lack of Product Benefit, Perceived Personal Relevance* and *Lack of Trust* (β_1=4.975; β_4=-3.393; β_2=3.283; β_3=-3.095).

The shoe branch is a very interesting field for sustainability marketing due to the fact that ecology only plays a very marginal role when buying shoes at present. Purchase decisions for shoes are currently - and most probably will be in future - dominated by design, comfort and fit. Especially with eco-shoes, design has to be outstanding. Designers of eco-friendly shoes are asked to create a new design language, which on the one hand mirrors the sustainable positioning and on the other hand is eminently appealing to consumers. Also technicians are asked to develop new ecologic materials such as biopolymers, eco fabrics or wood-plastic-composites, which allow new shapes and structures. Thus, design remains the dominant benefit whereas eco friendliness is transported simultaneously via the application of eco-friendly materials (and has to be stressed not too intensively, but is taken for granted). Consequently, lifestyle conformity is attained by appealing design as well as health salutariness and salvation of conscience by using eco-friendly materials. Availability of shoes has to be assured or communicated better. In order to diminish the uncertainty concerning the trustworthiness of manufacturer and the ecological quality of the shoes, companies have to use certain signaling instruments to build up confidence and demonstrate credibility, such as the use of certified, independent labels or the application of certifications (see Gason & Gangadharan, 2002, for further explanations). Moreover, building a strong brand is still the best - even if time and resource consuming - action to create quality surrogates. Additionally, it is very important to reduce customers' information demand. Regarding this matter, the preparation of clear, transparent, comprehensive and authentic information as well as the installing of communication structures with the customer (using modern information and communication technology) are indispensable. Research in corporate communication and relationship marketing gives good pieces of advice for these endeavors. Similarly, the threatening impact of shoes on the environment, which is currently mostly unknown, has to be published in order to create awareness.

In spite of the result that people are willing to pay a 15% premium price on average for eco-friendly shoes, which is consistent with other studies in the field of sustainable consumer behaviour, measuring willingness to pay and its reliability are the main limitations of this study. Sociological studies measuring the degree of eco-consciousness have revealed huge inconsistencies between people's expressed concern about environmental issues and their willingness to act accordingly. Usually, this phenomenon is referred to as the attitude-behaviour or intention-behaviour gap and can be traced back on social acceptability (Vermeir & Verbeke, 2006; Belz & Peattie, 2009). Especially attitudinal studies typically overestimate market response, as the example of renewable energy shows. It is consistently reported that a large number of customers (40-70%) are willing to pay a 5-15% premium for "green" products (Baugh, Byrnes, & Jones, 1994; Farhar & Houston, 1996 and Nakarado, 1996), whereas typically less than 3% of consumers really show such purchasing behaviour (Wiser & Pickle, 1997). Further large scale studies incorporating other methods to evaluate *Willingness to Pay* such as Vickrey Auction are needed to validate the results of this study, especially in the field of eco-friendly shoes, which lacks of consumer behavior studies so far.

Appendix

Table 3: Results from exploratory factor analysis

Items	Components			
	1	2	3	4
PPR				
Eco-friendly shoes help me to express my ecological attitude	0.782			
Eco-friendly shoes are better for my health	0.673			
Buying eco-friendly shoes salve my conscience	0.650			
Eco-friendly shoes fit well with my lifestyle	0.630			
SR				
Producing shoes is an ecological problem for which no sufficient solution exists		0.877		
Producing shoes is a mainly underestimated ecological problem		0.645		
LPB				
Eco-friendly shoes that fit with my preferences are difficult to find			0.835	
The design of eco-friendly shoes is most often not appealing			0.665	
LOT				
Manufacturers of eco-friendly shoes are often not very trustworthy				0.835
The quality of eco-friendly shoes is below conventional shoes				0.656

Notes: Main component extraction and Varimax rotation with Kaiser normalization; loadings below .4 are not shown.

Table 4: Descriptive statistics of model constructs

	Constructs	Mean	Std.	Cronbach α	Correlations 1	2	3	4	5	6	7
1	**WTP**	14.76	17.20	N/A	*N/A*						
2	**SR**	2.99	0.94	0.65	0.315	*0.823*					
3	**PPR**	2.90	0.91	0.72	0.317	0.433	*0.736*				
4	**LOT**	2.69	0.85	0.69	-0.234	-0.028	-0.134	*0.763*			
5	**LPB**	3.75	0.89	0.71	-0.160	0.074	-0.067	0.001	*0.781*		
6	**ELC**	3.60	0.82	0.74	0.245	0.242	0.413	-0.420	0.016	*0.714*	
7	**PID**	8.84	3.05	N/A	0.157	0.203	0.314	-0.141	0.194	0.379	*N/A*

Notes: Diagonal elements of the correlation matrix are the square root of explained construct variances.

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Chapter 18

Green, social and profitable - the role of front end of innovation decision making in achieving more sustainable new products

Katrin Eling

Abstract

In our globalized world, the competitive pressure on organizations to develop more sustainable new products is constantly on the rise. Next to the increasing amount of new legislations resulting into sustainability standards that new products need to comply with, developing more sustainable new products is becoming a necessity to achieve competitive advantage. Allowing employees to take action in this regard can thus increase the motivation and productivity of the existing personnel and, additionally, mean a competitive advantage in the "war for talent" that attracts high potentials to the organization. This chapter provides an overview of the opportunities that are available in the Front End of Innovation (FEI) to make a new product more sustainable according to the triple bottom line and the FEI decisions that have an impact on these opportunities. In this regards, special attention has been paid to defining the triple bottom line sustainability objectives of new product development. This overview and the objectives are the result of reviewing and combining the existing literature on product innovation, FEI management and sustainable innovation, in line with conducting the first steps of an inductive method of theory-building. Practitioners reading this chapter can use the presented overview to identify opportunities for increasing the sustainability of products under development and to define their sustainability objectives. For scholars, this chapter is meant as a call for future research to tackle the urgent question of how to best make decisions in the FEI to maximize the sustainability of new products according to the triple bottom line and thus as a stepping stone for future theory-building and testing.

Keywords: Front-end of Innovation; Ecological Sustainability; Social Innovation; Green Innovation; Competitive Advantage; Leadership

1 Introduction

In our globalized world, the competitive pressure on organizations to develop more sustainable new products is constantly on the rise (Porter & van der Linde, 1995; Watson, Wilson, Smart, & Macdonald, 2018). Next to the increasing amount of new legislations resulting into sustainability standards that new products need to comply with (such as the EU emission standards) (Adams, Jeanrenaud, Bessant, Denyer, & Overy, 2016), developing more sustainable new products is becoming a necessity to achieve competitive advantage. First, certain groups of customers are increasingly choosing sustainable products over their less sustainable counterparts, sometimes even at higher costs (Du, Yalcinkaya, & Bstieler, 2016; Lee & Tang, 2018). As such, in some industries sustainability rivalry is forcing innovating organizations

© Springer Fachmedien Wiesbaden GmbH, part of Springer Nature 2020
R. Tiwari and S. Buse (eds.), *Managing Innovation in a Global and Digital World*, https://doi.org/10.1007/978-3-658-27241-8_19

to meet certain thresholds (of, e.g., eco labels or organic, fair trade or ISO certificates). Second, the reduction of energy and raw material use during production can mean a competitive advantage through a simultaneous decrease of costs (Porter & van der Linde, 1995). Third, more and more individuals experience an ethical pressure to act upon the increasingly noticeable societal challenges, such as climate change, the extinction of species and the world-wide economic inequality, also in their work life (Lee & Tang, 2018). Allowing employees to take action in this regard will thus increase the motivation and productivity of the existing personnel and, additionally, mean a competitive advantage in the "war for talent" that attracts high potentials to the organization (Ambec & Lanoie, 2008).

Developing more sustainable new products should thus be seen as a new means for creating value (Bocken, Farracho, Bosworth, & Kemp, 2014; Hansen, Grosse-Dunker, & Reichwald, 2009). In fact, sustainability has already been considered "as innovation's new frontier" (Nidumolu et al., 2009, p. 2) because organizations that perform higher in sustainability are predicted to soon outperform other organizations also in terms of their overall economic performance (Ambec & Lanoie, 2008; Eccles, Ioannou, & Serafeim, 2014). As a reaction to this trend, academic research on the topic of sustainable-oriented innovation is on the rise (Adams et al., 2016; Baumann, Boons, & Bragd, 2002).

This existing research has however not yet paid enough attention to what actually needs to be done during the development process to increase the sustainability of the resulting new product (Adams et al., 2016; Nielsen & Wenzel, 2002). If so, the focus has been on strategizing (Du et al., 2016) or on making production processes or supply chains more eco-efficient (Bocken et al., 2014), which reflects only a small portion of the existing opportunities for more sustainability. On the one hand, the goal should be to consider sustainability in light of the triple bottom line, referring to balancing *economic*, *environmental* and *social* sustainability (Dyllick & Hockerts, 2002; Maxwell & van der Vorst, 2003), thus not only to an environmental perspective. On the other hand, to-date studies often only reflect a small part of a new product's life-cycle. It is however important to investigate how a new product can be made more sustainable throughout its *whole* life-cycle, from its development and production throughout its distribution, usage, maintenance and repair until its end of life (Gauthier, 2005; Maxwell & van der Vorst, 2003).

In this regard, previous research has highlighted the important role of the Front End of Innovation (FEI) for new product sustainability (Bocken et al., 2014; Hart & Milstein, 2003; Pujari, Peattie, & Wright, 2004). The FEI is the messy getting started phase of the product development process in which innovation opportunities are identified and developed into a well-defined new product concept and a corresponding business case (Eling & Herstatt, 2017). Decisions made for a specific technology, target market or product form throughout this concept development process determine to a large extent the life-cycle characteristics of a new product (Eling, Griffin, & Langerak, 2014; Maxwell & van der Vorst, 2003). Consequently, decision making in this phase holds the highest potential to increase the overall sustainability of a new product (Hart & Milstein, 2003). Unfortunately, research to-date has not provided an overview of the options that exist in the FEI to increase new product sustainability and of the FEI decisions that have the claimed impact. In general, the precise sustainability objectives to be achieved through product innovation with regard to the triple bottom line remain unclear (Adams et al., 2016; Hansen et al., 2009).

To make a start in filling this research gap, this chapter provides an overview of the opportunities that are available in the FEI to make a new product more sustainable according to the triple bottom line and the FEI decisions that have an impact on these opportunities. In this regards, special attention has been paid to defining the triple bottom line sustainability objectives of new product development. This overview and the objectives are the result of reviewing and combining the existing literature on product innovation, FEI management and sustainable innovation, in line with conducting the first steps of an inductive method of theory-building (Eisenhardt, Graebner, & Sonenshein, 2016). Practitioners reading this chapter can use the presented overview to identify opportunities for increasing the sustainability of products under development and to define their sustainability objectives. For scholars, this chapter is meant as a call for future research to tackle the urgent question of how to best make decisions in the FEI to maximize the sustainability of new products according to the triple bottom line and thus as a stepping stone for future theory-building and testing.

2 The sustainability objectives of new product development

Unfortunately, while many studies have been conducted on the topic of sustainability-oriented innovation, no agreement does yet exist about what exactly the sustainability objectives for product innovation are (Adams et al., 2016). Since there is an urgent need for discrete sustainability goals for innovation (Hansen et al., 2009), this section makes a next step in reaching an agreement on such goals based on a review and recombination of the literature.

Clearly, there is an agreement in the literature that the overall objective should be to achieve a new product that is sustainable in terms of the so called triple bottom line (Calik & Bardudeen, 2016; Elkington, 1999; Kusi-Sarpong, Gupta, & Sarkis, 2018; Maxwell & van der Vorst, 2003; Watson et al., 2018), which refers to achieving a balance of *economic*, *environmental* and *social* sustainability. However, these three dimensions have been criticized for being too generic and theoretical to serve as objectives (Hansen et al., 2009) and are highly interrelated and affecting each other (Dyllick & Hockerts, 2002). For example, less pollution or a more intact ecosystem as part of the environmental dimension are likely to also increase societal health and thus affect the social dimension. Also, the overuse of natural resources as part of the environmental dimension affects the economic dimension as soon as natural resources become scarce and thus more expensive (Watson et al., 2018). Nevertheless, it is reasonable to distinguish the three dimensions theoretically, especially with the intention to define clear, lower-level sustainability objectives for new product development.

Before going into depth with such lower-level objectives, it is important to note that the sustainability of a new product within all three dimensions needs to be considered as a continuous spectrum of *more or less* sustainable rather than as a dichotomous characteristic (i.e., sustainable versus not sustainable). One rationale for taking this continuity perspective is the impossibility of determining a threshold or a maximum for when a new product is sustainable and when not. Instead, it is more expedient to compare the level of sustainability (i.e., more or less sustainable) with similar products previously developed by the organization or by competitors (Nielsen & Wenzel, 2002). The second rationale is that, when sub-dimensions are established, a new product can be more or less sustainable as a result of adding up the sustainability level on each of these sub-dimensions (e.g., high on one dimension, but low on all others vs. high on all dimensions). Below, the sub-dimensions that could be identified from the literature for each triple bottom line dimension will be introduced as the sustainability objectives of new product development.

2.1 The economic dimension

Looking at sustainability from an economic perspective is certainly the most established of the three triple bottom line dimensions within the product innovation literature. Nevertheless, it needs some explanation, as different views exist on how the economic performance of a new product can be translated into economic sustainability. The first distinction in this regard is made between a firm-internal and a firm-external perspective. The firm-internal perspective focuses on the impact of a new product on the economic sustainability of the developing organization (Dyllick & Hockerts, 2002). At the external side, some studies have also taken into account the economic situation of stakeholders external to the organization (i.e., suppliers) (Juntunen, Halme, Korsunova, & Rajala, 2019) or the economic situation of the region or the economy in which the new product is developed or launched (Halme, Anttonen, Hrauda, & Kortman, 2006). With the latter levels of externality, the economic dimension however starts overlapping with the social dimension, which is why the external perspective is disregarded in this chapter.

A second distinction can be made internal to the organization between project and organizational levels (Dyllick & Hockerts, 2002; Maxwell & van der Vorst, 2003). On the project level, the goal is profitability of the one product that has been developed, while at the organizational level the goal is to have cash flow for new investments without focusing on the profitability of individual projects. Thus, in line with a portfolio management perspective (Chao & Kavadias, 2008; Kock, Heising, & Gemünden, 2015), even projects with higher associated risk and no profits can add value to an organization as long as they contribute to the development of "cash cows" that bring in the required organizational-level profits. Although looking at this organizational level surely is most reasonable from an organizational economics perspective, this chapter focuses on economic sustainability at the project level. The rationale behind this focus is that it is easier to create first insights on the topic of decision making for more sustainable products on this lower, one-dimensional level. Clearly, future research should however also take the organizational portfolio level perspective on a new product's economic sustainability into account.

A product development project should thus lead to a return of the investment that has been made for its development, production, launch and distribution in order to be economically sustainable (Dyllick & Hockerts, 2002; Maxwell & van der Vorst, 2003). With this focus in mind, four objectives can be distinguished:

- *Lower development and product costs:* The investment, thus the costs for the development and the resulting product should be kept as low as possible (Dyllick & Hockerts, 2002).
- *Higher development speed:* With the goal of increased sales (i.e., income) in mind, a speedy development is important to ensure that the product is available on the market at the time when sales in the particular market is taking off (Cankurtaran, Langerak, & Griffin, 2013).
- *Higher customer value:* The chosen target market should be big enough to actually achieve a higher sales (Evanschitzky, Eisend, Calantone, & Jiang, 2012). As such, it is important to satisfy the needs of a big amount of potential customers with the product offering (Anderson, Fornell, & Lehmann, 1994; Griffin & Hauser, 1993)

- *Higher competitive advantage:* To increase the sales, the product offering should also deliver an advantage over the offers of competitors in the same market (Evanschitzky et al., 2012).

With these four sub-dimensions this chapter thus distinguishes four classical project-level new product performance measures as economic sustainability objectives (Griffin & Page, 1993; Maxwell & van der Vorst, 2003; Tatikonda & Montoya-Weiss, 2001).

2.2 The environmental dimension

Although the literature on environmental, or also green or eco(-logical) innovation, is scattered, agreement exists about the actual objectives. The ultimate goal within the environmental dimension is that the new product does not harm the condition of the overall natural environment consisting of the atmosphere (air), the geosphere (land), the hydrosphere (water) and the biosphere (all living species) (Polonsky, 2011). This includes the potential pollution or even complete destruction of all four types of sphere through, for example, carbon dioxide emissions, creation of residual waste, deforesting, or the wasting and overuse of (natural) resources, such as water or oil (Dyllick & Hockerts, 2002; Hart & Milstein, 2003; Watson et al., 2018). From a continuity perspective, this means that every type of harm that can, at best, be prevented or, at least, be diminished makes a new product environmentally more sustainable. A review of the literature (Adams et al., 2016; Halme et al., 2006; Juntunen et al., 2019; Ljungberg, 2007) based on this definition and a comparison with the UN Sustainable Development Goals (https://www.un.org/sustainabledevelopment) has resulted into the distinction of four sub-dimensions:

- *Preventing or reducing the use / making a sustainable use of natural resources:* This refers to any natural resources, such as water, gas, oil, sand, stone, rare earth, wood and vegetables and thus also includes the aim to prevent wasting of these resources for any means (including e.g., energy production, combustion in engines, or food waste).
- *Preventing or reducing pollution of land, water and air:* This refers to any possible pollution through substances and materials that (could) escape into the environment and that do not resolve at an acceptable speed, such as carbon dioxide and other (toxic) emissions, or plastic and toxic waste.
- *Preventing or reducing the destruction of ecosystems (land or marine):* Such destruction may occur through e.g., mining, deforesting, desertification, overfishing, asphalting or the application of insecticides, herbicides and fungicides.
- *Preserving and protection of living species:* This sub-dimension partly overlaps with the above, but includes additional aspects that are not directly linked to ecosystem destruction, such as intensive livestock farming or harming product testing with animals.

2.3 The social dimension

For the social dimension of sustainability, again three different perspectives need to be distinguished. On the one hand, the development of a new product should have a socially sustainable impact on employees internal to the organization. On the other hand, external to the organization it should have a positive social impact on individuals, organizations and societies within the value chain (e.g., suppliers, distributors, customers or end users) and outside of the value chain of the new product (e.g., humans and society in general) (Gauthier, 2005; Hansen et al., 2009; Juntunen et al., 2019; Tello & Yoon, 2008). In addition, also here two levels can be distinguished, i.e., (i) individuals or small groups of human beings, here referred to as "human(s)" and (ii) groups of humans having common traditions, institutions and interests, here referred to as "society". This chapter aims to reflect all above presented perspectives and levels within the objectives for the social sustainability dimension. From reviewing the literature (Dyllick & Hockerts, 2002; Gauthier, 2005; Halme et al., 2006; Hart & Milstein, 2003; Lee & Tang, 2018; Ljungberg, 2007) and from a comparison with the UN Sustainable Development Goals (https://www.un.org/sustainabledevelopment), the following three social sustainability objectives for product development can be distinguished:

- *Preserving human rights:* This objective represents the need to prevent any form of discrimination (e.g., racial, sexual, of minorities), unequal treatment, suppression and deprivation of liberty and instead to achieve freedom, equality and inclusion in line with the Universal Declaration of Human Rights (https://www.un.org/en/universal-declaration-human-rights/).
- *Preserving or increasing human / societal health and wellbeing:* This objective represents the need to ensure the safety, healthiness and wellbeing of humans and society.
- *Preserving or increasing human / societal wealth:* This objective reflects the need to ensure fair compensation of humans world-wide and the need to preserve or even to contribute to the wealth development of poorer societies.

3 Opportunities for making new products more sustainable

From a sustainability perspective, the goal in developing a new product should be to achieve sustainability within the above presented sub-dimensions of the triple bottom line dimensions along the whole life-cycle of the new product (Gmelin & Seuring, 2014; Hart & Milstein, 2003; Ljungberg, 2007; Pujari, 2006). In the literature, many different versions of product life-cycle stage distinctions in relation to new product sustainability can be found (e.g., Gauthier, 2005; Hansen et al., 2009; Ljungberg, 2007; Maxwell & van der Vorst, 2003). From these different versions, it was concluded that sustainability can be increased in all of the following product life-cycle stages:

- *Development & Testing:* The period from having a first idea for a new product until its launch in the market, including internal and market testing of the new product.
- *(Extraction / Growing of) Raw Materials:* The period of extraction, purchasing and delivery of raw materials to the production facilities or, if no production is included, to the packaging facilities or point of sale.
- *Production & Assembly:* The period of the production of materials and product components and the assembling of raw materials and components, as well as to the transport of the product or of product components to the packaging or distribution facilities.
- *Packaging & Distribution:* The period in which the product or the components of the product are prepared for sales through packaging and are distributed through the chosen distribution channels (e.g., in store, via online shops), including the storage of unsold products and the transport to the stores or distribution centers.

- *Usage & Stand-by:* The period of usage (or consumption) starts with the buying through / arrival at the customer and includes the usage of the product by the end-user (i.e., the end-user sometimes differs from the customer purchasing the product) as well as the periods of non-usage (e.g., stand-by, storage).
- *Maintenance & Repair:* This period refers to the situations when the product breaks and thus requires repair and spare parts or when the product does not anymore function without maintenance being conducted by either the end-user, the customer, the selling organization or an external service provider.
- *End of Life:* This period describes the end of the life of a product, meaning that it is not anymore used by end-users and is thus either stored away, thrown away, or put into a recycling or up-cycling process.

It needs to be emphasized that products might iterate back and forth through these stages, so that the order of presentation cannot be fully equalized with the presentation of a linear process. Moreover, not all new products go through all of these life-cycle stages. For example, unprocessed food products miss the production & assembly, and, as many other fast-moving-consumer-goods, they miss the maintenance & repair. Software and other digital products as well as many services do not go through the stages of raw materials extraction, production & assembly, as well as packaging (& distribution). Thus, depending on the product and industry, some of the above defined lifecycle stages may be neglected.

Aiming for achieving the earlier presented sustainability objectives for new product development along these life-cycle stages results into many opportunities for increasing the economic, environmental and social sustainability of a new product, as illustrated in Table 1. The table should be read by starting with picking one objective in the left column and then moving to one life-cycle stage from the top row. Each cell concurring between an objective and a life-cycle stage represents one potential action point for increasing sustainability. For illustration purposes, one (sometimes two) example(s) per action point are presented in the concurring cells. These examples refer to actions for sustainability that can be taken either (#) through the design of the product or (*) through a change of the processes of e.g., developing, producing, distributing or maintaining the product. Clearly, these examples do not fit every product type and industry and, surely, many more opportunities exist per action point. Therefore, it may be useful for practitioners to develop an own version of this table for their own organization or product category in order to have a complete overview of applicable and actionable opportunities, similar to Alston and Roberts (1999).

Most importantly, from a theoretical perspective, Table 1 again highlights the need to take a continuity perspective to new product sustainability. Each organization can decide to add up more or less of these action points for achieving a more or less sustainable new product. However, for actually having the full choice of opportunities for a higher new product sustainability as presented in Table 1, the important role of decision making in the FEI comes in.

4 The role of FEI decision making in determining a new product's sustainability

Previous research has emphasized the role of the FEI in determining the sustainability of a new product (Bocken et al., 2014; Hart & Milstein, 2003), based on the argument that the sustainability characteristics of a new product are "largely fixed" (Baumann et al., 2002, p.

413) as soon as the new product concept is defined and the product moves into development (Bocken et al., 2014; Maxwell & van der Vorst, 2003). This research has however left unclear what exactly the role of the FEI is in this regard. A key role can certainly be seen in the many important decisions about the new product and the development process that are made in this phase. Amongst others, the decisions in this phase determine *what* (i.e., the product concept) will be developed and also *how* (i.e., project planning) it will be developed (Eling et al., 2014; Hultink, Griffin, Hart, & Robben, 1997). Determining the *what*, i.e., the product concept, means that a decision is made about (i) which target market to focus on and thus which customers to deliver value to, (ii) with which technology(/-ies) this value will be delivered to the targeted customers, and (iii) in which general product form (e.g., physical vs. digital) the value will be delivered. All three *what* decisions and the *how* decision have important implications for the characteristics of a new product throughout its life-cycle and thus for the amount and type of available action points for more sustainability (Figure 1). In describing the impact of these FEI decisions, this chapter takes the traditional project-level perspective on FEI decision making of aiming for a certain level of economic sustainability (i.e., profits instead of a loss) of the project (Eling, Griffin, & Langerak, 2016; Maxwell & van der Vorst, 2003).

First, and in line with this economic perspective, the decision for a *target market* determines what the new product has to deliver at a minimum in terms of customer value and competitive advantage. In addition, first estimations of the expected sales in this market give an indication of how much the development may cost and how long it may take in order to launch the product in the chosen market when sales is still taking off and not yet stagnating (Van Oorschot, Eling, & Langerak, 2018). If neglecting these economic sustainability requirements, the profitability of the new product is very unlikely, which is certainly unwanted in a for-profit context (from a project-level perspective). Based on the target market selection, the amount of options to also increase the environmental and social sustainability is thus already bound to cost and time constraints as well as to customer and competitive requirements. It constraints the product life-cycle characteristics of a new product in terms of, for example, material choices and the design of the product usage in line with the market needs, but also the resource availability for (raw) materials, production, or distribution. Consequently, in order to maximize sustainability according to the triple bottom line, it may be wise to choose a target market in the FEI that allows for or even asks for a product that is also environmentally and socially sustainable throughout its life-cycle.

Table 1: Opportunities (action points) for increasing the sustainability of a new product and examples of design or process actions that can be taken per action point

	Development & Testing	(Extraction / Growing of) Raw Materials	Production & Assembly	Packaging & Distribution	Usage & Stand-by	Maintenance & Repair	End of Life
Economically more sustainable through:							
Lower costs for / through ...	**Smaller development team, less hours available*	*#Using cheapest materials*	**Using existing production facilities (no new plant / tools)*	*#*Using simple packing and a small distribution network*	*#A small amount of features and a low-tech solution*	*#No or small need for maintenance - if so, make it paid*	*#Rather short life through low quality materials*
Faster development speed for / through...	**Working over hours, assigning a bigger team*	**#Using the fastest supply or the existing supply chain*	*#Using simple production methods / a simple product*	*#*Using simple packaging and extensive distribution*	*#A small amount of features and a low-tech solution*	*#Fast developed product = requires more maintenance*	*#Rather short life through low quality development*
Higher customer value through ...	**Understanding customer problems + testing solutions*	*#Using materials most valuable for the selected customers*	*#Choosing the best technologies to meet customer needs*	*#*High quality packaging, high coverage distribution*	*#Customizable or many features or usability*	*#Low to no maintenance needs*	*#A long product life or even reusability (of parts)*
Higher competitive advantage through ...	**More market analysis + generating novel ideas*	*#Using higher quality materials than competitors*	*#Achieve a better production quality than competitors*	*#*High quality packaging, high coverage distribution*	*#Better and/or more features than competition*	*#Low to no maintenance needs*	*#Longer life than competitor's products*
Environmentally more sustainable through:							
Reducing or making a sustainable use of natural resources for / during	**Less paper work, less prototyping*	*#Use of less or renewable materials / *avoid long transport*	**#Lower energy use / no waste of materials*	*#Small product = small material use / minimum waste*	*#Prevent the need of consumables / reduce energy need*	*#No materials (spare parts) needed for maintenance*	*#Design for a long life / disassembly and re-use of parts*
Preventing or reducing the pollution of land, water and air for / during ...	**Less traveling to firm locations or customers*	*#Materials that naturally dissolve / *avoid long transport*	**Lower emissions during production / avoid long transport*	*#Small product = small space use / *avoid long transport*	*#Use of naturally dissolving or reusable consumables*	*#No emissions or waste created during maintenance*	*#Use naturally dissolving or reusable materials*
Preventing or reducing the destruction of ecosystems (land or marine) for / during ...	**Do not build new buildings, labs or test areas*	**#No materials extracted or grown in ecosystems at risk*	**#No building of new production or assembly plants*	*#Smaller need for transport (routes) / less storage need*	*# (Non-)usage does not require big space / infrastructure*	**No extra building (e.g., a repair center) required*	*#Use naturally dissolving or reusable materials*
Preserving or protecting living species through / during ...	**Avoid product testing with animals*	*#Avoid materials extracted at risk of harming living species*	*#Avoid noises or emissions that could harm animals*	*#Avoid packaging that can harm animals (e.g., plastic)*	*#Avoid noises, waste or emissions which could harm animals*	*#No animals harmed when the product is broken*	*#Avoid materials that can harm animals (e.g., plastic)*
Socially more sustainable through:							
Preserving human rights through / during ...	**No discrimination in the development team*	**Human rights protected during material extraction*	**Human rights protected during production/assembly*	*#Packaging that is convenient to open for everyone*	*#Usage possible by everyone = supports inclusion*	*#Maintenance / repair intervals are equal for every user*	**Offer recycling options to prevent Third World recycling*
Preserving or increasing human / societal health & wellbeing through / during ...	**Prevent work stress / realize safe testing conditions*	**Materials extracted or grown under safe conditions*	**Healthy and safe production and assembly conditions*	**Healthy and safe packaging conditions*	*#Good usage ergonomics / safe for users & stakeholders*	*#The product is still safe even when broken*	*#Design a product that is safe to disassemble*
Preserving or increasing human / societal wealth through / during ...	**Equal pay of team members at different locations*	**Material supply under fair trade conditions*	**Equal and fair pay, move production to poor societies*	**Fair trade along the distribution line*	*#Fair pricing of product and consumables*	*#Costs for maintenance or repair are fair*	*#Design for a long life / disassembly and re-use of parts*

*#Example for a change to the product design, *Example for a process change*

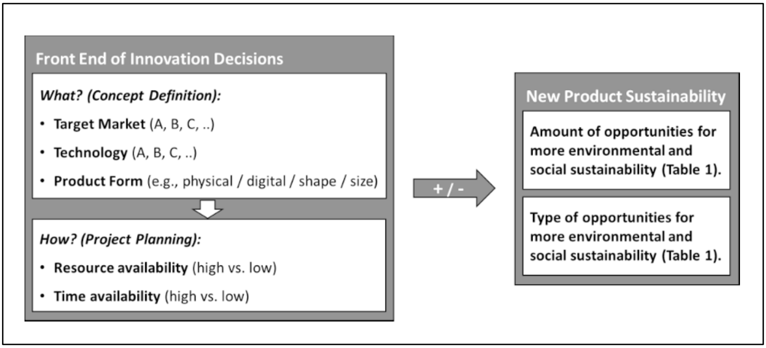

Figure 1: The impact of FEI decisions on the amount and type of available opportunities for more environmental and social new product sustainability while aiming for project-level economic profitability

Second, with the decision in the FEI to meet customer demands with a certain *technology*, the options for environmental and social sustainability are further limited. Every technology brings along certain requirements for the choice of materials as well as certain constraints for production and assembly processes, maintenance needs and end of life. Also, the usage and stand-by situation of a new product is determined to a certain extend by the technology choice. Thus, if many constraints are already set through the technology choice there is again less room for actions to increase the environmental and social sustainability of a new product, except these actions match the technology choice. Consequently, again, a wise decision in terms of the technology choice is required in the FEI in order to be able to maximize all three sustainability dimensions.

Third, while closely linked to the technology choice, also the decision for a certain *product form* in the FEI has important implications for the availability of opportunities for more sustainability. While the chosen technology already determines the product form to a certain extent (e.g., whether it will be physical or digital), still options exist in determining the exact form (i.e., in terms of physical size or shape) and also to add a physical component to a digital product or the other way around. This decision will again set certain constraints to material choices, production, assembly, packaging, distribution, and usage and will especially also have an impact on the need of space during storage and transportation. As such, a number of action points for a higher environmental and social sustainability are also affected by the FEI decision for a product form. Consequently, again an anticipatory decision making with regard to a new product's triple bottom line sustainability is required in determining the product form in the FEI.

Finally, also the decision in the FEI about *how* the new product will be developed can have an impact on the amount of available action points for more sustainability. While the decisions for a target market, technology and product form already determine to a great extend the resource and time planning of the development project, which is typically established through the business case, nevertheless some freedom still exists on how to make use of and distribute the available resources and development time throughout the project. As such, the project planning decisions made in the FEI can also have an impact on how much money and time is available to be spent on finding design and process solutions as well as stakeholders along the new product's value chain that can contribute to a higher sustainability of the resulting new product according to the triple bottom line.

These arguments clearly highlight the importance of FEI decision making for the sustainability of a new product. This importance however also means that future research is required to investigate how to best make these complex decisions in order to maximize the sustainability of a new product according to the triple bottom line.

5 Future research

Traditionally, the focus in making FEI decisions has mainly been on the economic sustainability perspective, which is also reflected in the commonly applied criteria for evaluating the potential of ideas to generate profits at this early stage in the process (Eling et al., 2016; Poetz & Schreier, 2012): i.e., feasibility (i.e., referring also to cost and time), use value (i.e., customer value) and novelty (i.e., competitive advantage). Making decisions and defining new product concepts in the FEI with the goal to simultaneously meet all these economic sustainability criteria is already challenging and, in most cases, trade-offs need to be made (Van Oorschot et al., 2018). Several studies have already looked into this problem, however, with inconclusive results so that future research is still required, even for only the economic dimension of sustainability (Eling & Herstatt, 2017).

Adding the objectives to also meet social and environmental sustainability criteria in developing new products further increases the complexity and difficulty of decision making in the FEI. From an ethical perspective, the goal would be to design a new product that has the highest possible level of sustainability according to all triple bottom line sub-dimensions throughout all product life-cycle stages. Clearly, for the vast majority of new products this is impossible to achieve (Nielsen & Wenzel, 2002). While several synergies can be observed in Table 1, such as the objective of cost savings for the economic dimension with lower energy or material use for the environmental dimension, the majority of objectives even within one column of Table 1 still contradict or even mutually exclude each other. An example is the objective to supply materials under fair trade conditions in order to increase the social sustainability versus the use of the cheapest materials or the fastest supply chain in order to reduce the product costs or the time-to-market. Many more of such examples can be found in Table 1.

Overall, the goal should certainly be to achieve the highest levels of environmental and social sustainability, while still creating an economic outcome that allows the developing organization to operate in an economically sustainable manner. This means a big challenge for future research and requires for answers to, amongst others, the following research questions:

- *Which action points for more social and environmental sustainability have (the strongest) positive effects on a new product's economic sustainability?*
- *Which groups of action points create synergies and which contradict or mutually exclude each other in this regard?*
- *What is the conditional impact of certain product-type (e.g., incremental vs. radical), market or industry characteristics on the effect of pursuing certain sustainability action points?*

- *Which impact do differences in an organization's sustainability objectives have, e.g., achieving cost savings versus meeting market demands for more sustainability?*
- *What happens when the economic dimension plays less of a role in, e.g., non-profit sectors, or when looking at organizational-level economic sustainability rather than at profits at the project-level?*

In light of the prediction that the triple bottom line sustainability of innovations will be a critical means for creating future competitive advantage (Ambec & Lanoie, 2008; Nidumolu et al., 2009), the theorizing in this chapter and the presented research questions will hopefully stimulate a fertile stream of future research on FEI decision making for more product sustainability. Moreover, practitioners will hopefully be encouraged by the presented overview of opportunities to develop more sustainable new products.

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Part IV

Developments in Innovation Ecosystems

Chapter 19

A framework for analyzing technology ecosystems – adopting insight from biology

Elisabeth Eppinger and Daniel Ehls

Abstract

Technology Ecosystems perspective has become a preferred approach to analyze complex interactions and integrate several domains like Technology Management, Innovation Management and Strategy. However, our understanding of ecosystems in management continues to remain limited. Management literature frequently speaks about ecosystems only in terms of a 'complex system' and highlights interactions without further differentiation. Enriching this perspective, we propose to adopt insights from biology, which has developed a far more detailed taxonomy for studying ecosystems. Transferring these insights can help management scholars gain a more nuanced understanding. Applying this 'bridging' idea to link the 'management ecosystem' perspective and 'behavioral ecosystems', this paper seeks to increase our understanding in multiple ways: (1) We refine our understanding of ecosystems with an aligned taxonomy; (2) We disentangle the relationships among different ecosystem layers, actors, and technologies; and (3) We provide an instrument to advance management research and structure future research on sustainable technology adoption and diffusion. We provide a taxonomy that differentiates dynamic, co-evolving technologies in co-evolving industry ecosystems.

Keywords: Inventive Analogies; Technology Ecosystems; Industry Ecosystems; Biomimicry

1 Introduction

Applying a Technology Ecosystems perspective has gained tremendous interest in the last years. They are a preferred approach to analyze complex interactions and integrate several domains like Technology Management, Innovation Management and Strategy (e.g. Adner & Kapoor, 2010; Gawer & Cusumano, 2014). However, our understanding of ecosystems in management is limited. Management literature frequently speaks about ecosystems only in terms of a 'complex system' and highlights interactions without further differentiation. Enriching this perspective, we propose to adopt insights from biology. This literature has a deep history studying our environment and in particularly the interaction of organisms. Not surprising, various fields of biology, such as phytology, zoology and human biology including developmental psychology have already developed a far more detailed taxonomy for studying ecosystems. As such, transferring these insights can help management scholars gaining a more nuanced understanding. Indeed, transferring insights across disciplines has a huge impact in the trajectory of science (Heisenberg, 1962), could introduce highly novel ideas (Jeppesen & Lakhani, 2010), and is often rooted in bridging insights that have its origin in our environment

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R. Tiwari and S. Buse (eds.), *Managing Innovation in a Global and Digital World*, https://doi.org/10.1007/978-3-658-27241-8_20

(Levin, 1997). It thus shows the gains from an integrative perspectives and interdisciplinary learning (Geels et al., 2008).

Applying this 'bridging' idea to link the 'management ecosystem' perspective and 'behavioral ecosystems', this paper seeks to increase our understanding in multiple ways. (1) We refine our understanding of ecosystems with an aligned taxonomy. (2) We disentangle the relationships among different ecosystem layers, actors, and technologies. (3) We provide an instrument to advance management research and structure future research on sustainable technology adoption and diffusion. We provide a taxonomy that differentiates dynamic, co-evolving technologies in co-evolving industry ecosystems.

2 Theoretical background on adoption and diffusion of technologies

Three streams of research with a strong focus on the adoption and diffusion of technologies have deepened our understanding of the success of technological innovations over the last decades: research on innovation diffusion, on business strategy, and on technology management. Innovation diffusion literature provides rich insights into factors that impact adoption dynamics (Rogers 2010; Hall 2004, Stremersch et al., 2007, Iyengar et al., 2011). But although e.g., Rogers (2010) emphasized that technologies and industries, as well as demands evolve over time, the studies are based on a static view of diffusing innovations, usually with a demand-side view. The core question that strategy research addresses in relation to technology are: Whether new technology will dominate old ones. With a strong supply-centered view, studies on strategy analyses technology substitution as an event that is governed by the rise of the new technology (Adner 2002, Sood and Tellis 2005; Tripsas, 2008). While technology management literature frequently analyses a focal technologies as independent and co-evolution is underexplored (Adner and Kapor 2016). Yet, for a deeper understanding of technology adoption and diffusion, it is also necessary to bridge demand-side and supply-side views.

Ecosystem studies promise to provide this bridge, while acknowledging the co-evolution of technologies. Management studies on ecosystems have focused on how firms sustain competitive advantage by orchestrating their value network (e.g., Adner and Kapoor, 2010, 2014; Iansiti and Levien, 2004). Ecosystems allow to account for evolving, socio-cultural systems with complex interdependencies beyond dyadic stakeholder relationship and linear value-chains (Gyrd-Jones and Kornum, 2013). The concept addresses heterogeneous constellations of organizations, co-evolution of capabilities and co-creation of value (Adner and Kapoor 2007; 2010; Adner, 2017). They are similar to dynamic networks, where each exchange, resource integration, value creation, etc. "changes the nature of the system (…) and thus the context for the next iteration and determination of value creation." (Wieland et al., 2012, 13). But they go beyond "complex, adaptive systems" (Anderson, 1999; Cilliers, 2005) as they have semi-stable boundaries or a distinct degree of "permeability" (Valkokari, 2015). Accordingly, the framework conditions may become equally important for understanding the manifestation of technologies for specific applications.

2.1 A framework for studying technology ecosystems

Empirical studies on business ecosystems in management have focused on application fields where both power relations within value chains and markets were stable in terms of which type of firms orchestrate the business systems, and which type of organizations are complementors (e.g., Moore, 1997; Adner & Kapoor, 2010; Kapoor & Agarwal, 2017). Evolutionary perspectives on technological development have shown that changes in technological paradigms such as radical and disruptive innovation may change power relations in industries, challenging the capabilities of incumbent firms and enabling entrants with different technological capabilities enter with completely new value propositions. Accordingly, to account for these evolution dynamics, in this study we shift the emphasizes to technological ecosystems.

In contrast to management studies on ecosystems, studies from biology and developmental psychology feature far more fine-grained aspects and allow for further configurations. As a suitable approach for analyzing ecosystems, especially the ecological model of Bronfenbrenner (1979) is a proven concept that deepen the discussion of explaining evolutionary growth dynamics. Bronfenbrenner´s ecological model explores the scope of influences in different settings and interactions of human development. It resonates within the broader concepts of lifespan development (e.g. Baltes, 1987). There are two approaches to use this analytical frame: (1) social address approach, which describes existing differences amongst individuals, their characteristics but also their biographies and how they cope with different events; (2) process-oriented approach: search for explanations why the differences are as described in the social address approach. This model helps to decode the complex ways of influence surrounding human beings as developing individuals by describing multiple interconnected and interlocked concentric rings of influence impacting the individual person.

In particular, the model comprises of five nested layers as well as a time-perspective. An *individual* conceptualized through the ecological perspective is an individual deeply embedded and linked in a specific cultural context. *Microsystem*: multiple relations and interactions straight from the individual with others in various settings (familial, academic, recreational, employment). *Mesosystem*: the interplay of experiences in multiple settings that shapes individual development; captures the developmental significance created by the connections across settings (e.g. child education: at least two adults in at least two settings (home & school) interact with each other's independent interactions with the child). *Exosystem*: interaction between two or more settings but the developing individual does not take part directly in those settings (e.g. the influence of the parents´ workplace). Powerful influences are legislative outcomes, local and state economic and social issues. *Macrosystem*: overall cultural patterns in society, most invisible influence (e.g. power relations, race, class, gender). *Chronosystem*: ontogenetic and historical times influence the system and the interaction of the systems (Bronfenbrenner 1979; 1999).

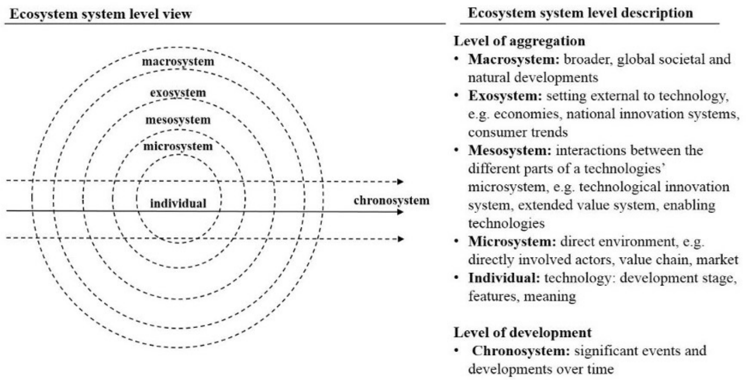

Figure 1: Technology ecosystem

As proposed in Figure 1, these levels can be adapted for managerial ecosystems across a wide area of application. We illustrate the model with the case of a technology. Technologies follow certain life-cycles and have several interactions with the environment, making them a suitable example. The *individual* technology has distinct features and characteristics including meanings, depending on its life cycle stage. These attributes are embedded in the *microsystem*, the business value network and application fields. The *mesosystem* such as the technological innovation system contextualizes the interaction in the microsystem. The *exosystem* such as consumer trends and current economic state impacts the technology as it directly affects the mesosystem. Mega trends and global developments such as climate change and increasing sustainability awareness are located at the *macrosystem* level. Accordingly, this model enables to consider technological ecosystems as open systems in terms of who and which types of organizations may enter and assume an important role, the meso and macro trends that manifest on the functionalities and specific technological characteristics (how technology generations are materialized), and the market dynamics that impact on the scope of application.

2.2 Interaction modes

Current research on technology relations provides rich insights into structures, policies, and management practices that support sustainable technologies. In stable technology trajectories such as in the fuel-based cars the power relation within value chains are stable over periods of time. For a long time, the large automotive companies dictated the innovation decision and dominant designs. This is currently disrupted by strong market pull forces towards more sustainable technologies. Hence, new technological paradigms require different technological capabilities and enable market entrants and companies from different industries to impact largely on the manifestation of a novel technological paradigm. With the attempt to define factors that lead to specific technological trajectories, research on technology evolution and dominant design has focused on competition between two or more technologies. But there are more relations amongst technologies than competition. While this research has contributed significantly to our understanding of path dependency of technology trajectories, we argue that a different emphasis is necessary to understand the emergence of new technological trajectories and how they shape and get shaped by application fields and business ecosystems.

A particular focus of these different streams is either the competition between two or more technologies or a complementary perspective. Yet, as suggested by Pistorius and Utterback (1997), there might be more relations amongst technologies than competition and complements. However, empirical studies that account e.g. for co-evolution of various technologies and relations beyond competition and complements are scarce (Sanden & Hillman, 2011). Sanden and Hillman (1997) described the interactions in terms of bundle of value chains. We build on their work and expand it to a perspective on relations including the application fields, as we argue that features of the application fields play as well an important role in defining the mode of interaction between two technologies.

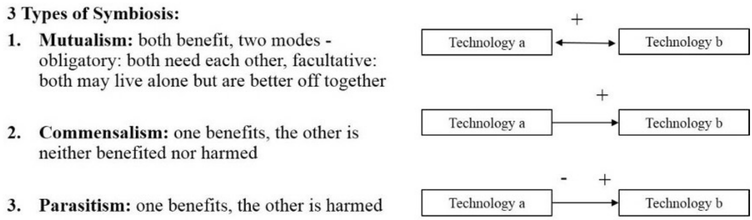

Figure 2: Symbiotic modes of technology relation

Drawing on the taxonomy of relation in biological ecosystems, we propose three types of symbiosis (Figure 2) and three forms of competition (Figure 3) for analyzing technology relations. The different types of symbiosis enable to differentiate whether one or both organisms benefit, or one might be harmed. The various competition forms relate always to direct context, the microsystem as the application field or the value network. Literature argues that organisms have simultaneously different types of relation, depending on the application field and value network. The relations may change over time. While the beginning of a new relation may start as commensalism, it soon changes, e.g. into parasitism, or interference competition. As such, this taxonomy has already benefitted conversation on relations of technologies.

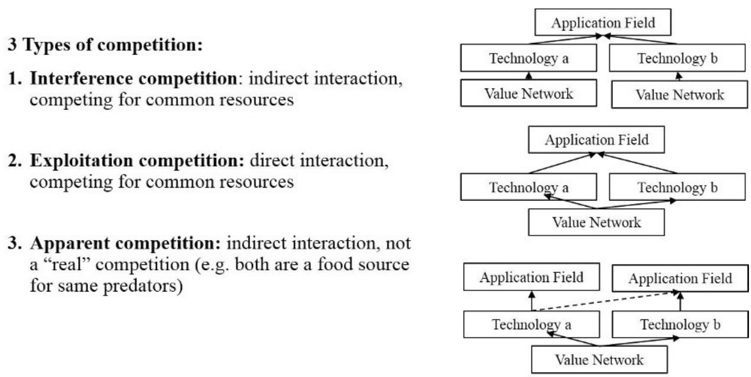

Figure 3: Competitive modes of technology relation

3 Information about different system levels for ecosystem analyses

Different system levels require different data sources. We identified different data sources that are suitable for analyzing the evolution stage at different system levels, as outlined in Table 1.

Table 1: Data sources for analyzing different technological system levels

	Indi-vi-dual	Micro	Meso	Exo	Macro
Interviews with focal entities and validation interviews: Technology providors, adoptors and non-adoptors (users, assemblers and complementors) industry experts	X	X	X	X	X
Patent data: technology (evolution of breadth and complexity, problems, products, application field) assignees (evolution of industry, organizational, and geographical breadth)	X	X	(X)		
Independent news platforms online magazines and blogs (content analysis, problem definition and solution definition, successful and unsuccessful use cases)	X	X	X	(X)	
Company/ forum news releases and product information content analysis, problem definition and solution definition, successful and unsuccessful use cases	X	X			
Industry data: Product sales (volumes, geographical coverage and diversity) Companies (type, industries)	X	X			
Trend and market reports Trends in payment and data transmission technologies Global macro trends, consumer and business trends			X	X	X

Interviews with key informants from companies and customers, especially in B2B markets, reveal important information about the evolutionary stage and the relation of technologies. But also informants from regulatory bodies, that define features for technologies for secure data transmission. Sales figures and market penetration provides insights into the diffusion of technologies. Patent data also serve as a rich source for data on different system levels. The bibliographic information reveal key inventors and geographical data where applicants see the most lucrative markets and locations for manufacturing facilities. Content analysis of news reports again provide insights into factors at different levels of the technology ecosystem. It shows framing of technology features in relation to larger societal trends. Accordingly, like interviews it may reveal how factors at different levels interact and manifest technologies for specific applications.

4 A brief discussion and conclusion on the value of technology ecosystem's research

It is frequently not clear which technological paradigm will become dominant and why. However, which technology will succeed over another technology is frequently a core question in Technology and Innovation Management and beyond. A cornerstone in these conversations is the application of the technology ecosystem. Based on interdisciplinary crossovers, we draw on concepts from biology and developmental psychology to refine the discussion of ecosystems with a more nuanced conceptual model. Our ecosystem approach exhibits an analytical framework accounting for dynamic and interactive developments with positive and negative feedback mechanism. It acknowledges and enables to disentangle changing roles and shifting power relations of various companies and organizations, especially in phases of turbulent market development. The results of our analysis demonstrate that the adoption and mitigation of technologies are processes with factors routed in different system levels and that changes of the functionality of technology and its meaning depends on space and time. Accordingly, factors that impact reduce the variability and lead to closure on different levels of the ecosystem (e.g., whether a technology is considered to be secure for users) can be distinguished into positive and negative feedback mechanisms, that affect the three different technologies also differently. Insights into factors at different ecosystem levels that channel relationships of technologies and account for dynamic industry developments are important to derive guidance for managers and policy makers promoting sustainable technologies.

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Chapter 20

Network externality vs. multi-layer platform link effect: "FeliCa" based electric money platform ecosystems analysis in Japan

Masaharu Tsujimoto

Abstract

In 1996, Sony succeeded in the mass production of the "FeliCa," one of the technological standards of an IC (Integrated Circuit) card. Based on the FeliCa, many applications have been introduced, for example, Electric Ticket, Electric Money and Mobile Wallet. This paper focused on the FeliCa based Electric Money platform ecosystems and analyzed the mechanisms of the dynamic evolution of the platform ecosystem. Regarding to the mechanism of the platform ecosystem evolution, previous researches have been emphasized the network externality. The strategy of the rapid install-base expansion is generally observed in the platform leader's behavior. Actually, the Bitwallet that is the first Electric Money provider in Japan invested huge resources to expand the member stores from the early stage. However, other providers those have other platform like JR east (railway), PASMO (railway and bus), Seven & I (retail) and AEON (retail) started their own Electric Money and took the first position of the number of the payment. They have not tried to expand the installed base but link to their existing platforms with physical positioning and virtual service program. Using the historical case analysis, the author found the network externality is weaker than the multi-layer platform link effect at the emerging stage of the platform ecosystem.

Keywords: Innovation Ecosystems; Digital Platforms; Electronic Money; Cashless Economy; Japan

1 Introduction

"Platform ecosystem" is one of the streams of the previous platform researches (Thomas, Autio, and Gann 2014). In this perspective, previous researchers defined the platform ecosystem (or industry ecosystems) as consists of platform leader and complementary players (Gawer and Cusumano 2014).There are important research topics regarding the platform ecosystem. One of them is the creation of the connection between inter-organizational network dynamics and platform theory to derive the insights on patterns of emergence and evolution of the platform ecosystem (Gawer and Cusumano 2014). We do not know well how platform ecosystems emerge and evolve (Gawer 2014). Moreover, the understandings of the competition of platform ecosystems are not enough.Based on this motivation, the "FeliCa" based platform ecosystem emergence and evolution was studied in this manuscript. FeliCa is one of the NFC (Near Field Contact) standard of an IC (Integrated Circuit) developed by SONY in 1996. The IC card is a plastic card equipped with an IC chip. This consists of a CPU, a ROM (EEPROM), and a RAM. Using memory unit area separation, FeliCa can contain many applications on one IC card, for example,

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R. Tiwari and S. Buse (eds.), *Managing Innovation in a Global and Digital World*, https://doi.org/10.1007/978-3-658-27241-8_21

Electric Ticket, Electric Money, Entrance Key, Members card and Electric ticket. This function enables FeliCa to be a platform and the platform ecosystem based on the FeliCa has emerged.

Electric Money is the most expanded application of FeliCa. The Bitwallet is the first Electric Money service provider in Japan established November 2001. SONY incorporated the Bitwallet. The Bitwallet adopted the neutral strategy from the beginning of their platform leadership strategy. The fifty-nine companies invested to the Bitwallet at 2006. This means that the Bitwallet tried to keep the neutral position among the industries that adopted the Bitwalet's Electric Money "Edy".The Bitwallet invested to realize the rapid expansion of the installed-base from the early stage. The Bitwallet invested for the I/O reader writer development and provided the hardware for their member companies with no charge. This shows the Bitwallet's clear strategy to focus on the installed-base expansion. Over forty major researchers have analyzed the mechanisms of the dynamics of platform ecosystems (Thomas, Autio, and Gann 2014). One of the dominant explanations of the mechanism is "Network Externalities". Based on the network externality mechanism, the installed-base expansion has been emphasized as a key of success in the platform competition. Actually, the Bitwallet has invested huge resources to expand the number of the member companies.

Consequently, the Bitwallet's share of the installed-base was continuously top among the Electric Money providers. However, the Bitwallet's number of the payment that means the direct income has not increased and the Bitwallet could not keep its top position of the number of the payment. This paper discussed about the reason why network externality has not effectively functioned using the FeliCa based Electric Money ecosystem emergence and evolution historical data. The multi-layer platform link effect will be proposed as the mechanism of the platform evolution mechanism that is more effective than network externality at the emergence stage of the platform ecosystem competition.

2 Previous researches

Regarding platform management, numerous academic research papers exist. Thomas et al. (2014) have systematically reviewed the previous platform literature (Thomas, Autio, and Gann 2014). They identified the four perspectives of the platform researches. The fourth stream is the "platform ecosystem" perspective. The share of the number of the papers is 22% (41/183).

The platform ecosystem perspective can be identified as the application of the two previous platform logics. The first logic is the product family logic of modularity, standards and product and/or service differentiation. The second logic is the market intermediary logic of direct and indirect network externalities and market power coordination. The platform ecosystem perspective recognizes the importance of the industrial community and surrounding ecosystem (Thomas, Autio, and Gann 2014). Theoretically, both of the product family logic and the market intermediary logic affect to the emergence and evolution of the platform ecosystem. Moreover, the coordination of the ecosystem is essentially important. Regarding Electric Money platform ecosystems, the product family logic does not affect. The technology including modularity and standards is perfectly same among the service providers. Almost all of the providers adopted the FeliCa technology as the basement of the service. The differentiation of the product/service is impossible because the technology is perfectly the same.

On the other hand, the network externalities strongly affect to the evolution of the platform ecosystem. The Electric Money is the service of the payment. Obviously, the number of the place of the payment is critical for the users. Electric Money service is the typical two-sided market business. One side is the member companies and the other is the cardholder. Exactly, there are the other sides in the Electric Money business model. The value issuer and card issuer pay the license fee to the providers. The network externalities among these multi-side market is critically affected to the evolution of the Electric Money platform ecosystem. Moreover, the coordination of the ecosystem is essentially important. Gawer and Cusumano (2014) indicated the effective practices for platform leadership in their recent research (Gawer and Cusumano 2014). The fourth practice has especially strong relation with this manuscript. The practice is "Evolve the platform while maintaining a central position and improving the ecosystem's vibrancy". To go forward from this practice, we should observe how can platform leaders maintain a central position?

Gawer and Cusumano (2014) proposed the three key research questions (Gawer and Cusumano 2014). First question is, what is the mechanism of the emergence of the platform ecosystem? Second is the question of the ecosystem emergence and evolution. Third question is the impact of platforms on innovation and competition. This manuscript has relations all of these three questions. Regarding the evolution of the platform, Tiwana et al. (2010) proposed five research questions for the information technology based ecosystem research (Tiwana, Konsynski, and Bush 2010). This paper aims to follow these broadly proposed questions about the platform ecosystem evolution. Tsujimoto et al. (2015) reviewed the ecosystem researches in the strategic management field (Tsujimoto et al. 2015). They found four perspectives in the ecosystem researches. The Platform Management Perspective (PMP) is the third perspective and this is paper based on the researches in this perspective. They also proposed the multi-layer structure model of the ecosystem. The multi-layer platform connection effect is the idea from this model. Consequently, this paper focuses on the identification of the pattern of the emergence and evolution of the platform ecosystem. More specifically, the impact of network externalities and ecosystem coordination is the major research topic of this manuscript. Regarding the ecosystem coordination, the multi-layer platform link will be focused as a result of the historical case analysis.

3 Purpose and one question of the research

Based on the previous research review, this paper focuses on the pattern of the platform ecosystem emergence and evolution. The author has observed the FeliCa based ecosystem for a long time and gathered qualitative and quantitative data including original interview and daily communication with the core practitioners in the FeliCa based ecosystem creation and evolution. This dataset enables deep discussion about the platform ecosystem creation and evolution mechanisms. In this paper, author discusses the network externalities and multi-layer platform link effect that is originally proposed by the author. This trial might be significant among the previous researches in the field of the platform ecosystem research. This is the motivation of the author. Therefore, the author sets the purpose of this paper to discuss and identify the strength of the network externality and multi-layer platform link effect at the emergence stage of the platform ecosystem.

To clarify the research purpose, the author sets the one question for this research. The number of the issued cards of the FeliCa based Electric Money is indicated in Figure 1. The number of the member stores is indicated in Figure 2. These figures show that Edy (the brand of the Bitwallet's Electric Money) continuously keeps their top position of the installed base.

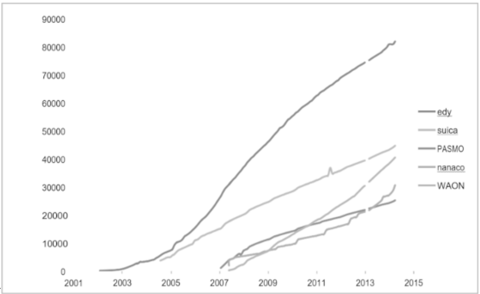

Figure 1: The accumulated number of the issued cards of Electric Money (Author calculated using Nikkei telecon)

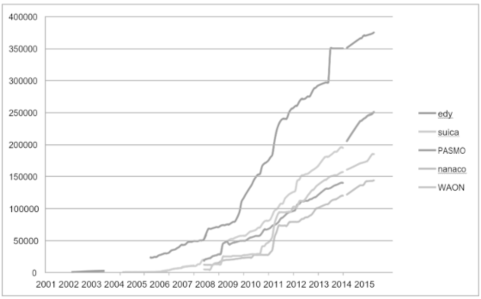

Figure 2: The accumulated number of the member stores of electric money (Author calculated using Nikkei telecon)

In contrast, the number of the payment is indicated in Figure 3. At the early stage of the emergence of the platform ecosystem of the Electric Money (2001-2005), Edy took the first position of the numbers of the payment same as the position of the installed base. However, in the middle stage of the diffusion (2006-2010), Edy's position has dropped to the fourth. After 2011, in the later stage of the emergence, nanako that is the Electric Money brand of the Seven & I keep their first position of the numbers of the payment. Here arises the research question, why this phenomenon happened?

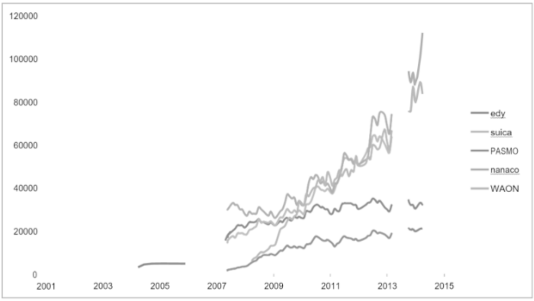

Figure 3: The accumulated number of the member stores of electric money (Author calculated using Nikkei telecon)

4 Research design and methodology

In this paper, the author selected the historical case study design. There are over 20 Electric Money brands in Japan. However, top five brands share over the 70% of the payment numbers. The base technology of these five brands is FeliCa. Consequently, the author selected five brands for historical case analysis: Edy, Suica, PASMO, nanako and WAON. Firstly, the open second hand data has been collected from the database of newspapers (Nikkei telecon), patent database (IPO), non-academic journals, academic journals, technical papers and resources on internet. Secondly, the key person using the collected data were identified and, the authors ask the key persons to cooperate with the interview. Consequently, 18 people adopted the request for interview. Thirdly, the data that gathered at first and second step was combined and the author discussed about the answer of the research question and tried to contribute the theory of the platform ecosystem.

Table 1: Interviewee list

Job Title of the day	Company name
FeliCa Business Division, Team Leader	Sony
FeliCa Business Division, Development Leader	Sony
Suica Business Division, Development Leader	JR East
Research Team Leader	Railway Technical Research Institute
Researcher (2)	Railway Technical Research Institute
Sales Division Manager (2)	Bitwallet
Division Manager	FeliCa Networks
Sales Manager	FeliCa Networks
Division Manager	NTT Docomo
FeliCa Business Division Manager	Sony
FeliCa Business Division Manager	Sony
New Business Manager	JR East
Business Team Manager	Bitwallet
Senior vice president	Toppan
COO (Chief Operation Officer)	Bitwallet
R&D Manager	Intel

5 Historical case analysis

5.1 What is “FeliCa”?

The FeliCa is one of the technological standards of an IC (Integrated Circuit) card. The IC card is a plastic card equipped with an IC chip. This consists of a CPU, a ROM (EEPROM), and a RAM. Based on their interface, IC cards can be classified into two broad categories: Contact IC cards and Contactless IC cards (Figure 4). Contactless IC cards can be further classified into smaller groups according to the distance between the IC card and the card reader/writer. The FeliCa belongs to the category of proximity-type contactless IC cards.

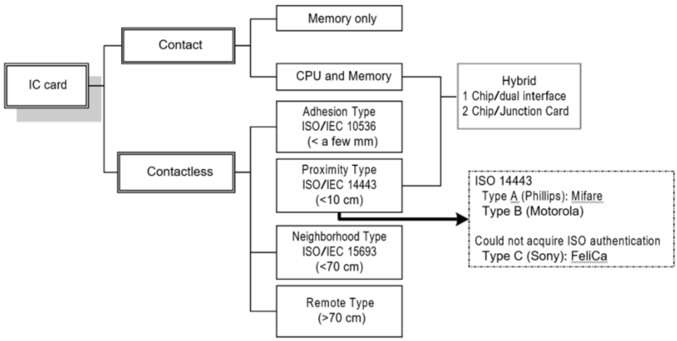

Figure 4: Categories of IC cards (prepared by author)

The IC card has three main characteristics. First, it has an excellent security function. The CPU controls a transaction and encodes the data. In particular, contact IC cards have a higher level of security. Second, the IC card has a large memory size - the memory size is currently 32 KB and is expected to reach 64 MB in the near future (a magnetic card has a memory of only 72 B). It can therefore record biometrics information for a security system. Third, the IC card is highly valued for its portability and user-friendliness. The contactless IC card has an antenna that can receive a signal and electrical power from the reader/writer. Among the four types of contactless IC cards, the proximity type is the most significant and well-developed category in Japan.

The proximity-type card can be divided into three categories: Types A, B, and C. Both type A and type B are regarded as global standards and have acquired ISO authentication (ISO14443). Type A was developed by Koninklijke Philips Electronics N.V. (Philips); it is referred to as “Mifare” and has a memory but no CPU. In Japan, the Nippon Telegraph and Telephone Corporation’s (NTT IC) telephone card is of type A. Type B was developed by a conglomeration of organizations formed with Motorola as the central company. The administration authority in Japan uses this type as the IC card in the Basic Resident’s Registration Network (the “Jū-ki Net”).

Type C was developed by Sony Corporation (Sony) and has not acquired ISO authentication. However, the NFC technology of Sony and Philips is accepted as an ISO18092 standard. This is backward compatible to the FeliCa technology, although the reason for is unclear. The focus of the FeliCa was to improve transaction speed and achieve a speed two times (0.2 s.) that of other standards. However, due to this specification, the security problem remains unresolved. The FeliCa uses a DES security key, which helps improve the transaction speed but decreases the security level. In 1996, Sony succeeded in the mass production of the FeliCa one of the technological standards of an IC (Integrated Circuit) card.

5.2 Short history of "FeliCa" based electric money platform ecosystem

In this section, the short history of FeliCa is explained. The detailed events of each Electric Money providers are indicated in the continuous sections.

November 2001, Sony incorporated Bitwallet, Inc. (Bitwallet). The Bitwallet provided "Edy" which is the first Electric Money in Japan. On 2004, JR East introduced the FeliCa to an Electric Money system called "Suica" (Super Urban Intelligent Card). At the early stage of the diffusion of the Electric Money, these two brands competed. The strategy of these two brands was clearly different. Bitwallet focused on the install base expansion strategy and JR East announced the "Eki-naka" strategy that means they expand the Suica only inside the railway stations. March 2007, private railway companies and bus companies, one hundred one companies as total, launched their own Electric Ticket and Electric Money named "PASMO". April 2007, Seven & I holdings started new Electric money named "nanako". Also on April 2007, AEON started "WAON." Both of these companies are huge retail company group in Japan. They expand their Electric Money brand inside their group retail shops. According to the statistics data of the number of the issuance of the Electric Money in 2015, Edy is the top brand in Japan. However, regarding to the number of the payment, Edy has dropped down to the third position. On December 2009, the Rakuten obtained 50% of the Bitwallet's share. This means Bitwallet became a subsidiary company. The author focused on the historical event sequence and compared the five Electric Money Platform Ecosystems. A sequence of events related to the FeliCa is summarized in the following chronological chart (Table 2.).

Table 2: A chronology of events related to the FeliCa based electric money (* means the key events)

Year	Event
1988	Sony started the development of an electric tag
1991	Sony commenced a one-year joint research and development project for developing an electric ticket in collaboration with the Railway Technical Research Institute (RTRI)
1992	Sony resumed the joint project with the East Japan Railway Company (JR east)
1996	Sony succeeded in the mass production of the FeliCa
1997	The "Octopus Card," which introduced the FeliCa, was issued by the Hong Kong transportation system
2000	Number of Octopus Cards issued reached the 10 million mark
2001	JR East introduced the FeliCa to an electric ticket system called "Suica" (**S**uper
	Urban Intelligent Card)
January 2001	*Sony incorporated Bitwallet, Inc. (Bitwallet)
November 2001	Bitwallet started the Electric Money service called "EDY": Euro Dollar Yen
2002	"ez-link Card" of Singapore and "Travel Card" of India (Delhi) adopted the FeliCa
2003	West Japan Railway Company (JR West) adopted the FeliCa on the "ICOCA" card
2004	*JR East started the Electric Money service using Suica brand
2004	The FeliCa was introduced on the "PiTaPa" card in the Kansai Region (a highly urbanized western region of Japan), on "Trans Card" in China (Shenzhen), and on a pass for the Chaloem Ratchamongkhon Line (Blue line) in Bangkok, Thailand
January 2004	Sony incorporated FeliCa Networks, Inc. (FeliCa Networks)

July 2004	NTT DoCoMo began the “i-mode FeliCa” service
2005	The Bank of Tokyo-Mitsubishi (known as Bank of Tokyo-Mitsubishi UFJ starting 2006) adopted the FeliCa on its “super IC card”
March 2007	Private railway companies and bus companies, one hundred one companies as total, launched their own Electric Ticket and Electric Money named “PASMO”
April 2007	*Seven & I holdings started new Electric money named “nanako”
April 2007	AEON started “WAON”
December 2009	*Rakuten obtained 50% of the Bitwallet’s share

5.3 Edy: Bitwallet, Inc.

Edy is a form of prepaid electric money as well as an application program that applies the FeliCa technology. The name Edy indicates the company’s ambition to establish it as the fourth key currency after the “**E**uro,” “**D**ollar,” and “**Y**en.” Bitwallet was established as the management and planning company of Edy in January 2001. Initially, the company was financed by 11 different companies from diverse industries (including companies from the electrical, communication, finance, and automobile industries) under the leadership of Sony. Thereafter, the company increased its capital by four times and stood capitalized at 26.7131 billion yen, with 59 institutional stockholders (as on January 1, 2006). Sony Finance International is currently the largest stockholder with a holding of 25.21%, followed by NTT DoCoMo and Sony at 15.88% and 9.34%, respectively.

Although operational tests were carried out for several types of electric money (“VISA Cash” in Shibuya city in Tokyo and Kobe city in Hyogo and “Super Cash” in Shinjuku city in Tokyo in 1998), this was the first system that was put into practice and grew rapidly. A gradual diffusion strategy is considered as the foundation of this widespread popularity (ref. 3). Initially, the use of Edy was promoted intensively with the aim of increasing its frequency of use by restricting its use to small areas (at the Gate City Osaki building in Tokyo) such as within a building or an organization. In the second stage, it expanded through an alliance with a nationwide chain of stores. In the third and final stage, the diffusion was stimulated by enabling the use of Edy on mobile phones.

The Edy can be used at the following establishments: The All Nippon Airways (airlines), am/pm, Circle-K Sunkus (convenience stores), Pronto (café bar), Yodobashi Camera (electric appliance stores), GEO (video rental stores), and Cosmo-Oil (oil refining and sales). It can also be used at 26,000 stores across Japan (twice the number of stores in the year 2004). The Edy is used for shopping 11 million times every month, and the total number of issued cards and mobile phones with Edy exceeds 14 million (source: press release of Bitwallet). The total number of Edy on mobile phones exceeded 2 million by January 2006. The total number of mobile phones equipped with the Edy doubled within five months (Nikkei Ryutsu Shimbun MJ, January 2006). Its usage in 2005 exceeded 100 million.

Since the IC card Edy is a prepaid card, it needs to be charged before use. The methods of charging have also evolved gradually. Initially, charging was done primarily by cash; however, many charging options are offered nowadays. The following are the four channels through which the IC card Edy can be charged: (1) a register or a charging machine at authorized stores, (2) a credit card (19 types of credit cards) charging through the Internet using PaSoRi, (3) Internet charging through an e-bank using PaSoRi, and (4) automatic withdrawal from a user's postal savings with the Japan Post. As mentioned previously, 90% of all charges are done at register/charging machines at authorized stores. The upper limit on the charging amount is 50,000 yen.

The charging for the mobile phone Edy can also be done through the third channel mentioned above without PaSoRi. Two other banks, namely, the Bank of Tokyo-Mitsubishi UFJ, Ltd. and the Sumitomo Mitsui Banking Corporation are added as a channel ("Mobile Banking"). By making use of the mobile communications the charging can be processed by the registered credit cards.

5.4 Suica: JR East

The use of Suica as electric money is also gaining popularity. As mentioned previously, 9.5 million card holders own Suica cards with the electric money function (as on the end of January 2006). While the total number of transactions per day is 160 thousand (average number of transactions as on the end of October 2005), the number of authorized stores remains 3,400 (as on the end of January). The major authorized outlets include Japan Airlines (airlines), Family Mart (convenience stores), Bic Camera (electric appliance stores), Jonathan (family restaurants), and ENEOS Nippon Oil Corporation (oil refining and sales).

Since the IC card Suica is also a prepaid card like the IC card Edy, it also needs to be charged. The primary method of charging the IC card Suica is to charge by cash at the ticket vending machine close to the ticket gate at stations. It is also possible to charge the Suica at some shops by cash. Further, View Card holders can also charge at a machine called "View Altte." Only a View Card can be used to charge the mobile Suica. Therefore, a user of the mobile Suica should necessarily be a View Card member as well. A new function that automatically charges from the View Card to the Suica will be provided in the future.

The basic strategy of JR East in relation to the introduction of the Suica and the support of electric money business can be explained as follows. According to their mid-term plan in 2005, the Suica project was slated "to develop as a third pillar that can be ranked alongside the railway operation and lifestyle business" of the company. Since its peak in 1993, the railway service has been facing a decline in the number of passengers. Furthermore, faced with a drop in the birthrate and competition from a rival transportation service, setting up an alternate project with high potential was strongly recommended for the company. This basic strategy is summarized in Figure 5.

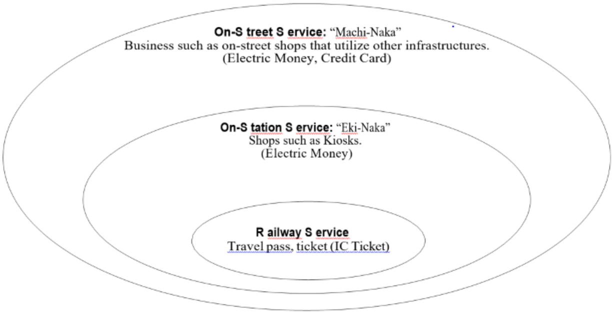

Figure 5: The Suica business model of JR East (prepared by the author)

In addition to reducing maintenance costs by switching to the IC ticket in its railway business, JR East also intends to adopt the Suica as electric money for use in shops and retail outlets at stations in order to develop an "Eki-Naka" (on-station) business project. Furthermore, the company is currently drawing up a scheme to expand the use of the Suica as electric money to shops outside the station in order to develop a "Machi-Naka" (on-street) project. After confirming a reduction in the maintenance cost in its railway service, the company agreed upon an additional investment of 13 billion yen based on a master plan for the gradual expansion of the electric money business. The Eki-Naka (on-station) project is being led by a subsidiary of JR East called the JR East Station Retailing Co., Ltd. With regard to the Machi-Naka project, the "Suica division" and the "IT business division" were launched within the railway service department in July 2004 and have been operating till date as centric divisions in the company.

5.5 PASMO: private railways and metros

A Liaison Committee of the "Passnet" and the bus service announced the launch of the "PASMO" starting March 2007. The PASMO is the contactless IC card version of the currently used magnetic pass called Passnet, which can be used on the private railways and metros around the Kanto Region (a generic term for the seven prefectures including Tokyo). Simultaneously, a direct exchange service between the PASMO and the Suica of the JR East has started. This means Suica and PASMO has perfect compatibility.

5.6 nanaco: Seven & I

Seven & I Holdings Co., Ltd (Seven & I) announced the issue of the company's original electric money, nanaco on April 2007. The introduction of the FeliCa has been decided on 2005. By allying with the card operating company JCB Co., Ltd. (JCB), business know-how is available to Seven & I. Although both Edy and Suica had considered collaborating with Seven Eleven (a convenience store run by Seven & I), Seven & I decided to introduce its own electric money. The date of launch is expected to be in spring 2007. The company aims to attract 10 million users and an estimated 12,500 authorized stores and has achieved on March 2010.

5.7 WAON: AEON

On April 2007, AEON that is the one of the dominant retail group company started the Electric Money Service. They adopted FeliCa as a basic transaction technology. WAON is equipped at not only the group stores but also the vendor machine and handy terminal with delivery drivers. The non-AEON group huge companies have agreed to adopt the WAON as follows: MacDonald's, Family Mart and Bic Camera. WAON is the first brand that has achieved over two thousand billion Yen payment per year 2015.

5.8 Three key events: turning points of the electric money platform ecosystem

There are three key events in the history of the Electric Money platform ecosystem in Japan. Before the discussion of the mechanism of the emergence and evolution of the platform ecosystem, it is useful to review these key events as an analysis of the historical case study. Because these three key events (facts) directly/indirectly connect to the discussion of the mechanism of network externality and multi-layer platform link.

The first event has occurred on 2001. Sony incorporated Bitwallet Inc. At that point, JR East asked to use Edy as JR East's Electric Money. Suica as Electric ticket is not designed for Electric Money at the emerging point because the monetary transaction requires the high-level security. However Bitwallet developed own Electric Money system independently. This means they have decided to compete with JR East. The Second event has occurred on 2004. JR East started the service of Suica as Electric Money. Bitwallet and JR East have decided not to set the compatibility each other. Today, we can use both of them using the reader that can accept both of the brands. However, there is not the compatibility between Edy and Suica. The Third event is the nanako launch at 2007. Seven & I started own Electric Money brand. However, they have originally planned to use Edy as Electric Money for their group because of the cost reduction of the development. However, Bitwallet has denied adopting this proposal because of their neutral positioning strategy. Bitwallet has aimed to gain the installed base with the neutral positioning and succeeded at 2005. Consequently, Bitwallet has decided to refuse the alliance with Seven & I.

Additionally, Rakuten obtained 50% of the Bitwallet's share on 2009. This event show the independent installed base expansion strategy has not succeeded well. The mechanism behind this dynamic phenomenon will be discussed in the next section.

6 Discussion

6.1 The answer of the RQ: network externality vs. multi-layer platform link

Why this phenomenon happened? This is the research question of this manuscript. What is the mechanism behind this phenomenon? The key points are three as following. Bitwallet's independent installed base expansion strategy is the first point. Bitwallet has decided to keep the independent and neutral position for the installed base expansion. Theoretically, this strategy is collect based on the exiting platform perspectives. However, if based on the platform ecosystem perspectives, the coordination among the ecosystem is more critical. Potentially, Bitwallet had at least three opportunities to coordinate with other actors, JR East and Seven & I. However, they could not adopt the proposal for compatibility because of their neutral positioning based installed base rapid expansion strategy.

Suica and PASMO decided to guarantee the compatibility for each other at on 2008 and create the strong install base nearly forcibly. Suica and PASMO is the Electric Ticket at the same time and almost all people use the railway or/and bus in their daily life. This means nearly automatically, Suica and PASMO can gain the install base without campaign. After the compatibility creation, Suica and PASMO execute the “Eki-naka (inside the railway station)” strategy. They used the railway station platform exclusively for the Suica and PASMO. The platform link between physical platform and virtual Electric Money platform is the second point. JR East has railway network and own credit card (View Card). Users of the Electric ticket automatically have Suica as Electric Money after 2004. JR East provide strong point incentive program on Electric Money service. They do not need to gain enough profit from Electric Money service because they can consider the Electric Money as a part of their multi-layer platform consists of hardware, software and service.

The basic structure of Nanako and WAON is same as JR East’s situation. They executed the point exchange program and daily point up campaign at their chain stores. That means the Electric Money transaction never create the profit itself. However, they are the retail companies and they aim the customer retention. The loss of the Electric Money could be justified. On the other hand, Edy must earn from the Electric Money transaction because they are the independent from any other platform. Thirdly, Edy could not create their own other platform that they can connect. Because they have their customer stores. If Bitwallet have their own chain store, the customers will resist because of the conflict of the interest. This dilemma was fatal for Bitwallet.

6.2 The multi-layer platform link strategy of Rakuten Edy

On December 2009, Rakuten obtained 50% of the Bitwallet’s share and the name of the brand was changed from Edy to Rakuten-Edy. However, the increase trend of the numbers of the payment has not observed yet. We should be careful to discuss about this phenomenon because Rakuten is the virtual market platform. Regarding the point incentive, Rauten had own point program “Rakuten Point” when they obtained the Bitwallet’s share. This fact implies the position of the Rakuten-Edy in Rauten platform. Rakuten-Edy is not connected to the Rakuten platform directly but indirectly mediated by the Rakuten point.

7 Conclusion and implication

Based on the historical case study of the Electric Money platform ecosystem in Japan, this paper discussed about the mechanism of the network externality and multi-layer platform link effect. If there were no competitors that have other platform in the platform ecosystem, install base expansion might be effective. However, the effect of the multi-layer connection is stronger than the network externality if the competitors that have other physical platform ecosystem connect the service and/or customer base to the other platform ecosystem especially in the emerging stage.

Acknowledgements

This work was supported by JSPS KAKENHI Grant Numbers 26285079, 26380507, 25780244, 23243056 and by Research Institute of Science and Technology for Society (RISTEX) of Japan Science and Technology Agency (JST).

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Chapter 21

Enabling the digital economy - distributed ledger technologies for automating IP licensing payments

Frank Tietze and Ove Granstrand

Abstract

Developing innovations for the digital economy, such as IoT devices and connected mobility solutions is likely to require OEMs to combine IP from multiple sources (licensors) who exploit their IP to as many as possible licensees (other OEMs). Those involved in the provision of what we call distributed multi-IP solutions (d-mIPs) find themselves entangled in a complex many-to-many network or 'licensing web' having to operate payments based on licensing contracts under a variety of terms and conditions. In the digital economy and 'pro-licensing era' efficiently operating licensing payments to/from multiple licensors/licensees becomes increasingly mission-critical. Unfortunately, the current semi-manual processes are inherent of information asymmetries, uncertainties, trust problems and transaction costs, hence must be considered as inefficient. This paper discusses the challenges licensees and licensors face when operating licensing payments for d-mIPs. We propose a system based on distributed ledger technologies and smart contracts for automating trustworthy licensing payments that can substantially reduce currently existing challenges. The proposed system not only contributes to enabling the digital economy, but has further potential to enable new business models.

Keywords: Licensing payments, intellectual property, digital ledger technologies, distributed multi-IP solutions (d-mIPs), smart contracts, bill of IP

1 Introduction

The digital economy (Krishnan and Chakravarti, 1997; Tapscott, 1999, 1996; Teece, 2018) is on the rise with increasingly complex products and services (Rycroft and Kash, 1999) that are equipped with and connected by digital technologies (Nalebuff and Brandenburger, 1997; Tapscott, 1999, 1996) often developed through a process of distributed/ open (Chesbrough, 2006) and cumulative innovation (Scotchmer, 1999). Digital technologies comprise a wide set of technologies, such as embedded software, sensors, wireless data transmission technologies, centralized or decentralized databases, encryption and artificial intelligence (AI) algorithms. In the digital economy, data is becoming the currency of the global economy and mission-critical for value appropriation (Teece, 2018, 1986), e.g. from sophisticated advanced artificial intelligence (AI) algorithms for deep learning or long short-term memory (LSTM) based applications. Companies dominating the digital or rather 'data economy', such as large US multinationals, are built on large amounts of valuable (and growing) datasets, other digital technologies and successful data-driven business models (Bulger et al., 2014; Hartmann et

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R. Tiwari and S. Buse (eds.), *Managing Innovation in a Global and Digital World*, https://doi.org/10.1007/978-3-658-27241-8_22

al., 2016) and a set of intellectual property (IP) assets typically combined from multiple owners through licensing.[1]

Products that are merged (or fused) and converge (Blackman, 1998; Kodama, 1992) with other technologies, such as digital ones, are known as multi-technology products (Granstrand and Oskarsson, 1994) or multi-invention innovations (Somaya et al., 2011; Teece, 2018, 2012). Traditional examples of multi-technology products include, for instance, vehicles as they combine various technologies, such as combustion engines, breaks, gear boxes, wheels, paint shop, etc. In recent decades the technological complexity (as a proxy for multi-technologiness) of vehicles has increased further with products becoming increasingly 'electronised' with sensors, chips and software being embedded. Recently, one may argue that the complexity has increased even further when vehicle manufacturers started to integrate digital technologies, e.g. for cars to be connected to each other, the cloud and other 'apps'. Similar trends are being observed in various consumer sectors (e.g. for TVs, cameras, smart home solutions, and mobile electronic devices), but also across B2B sectors (e.g. connected manufacturing systems, 'facebook for machines' relying on machine-to-machine communication).

While products can be considered multi-technology, products are nowadays often complemented with services. Those are sometimes referred to as product-service systems (PSS) (Tietze et al., 2013) or complex service solutions (Dinges et al., 2015). For these 'solutions' to be operated efficiently, they typically require a complex set of hardware and software technologies in combination with digital technologies (Tietze et al., 2013). Often, those technologies are not developed solely by the company operating a solution, but are acquired externally, e.g. through in-licensing multiple of the required technologies from different IP owners (licensors). Hardly any company nowadays is able to develop all relevant technologies (hardware, software, sensors, etc.) internally, but relies on interactions along the innovation process with actors outside its boundaries (Chesbrough, 2006). Companies therefore focus on key technologies and often collaboratively develop complementary technologies with external experts, e.g. license networking components that enable connectivity with the cloud and other devices from external sources. Companies such as ARM and PragmatIC in Cambridge develop and provide cheap processors and flexible, low-cost electronics that are needed by the many companies that transition into the digital economy. For instance, to operate modern car sharing solutions profitably, operators need to modify their products to embed sensors and telematics technologies to track the positions of vehicles and transmit operational data (e.g. fuel levels) for allowing them to be serviced, e.g. relocated to optimal locations, refuelled and cleaned (Tietze et al., 2013). We thus suggest to broaden the notion of the multi-technology product or multi-invention innovation to what we label distributed multi IP solutions (d-mIPs). Accordingly, we propose to define d-mIPs as: *"one or more organisations (licensees) combine technical and non-technical IP from one or more IP owners (licensors) for developing, manufacturing and offering solutions that combine products (hard- and software) and services"*.

With the rise of the digital economy and the Internet of Things (also known as Industry 4.0 or the fourth industrial revolution) (Atzori et al., 2010; Gubbi et al., 2013; Lasi et al., 2014),

[1] Efficient licensing (technology, knowhow and patent) markets are thus becoming increasingly important. Due to prevailing inefficiencies market intermediaries are developing different business models. This discussion is however beyond the scope of this paper (Tietze, 2012).

the emergence of a ‘pro-licensing era’ (Granstrand, 2004), shifting consumer preferences towards a ‘sharing society’ (Cohen and Kietzmann, 2014; Hamari et al., 2016, 2016) are likely to lead to an even increasing prevalence of d-mIPs. Hence, the digital economy will rely on efficient licensing markets and licensing management of those organisations involved. Efficiently executing correct IP licensing payments among multiple IP owners (licensors) and IP users (licensees) in a ‘licensing web’ almost seems to be a necessity for an efficient digital economy. Apparently, this part of the digital economy has hardly been digitized, but rather remains semi-automated (at best). Emerging technologies, such as artificial intelligence (Aristodemou et al., 2017; Aristodemou and Tietze, 2018) and distributed ledger technologies are being discussed to impact IP management and may be of use also for making this process more efficient.

This papers is less so concerned with match-making of licensing partners (Holzmann et al., 2014) and with the challenges around licensing negotiations (Gilbert, 2010) - two undoubtedly critical processes - but rather with the procedural challenges that licensees and licensors face to efficiently execute licensing payments ensuring compliance with the terms and conditions agreed in licensing contracts (sometimes referred to as ‘post-deal management’). Particular challenges arise when licensees have to pay licensing fees to multiple licensors from whom they have in-licensed IP often under different terms and conditions. On the other hand, this paper is also concerned with the challenges that licensors face to verify correctness of payments that they receive (i.e. discover underpayments), which is particularly complex when they receive payments from different licensees often under varying terms and conditions. Surprisingly, published research on this increasingly important issues seems scarce, with few exceptions (Burns and Sandelin, 1998; Kiernan, 1998).

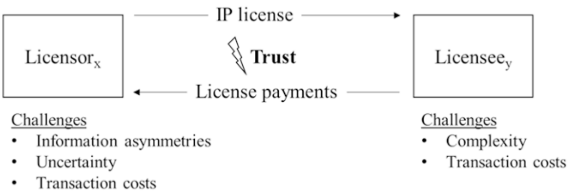

Figure 1: Licensing payment challenges for licensors and licensees

In the following, we explain why both licensees and licensors face substantial transaction costs in that process, while licensees suffer in addition from information asymmetries and uncertainty leading ultimately to a trust problem that can undermine licensor-licensee relationships (see Fig. 1). We then explore if and how distributed ledger technologies (DLT), such as Blockchain can be used to facilitate this process and reduce the associated problems through automatizing licensing payments with smart contracts. Finally, we propose as DLT-based system to automate licensing payments that can reduce the challenges and problems licensors and licensees face when executing and verifying correctness of licensing payments.

2 Correct IP license payments - a two-sided problem

IP licensing for different intellectual property rights has been known and recognized for decades, if not centuries as important for products, companies, and markets. IP licensing comes in different forms across various IP assets increasingly so in what might be called a 'pro-licensing era'.

Patent licensing is common in certain industries but takes various forms (Bogers et al., 2012). For instance, in the electronics industries technologies are often complex, protected by numerous patents that are owned and spread across various companies. To not block each other due to fragmented and distributed ownership situations cross licensing models, patent pools and other approaches are used to prevent hold-up situations (Eppinger, 2015; Granstrand, 2003). The situation is often different in the pharmaceutical industries, where novel chemical formulations are commonly patent protected and then licensed, if at all, only for different indications or regions often to a small number of companies.

Trademark licensing happens for instance in formally successful business segments with well-known technology brands from which OEMs exited (e.g. Philips TVs or Polaroid cameras can still be bought being marketed by companies that license the trademarks). Brands, such as Hugo Boss also leverage their trademark through out-licensing, for instance to companies such as Coty for producing and marketing perfumes under that brand-name. Other examples from consumer markets include trademark licensing for merchandise equipment (e.g. sport clubs and entertainment firms out-license manufacturing and sales of merchandise) (Meyer et al., 1985; Tomar, 2009; Treece, 1967).

Copyright-based licensing is relevant for software development, where software development is often cumulative building on previously developed code, which is either proprietary and can be licensed for payments of fees or open source, where non-monetary returns are often expected (e.g. also sharing the newly developed software code with the open source community). Copyright licensing is important also in the creative industries by music and broadcasting companies, such as Spotify, Apple Music, but also publishing houses for written content.

Often individual firms (particularly larger ones) are involved in licensing of different types of IP rights. All forms of IP licensing typically require licensing partners to (i) find each other (match-making), (ii) negotiate a licensing contract with its associated terms and conditions and then, following the contractual agreement, (iii) the licensee to make licensing payments to the licensor during the license lifetime (see Fig. 2). These payments can take many forms ranging from simple one-off payments (e.g. for a software license) to rather complex variations (e.g. a progressively, annually increasing royalty fees based on sold units, with different rates applying to different countries).

Various challenges arise related to these payments for both licensees and licensors that are discussed below and which we refer to as a two-sided problems. In a digital economy these challenges become particularly critical as (i) licensees often have to arrange payments to multiple licensors from which they have in-licensed IP under different conditions and (ii) licensors deal with many licensees to which they have out-licensed IP needing to ensure that the payments they receive are correct.

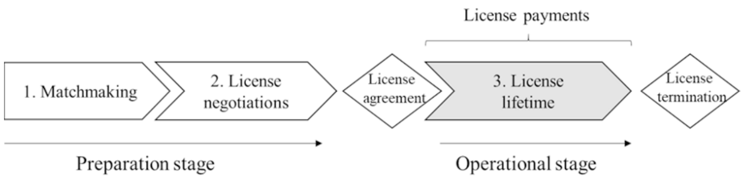

Figure 2: Licensing management process

2.1 (i) Licensees challenge: making correct payments

Licensees need to ensure compliance with the terms and conditions set out in licensing agreements. Executing licensing payments can result in substantial resource commitments for licensees. These may depend on, for instance, on the complexity of the conditions set out in agreements, such as the number of payments but also the number of licensors that licensees are dealing with. In a rather complex case, let's say a multinational corporation, the company needs to track down relevant sales data with corresponding unit prices from various countries for a product and all product variants that make use a certain IP asset that was in-licensed to then determine the corresponding royalty payments. Hence, ensuring licensing contract compliance comes potentially with substantial transaction costs (North, 1992; Williamson, 1985) due to the potential complexity of the data collection task.

While software, such as ERP solutions (enterprise resource planning) help to compile relevant data from throughout the business and supply chains for calculating licensing fees and licensing management systems assists with that process, processing licensing payments is still completed at least semi-manually. Various related problems also persist, such as that licensees usually can only determine the number of units that have been sold to their customers, while it remains uncertain how many of these units really reach the end customers, if the supply chain has multiple tiers. Compiling this data can be complex as different companies along a supply chain use different and disintegrated systems. Associated transaction costs can thus become substantial, particularly if licensees have to make payments to several IP-owners (licensors) at different times and based on different contractual conditions (see Fig. 3).

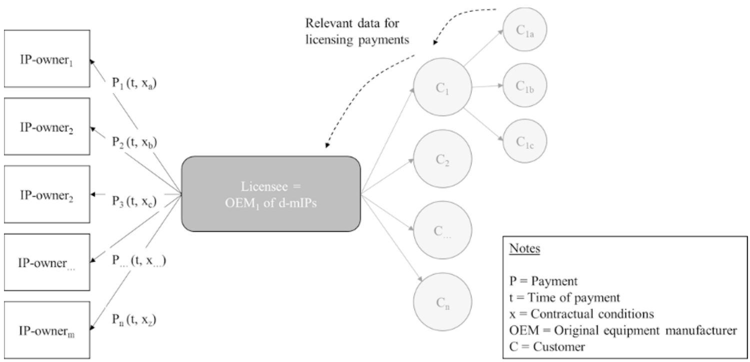

Figure 3: Licensee making payments to multiple licensors

2.2 (ii) Licensors challenge: verifying licensing payment correctness

Licensors (IP-owners) face different challenges with regard to licensing payments. They have to monitor licensing payments, potentially chase payments from licensees, and face the major challenge to establish and verify that payments they receive comply with the agreed terms and conditions, i.e. are correctly calculated based on valid data to avoid underpayment.[2] One of the few examples reported in the academic literature is a licensing examination programme carried out by Stanford University for Phycobiliproteins, a tag used in medical diagnostic devices. When Stanford announced an audit to their licensees, even before the audit had started two companies made additional royalty payments of $247,000 to the university (Burns and Sandelin, 1998). Overall, ensuring correctness of licensing payments can result in transaction costs for licensors mostly resulting from uncertainty and information asymmetries. Again, when licensors deal with many licensees (see Fig. 4), the associated transaction costs can be substantial. In the worst case, a trust problem can emerge between licensors and licensees as will be explained below.

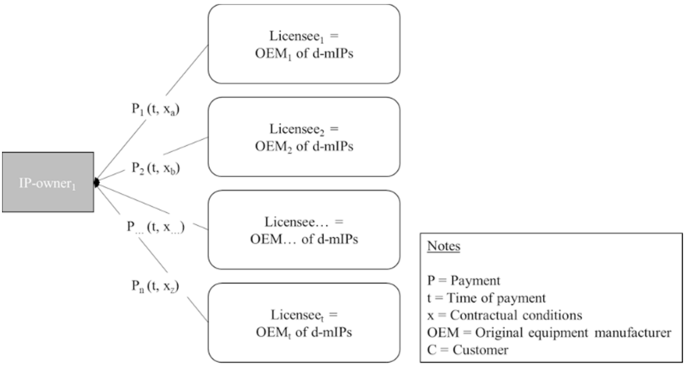

Figure 4: Licensor receiving payments from multiple license

Licensees have to have insights into relevant internal data (such as sales figures) for licensing payment calculations. Commonly, this data is considered sensitive or confidential, wherefore they are hardly willing to share this data with licensors. This lack of data makes it then difficult for licensors to establish if the payments they receive were correctly calculated. While licensors most likely not suspect licensees to make overpayments, licensors may suspect that licensees under-pay them. In such a case, licensors may can find it very difficult to establish proof due to the lack of evidence (Burns and Sandelin, 1998). In practice, these information asymmetries are a well-known problem, wherefore licensors typically seek audit-clauses in licensing contracts (Kiernan, 1998). Audit clauses enable licensors to request the necessary data for investigating and verifying the correctness of licensing payments. However, audit-clauses are often difficult to enforce, audits often difficult to conduct and as such can be costly. For another Stanford example for a licensing programme with about 300 licensees the university reported audit costs of $211,000 (Burns and Sandelin, 1998). Small licensors (e.g. individual inventors or start-ups) may simply lack the resources to audit a large multinational

[2] In the creative industries royalty underpayments are widely discussed (Bezozi, 2017; Royalty Exchange, 2017)

OEM. In other words, information asymmetries (Akerlof, 1978; Stigler, 1961) between licensees and licensors make it difficult for licensors to verify whether payments have been correctly calculated. This can result in substantial transaction costs and a trust problem. While these challenges can be difficult enough for licensors if they deal with one or few licensees, these challenges become rather complex and exacerbated when licensors deal with many licensees, with whom different terms and conditions were agreed (see Fig. 4).

In summary, we can conclude that both licensees and licensors face transaction costs for ensuring correct license payments are being made from licensees to licensors, besides all challenges associated with the matchmaking and agreement negotiations. The problem is exacerbated when licensees deal with multiple licensors and vice versa. Unfortunately, this is what we expect to see increasingly in a digital economy with a prevalence of multi-IP solutions and the rise of a 'pro-licensing era' with the need for efficient licensing markets.

Currently, the predominant approach for calculating licensing payments and verifying correctness is at least semi-manual and resource intensive, thus prone to errors, uncertainties and a trust problem, not the least due to information asymmetries. These challenges in fact also impact the terms and conditions for licensing payments that licensees and licensors agree. Due to the challenges they face, both licensees and licensors have incentives to agree rather simple and 'doable' payment terms, which however might be sub-optimal. For instance, due to the inefficiencies in this process both partners may favour one-off lump-sum payments, which however could mean that licensors will not participate fairly if the licensees solution suddenly becomes a major commercial success. Instead, a per-unit royalty rate would be the better way to ensure fair sharing of joint value creation from the IP generated by the licensor. Hence, one may want to conclude that current practices for licensing payments are rather inefficient and question whether this is satisfactory for a digital economy in which we even expect a further growth of licensing among many organisations. So far, this whole process has hardly been automated. Distributed ledger technologies, such as Blockchain with their smart contract features offer potentially promising opportunities, which are discussed below.

3 Can distributed ledger technologies help solving IP licensing payment challenges?

Distributed (or sometimes call 'decentralized') ledger technologies (DLT), such as Blockchain are widely discussed as potential solutions to solve trust related problems between transaction parties for an ever growing number of applications across different sectors and applications. Examples include the trading of tangible products (Notheisen et al., 2017), proving provenance in supply chains (Montecchi et al., 2019), the real estate sector (Veuger, 2018), vehicle-to-vehicle communication (Iqbal et al., 2019), smart cities (Kundu and Kundu, 2019) and IoT networks (Alexopoulos et al., 2018; Urien, 2019; Yu et al., 2018).[3] So what can DLT do for solving the challenges discussed above among licensees and licensors when it comes to making and verifying correct IP licensing payments throughout the lifetime of a license contract? In order to understand that, we explain (i) what DLTs are and which features might be relevant for IP licensing payments and (ii) explore whether and how smart contracts can potentially help to reduce or resolve the associated challenges discussed above.

[3] For a recent review on Blockchain technology and its applications see Yli-Huumo et al. (2016).

3.1 Distributed ledger technologies and IP

DLT refer to a group of technologies that employ encryption techniques and a distributed/decentralized architecture for keeping records of transactions (Mathews et al., 2017). The underlying ledger technology is seen as the main technological innovation because it stands as a ‘trustless’ proof mechanism of all the transactions on the network (Swan, 2015). Because of its decentralized architecture and strong encryption, users can trust the system of the public ledger stored worldwide on nodes as opposed to having to establish and maintain trust with the transaction counterparty or a third-party intermediary (Swan, 2015). Essentially, a key feature of all DLT applications is the elimination of third-party intermediaries (e.g. notary) through eliminating the need for trust and relational transactions through their distributed architecture. Currently, Blockchain is probably the best known DLT, widely popularized because of the cryptocurrency Bitcoin.

Ledgers as such have been central to commerce since ancient history and are used to continuously record transactions of various tangible and intangible assets (Walport, 2015). In 2008, Nakamoto published the conceptual basis for the technology we know today as Blockchain (Nakamoto, 2008), following which several alternative DLT have been developed, such as Ethereum, Hyperledger, Hashgraph and Multichain. DLT are widely acknowledged as breakthrough technologies with the potential to substantially alter the internet, ecommerce, but also governmental processes that are conducted electronically and thus of major relevance for the digital economy (even though this may widely go unrecognized for the users) (Walport, 2015). It has even been argued that DLT will play a major role in the post-Facebook economy (web3.0) as DLT allow users to track and enforce ownership of their data (Walport, 2015), which is very much aligned with the EU’s GDPR rules.

While cryptocurrencies are currently the most widely known DLT application, they are by no means the only DLT applications. DLT have been attested a wide range of applications, such as the financial sector (Cai, 2018), supply chain management (e.g. for food traceability and diamond provenance) (Lin et al., 2018; Ramachandran and Kantarcioglu, 2018), IoT (Fernández-Caramés and Fraga-Lamas, 2018; Park et al., 2018; Wibowo and Hw, 2018) and 3D printing (Felix et al., 2018; Holland et al., 2018, 2017), energy management (Zhang et al., 2018, 2018), shipping (Jabbar and Bjørn, 2018), real estate (Chavez-Dreyfuss, 2016; Karamitsos et al., 2018; Spielman, 2016; Veuger, 2018) and not the least IP. DLT are also discussed by governments, for instance, to collect taxes, issue passports, record land registries (Baraniuk, 2016).

Specifically for IP assets various DLT applications are being discussed or are being explored already by companies. Examples include the ownership registration for trade secrets through hashing and time stamping (e.g. Bernstein.io, Trade Secret Office), digital asset proof, product provenance and counterfeits (Walport, 2015), digital rights management (Ma et al., 2018; Pãnescu and Manta, 2018; Zhang and Zhao, 2018) and defensive publishing. DLT are also being explored by patent offices to use for trusted record keeping along the patent lifecycle.

Probably the application that comes closest to the use case explored in this paper is the use of DLT for making trusted copyright fee payments in the media/ entertainment sector often labeled the ‘creative economy’ (e.g. https://www.ujomusic.com/; Binded; Copytrack) (O’Dair, 2018, 2018). Essentially, songs and videos can be seen as bundles of IP (i.e. multi-IP products) jointly created by multiple inventors, mostly protected by copyright. For instance, songwriters contribute lyrics, various musicians play the different instruments, but also graphic designers develop the sleeve, etc. While it is often claimed that in today's digital economy intermediaries tend to benefit most from d-mIPs, such as the record labels and publishing house in the creative industries, DLT enable digital transactions so that payments are made directly to inventors that contributed to d-mIPs so that all contributors participate fairly (Savelyev, 2018). The ASCRIBE project ('blockchain-based intellectual property attribution'), the CO-ALA IP protocol, Bigchain.db and the Ocean protocol are related projects (BigchainDB GmbH, 2018; McConaghy et al., 2017).

3.2 Smart contracts

While establishing and tracking ownership of assets is one of the key DLT features, DLT allow the execution of automated transactions depending on specific events or conditions, widely known as smart contracts (Swan, 2015). Smart contract were first proposed in 1994 by Nick Szabo. They have contractual terms of an agreement between transaction parties written directly into the software code so that they trigger transactions (e.g. payments) when a specific value of a certain exchange good is reached or when something 'transpires' in the real world (e.g., a news event of some sort, or the winner of a sports match) (Swan, 2015). For instance, a smart contract could automatically transfer ownership title of a vehicle from the financing company to the individual owner when all loan payments have been made (as automatically confirmed by other blockchain-based smart contracts). Similarly, mortgage interest rates could reset automatically per another blockchain-based smart contract checking a pre-specified and contract-encoded website or data element for obtaining the interest rate on certain future days (Swan, 2015). Ethereum is a DLT that can execute smart contracts. When Ethereum was first developed in 2013, a developer (Vitalik Buterin) proposed the extension of the Turing-incomplete Bitcoin script to a nearly Turing-complete language capable of handling smart contracts (Karamitsos et al., 2018; Pãnescu and Manta, 2018; Park et al., 2018). In other words, with smart contracts it is feasible to automate fairly complex term structures and complete transactions.

A contract in the traditional sense is an agreement between two or more parties to do or not do something in exchange for something else. Each party must trust the other party to fulfill its side of the obligation. Smart contracts feature the same kind of agreement to act or not act, but they remove the need for trust between transaction parties. In other words, smart contracts do not enable anything possible that was previously impossible; rather, they allow common problems to be solved in a way that minimizes the need for trust. The trustless networks feature of blockchain technology is a key enabler in the context of smart contracts. This feature reduces fraud and mediation fees, but more importantly affords a much greater amount of trade to take place that otherwise would never have happened, because parties do not need to know and trust each other.

Smart contract are defined by the code and executed (or enforced) by the code, automatically without discretion. Three elements of smart contracts make them distinct. These are (i) autonomy, (ii) self-sufficiency, and (iii) decentralization. Autonomy means that after a smart-contract is launched and running, a contract and its initiating agent need not be in further contact. Second, smart contracts might be self-sufficient in their ability to marshal resources, for instance, raising funds by providing services or issuing equity, and spending them on needed resources, such as processing power or storage. Third, smart contracts are decentralized in that they do not exist on a single centralized server; they are distributed and self-executing across network nodes (Swan, 2015). Smart contracts permit trusted transactions and agreements to be carried out among disparate, anonymous parties thereby eliminating the need for central (third party intermediary) authority to govern transactions or external enforcement mechanisms. They render transactions traceable, transparent, and irreversible.

4 A DLT-based system for automated IP license payments

We have seen above that in open and distributed innovation processes and the wider context of IP and its management, licensing is a common and increasingly relevant contractual form, whether for copyrights, trademarks or patents (e.g. in the context of open innovation). However, as discussed above, challenges persists that create inefficiencies on the operational side of executing licensing payments and hence the licensing markets. Based on what colleagues have discussed in prior literature about DLT and possibly applications, it seems sensible to explore the use of smart contracts for automating IP licensing transactions. In the following we are particularly concerned with the automated execution of licensing payments for distributed multi-IP solutions (d-mIPS) in the digital economy, where licensing is complex as multiple licensees and licensors get involved and where the digital economy heavily relies on efficient licensing markets. As we show below, implementing such a system has potentially profound implications on business models and industrial dynamics. It seems to make sense that such a system for automated IP licensing payments would be run by a trusted third-party intermediary that would operate the DLT and smart contract facilities.

The system we propose below focuses particularly on IoT devices or any device that (can) register 'online' (at a cloud server) when they are used for a very first time. For instance, a smartphone is most likely to 'go online', when the customer starts using the phone after having purchased it. Smartphones and increasingly many other d-mIPs commonly have unique identification numbers, e.g. known as IMEI or MAC-addresses, which are required for the proposed system to work. We propose that for d-mIPs DLT based smart contracts can be used to automate IP licensing payments following a three-step process (see Fig. 4).

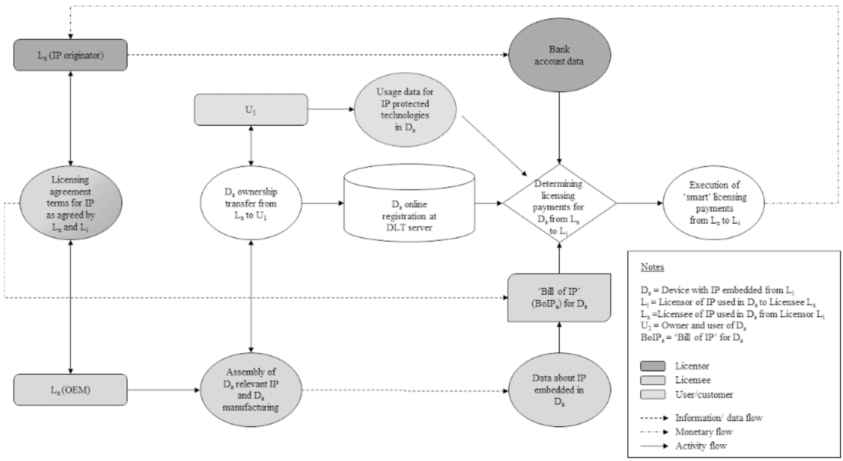

Figure 5: Automated DLT-based IP license payment system

First, after an IoT device (D_a) is sold it can be made to register on a server after it is initiated (booted) a first time. This process is similar to what is widely used for software activation. During the installation process of a new piece of software a computer typically connects to a license server in order to verify a license code. Essentially, that registration can be interpreted as a signal that one unit of a specific product has been sold and is now in operation. If such information can be used to trigger licensing payments, this completely eliminates the need for semi-manual collection of sales data for products to execute payments. Obviously, such a system for automated IP licensing payments would be limited in a first instance to IoT devices or rather any device that can be made to register with an online server. In the future, we will likely see this being true for an increasing number of devices.

In a second step, the registration information for D_a is then matched with the corresponding device-specific 'Bill of IP'-data ($BoIP_a$). The BoIP is inspired by the BOM (Bill of Material) concept that is widely used in operations management. A BOM encompasses information about the raw materials, sub-assemblies, intermediate assemblies, sub-components, parts, and the quantities of each needed to manufacture a specific product (typically physical, but also including software) or a service (Cohen et al., 2006; Slack, N., S. Chambers, C. Harland, A. Harrison and R. Johnston, 1995). In the field of IP management, a BOM-related concept is often called 'patent to product' maps (Granstrand, 1999). Different types of these exist, such as element-based maps, interpatent relation maps, matrix maps, systematized art diagrams, maturation maps and skeleton maps (Suzuki, 2011). Typically such maps match products, services or combinations of both and their components to the corresponding IP assets. A BoIP encompasses not only details about the matching IP assets, but actually two sets of information for any d-mIPs: First, it includes ownership data for all IP assets that are embedded in a specific device (D_a). This data could, for instance, be fed into the BoIP from an OEM's ERP system or product design CAD data. Second, it includes data about the corresponding licensing conditions as agreed between the IP originators (licensors) and licensee (OEM) for every IP asset that is embedded in D_a and which is not owned by the OEM. That data can be fed into the BoIP from the actual licensing agreements signed by the licensor and licensee. Optionally, the BoIP may comprise additional data. For instance, if licensing payments are based on sales prices, which may vary across retailers and countries for the same device, this information may have to be fed into the BoIP too.

In a third step, based on the two sets of data contained in the BoIP, smart contracts can trigger automated licensing payments from the licensee (OEM, i.e. IoT device manufacturer) to all relevant licensors (L_i) in compliance with the licensing conditions set out in the licensing agreements. In order to do that, the payment system also needs to be fed with the information of the bank account data from both the licensors and licensees.

5 Implications

Implementing such a DLT-based system for automated IP licensing payments with smart contracts for distributed multi-IP solutions (d-mIPS) would have at least three managerial and two economic implications.

5.1 Managerial implications

First, the proposed system reduces transaction costs for licensors and licensees. Licensees will not need to compile potentially complex data (e.g. sold units across various countries for all products and product variants) through a semi-manual process to then calculate corresponding licensing payments. Instead, the device activation at an online server circumvents that problem and acts as a trusted proxy signal that a device has been sold and now is in use to trigger precise licensing payments. This also reduces the pressure on licensees to reveal sensitive commercial data to licensors so that these can verify the correctness of licensing payments. Transaction costs for licensors would thus be reduced as well, because they will not need to investigate (and audit) the correctness of the payments they receive from licensees. Hence, such a system would reduce the consequences from information asymmetries and the trust problems by substituting the current semi-manual approach with an automated and trustworthy process. Overall, such a system thus reduces transaction costs for both licensors and licensees.

Second, the proposed systems and automated licensing payment process can help with adapting more efficient licensing models than those currently employed, often too simplistic ones because of the existing process inefficiencies. While licensing fees can be calculated automatically based on almost any conditions and even for a small number of products (in fact even for one product), licensors may find it beneficial to prefer licensing conditions that enable them to benefit in a fair(er) way from the use of their out-licensed IP, instead of agreeing to rather crude lump sum payments (which could result in substantial underpayments in case of commercial success). In an extreme case, the licensor could even receive micro-payments on a per-unit basis.

Third, such a system can possibly enable new business models, which are simply not possible in the current digital economy dominated still by semi-manual licensing payment processes. For instance, many multi-IP solutions have components for functions that are used only infrequently. However, licensees often have to pay a lump sum to be able to embed such IP into their d-mIPs. Examples are Bluetooth and GPS positioning technologies, which are embedded in nearly all smartphones, however, not used regularly by users and certainly not by everyone. With an extended automated licensing payment system, where also users register on the system (see Fig. 4), license fees could be externalized to the users, who only pay for technical features, when they actually use them. This may come with different advantages for the users. Externalizing licensing fees to users, would reduce the total manufacturing costs for the product for the OEMs and possibly sales prices of the devices. Lower sales prices allow more users (e.g. in developing countries) to purchase smartphones and thus gain access to digital services. Furthermore, if user data is used to trigger licensing payments from users directly to the licensors, users may actually save total costs overall, particularly for less-frequently used features. Licensors may also benefit from usage-based licensing payments as these could result in higher cumulative payments over a devices life cycle from users than one-off payments from OEMs.

5.2 Economic implications

First, in the current digital economy and ‘pro-licensing era’ it is often argued that the value created from IP is captured largely by intermediaries (e.g. large corporates as platform providers), but not sufficiently redistributed to the actual inventors (IP originators). Examples range from record labels that pass on too few royalties to the musicians and songwriters (and other IP holders involved in the process of creating music), the large (academic) publishing houses, but also multinationals that operate digital content-based business models, such as Facebook and Google. With a system where IP (and data) is clearly attributed to the owners and traceable through all transactions, models can be established that allow inventors to participate fairly from the value that is generated based on their IP (and data). This seems to be of imminent importance to the post-Facebook digital economy (v.2). The proposed system can thus contribute to ensuring that inventors (i.e. licensors) can trust they benefit fairly from the value generated based on their IP throughout the entire life cycles. This is very much in line with the current thinking in Europe as reflected in the recently implemented GDPR regulations (European Union Blockchain Observatory, 2018). Also, this system are compatible with open science models with their associated open access publishing and open data sharing models.

Second, focusing on the determinants of transaction costs in the Williamson (1975) framework (i.e. uncertainty, information asymmetry, opportunism (possibly with guile), small numbers, and later also asset specificity), DLT might be expected to significantly reduce at least the first three determinants through offering transparency and security. Thus, the automated system proposed above can lead to growing and more efficient licensing markets, which are desperately needed in a digital economy in which innovation is often distributed and cumulative relying on IP developed previously by others.

6 Conclusions and future research

Efficient licensing markets ensuring correct payments of licensing fees are essential for the digital economy where we expect a prevalence of distributed multi-IP solutions (d-mIPs) that require multiple licensees to interact with multiple licensors. This paper has explored the challenges that licensees and licensors face when making and verifying the correctness of licensing payments. Essentially, licensors face transaction costs for collecting the relevant data to make payments to licensees. This become even more challenging when licensors deal with multiple licensees having to consider varying licensing terms agreed with different licensors. On the other hand, licensors face challenges to verify that the licensing payments they receive from licensees are correct to avoid they are underpaid. Verifying the correctness of licensing payments is difficult due to limited insights into the relevant data for calculating licensing payments, which only licensees have and which is often considered sensitive/ confidential so that licensees are hardly willing to share this data (information asymmetries). While audit clauses permit licensees to request the relevant data, doing so often comes with severe challenges itself. Overall, one may argue that information asymmetries not only lead to transaction costs for both licensors and licensees, but also create trust problems among them. That situation is exacerbated if licensors deal with multiple licensees under different licensing terms, which can be expected to be increasingly the case in a digital economy and the emerging 'pro-licensing era' with more and more d-mIPs emerging.

From exploring distributed ledger technologies (DLT) and smart contract features we find that those technologies offer the potential to automate IP licensing payment processes, thus reduce transaction costs and (re-)establish trust among licensing partners. Such a DLT based system has been proposed in this paper. The technical challenges to implement trusted DLT solutions for automating licensing payments are however considerably and need further research. Such payment system would additionally allow for more efficient licensing terms regarding royalties and thus ensure that licensors participate more fairly from the value created from their IP. Furthermore, DLT-based licensing payment systems will likely alter existing business models allowing the licensing payments to be externalised to users.

What remains to be understood is how licensees that manufacture devices (i.e. OEMs) can provide the relevant BoIP data in an efficient way. While firms in some countries link specific IP data (e.g. patent ownership) to products, e.g. in form of product-to-patent maps (e.g. because of the German inventor remuneration law or the UK patent box scheme), many companies actually lack that information in practice. The platform for hosting the DLT system and triggering payments would probably need to be hosted by an independent third party intermediary to ensure neutrality between licensees and licensors. The intermediary offering such licensing payment platform would be another data-driven business model, which should be researched further. Also, today several DLT platforms exist and it needs to be better understood, which of those platforms would be suitable. Finally, it needs to be evaluated if such payment system could possibly be even developed without a DLT solution as certain DLT are known to be energy intensive. DLT as such may have implications not only on licensing markets, but also on IPR systems, which are beyond the scope of this paper, but should be investigated further.

Acknowledgements

Research assistance was kindly provided by Pratheeba Vimalnath, Alexander Mörchel and Leonidas Aristodemou. Financial support from Vinnova under grant 2017-04469 for the project "Intellectual assets, innovation, growth and value creation and the role of new digital technologies and digital property" is gratefully acknowledged.

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Chapter 22

Smart cities - an analysis of smart transportation management

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Abstract

Following an extensive literature review, there appears to be no universal definition of a smart city and over the last decade, it has become a useful branding tool for ICT firms to sell their products to municipalities. Following the changing political climate, the adoption of smart city innovations has slowed as funding is no longer secured. As a consequence, municipalities found themselves in a position where they were no longer focusing on product-centric solutions. The risks involved in investing public funds in new programs is high, so the municipalities should be aware of them and attempt to mitigate them. This report contains a STEEP analysis to outline the benefits and risks of smart city innovations and a comparison of seven mid-sized US cities implementing different programs has been performed to contrast the different approaches to implementation. Beyond the technology involved, most of the research has pointed to governance of smart city programs as the greatest indicator of success or failure. Cities with a strong mayor's office and a top-down governance found it more difficult to carry through with these programs, but cities run by strong city councils have a bottom up governance that is best suited for smart city innovations. Additionally, the trend appears to be shifting from large scale projects that often carry a high price, to implementing several projects on a pilot basis to determine which will have the greatest probability for success in the future. While additional research is needed, this report hopes to add to the existing literature and provide greater insight into the rapidly evolving innovations surrounding smart city development.

Keywords: Smart Cities; STEEP Analysis; Digital Transformation; USA

1 Introduction

Over the last decades, cities have thought of ways to demonstrate their values and represent the direction they wish to continue. They have called themselves sustainable, green, low-carbon, eco-, intelligent, resilient, and digital. In an attempt to bring all these definitions under one term, "smart city" emerged as the most appropriate term. In 2015, the International Telecommunication Union settled upon a definition as "a smart and sustainable city is an innovative city that uses information and communication technologies and other means to improve living standards, efficiency of urban management and urban services and competitiveness while meeting the needs of current and future generations in the sectors of the economy and the environment" (van den Buuse & Kolk, 2018). The city of Portland has created a more detailed definition that encompasses the objectives of its smart city program that is abbreviated as "the use of existing and innovative technologies, data collection and data management tools to enhance community engagement, improve delivery of public services, and address

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R. Tiwari and S. Buse (eds.), *Managing Innovation in a Global and Digital World*, https://doi.org/10.1007/978-3-658-27241-8_23

City goals around equity, mobility, affordability, sustainability, community health and safety, workforce development, and resiliency" (Portland, 2018e).

As the political landscape has changed, momentum towards "smart city" policies and programs has slowed. However, this has allowed for time to reflect on what a smart city truly is and then determining the most effective implementation. Previous endeavors into smart city innovations have often been the domain of people in positions of power that were able to advance some big-ticket projects, but a poorly planned smart city may have negative consequences that exceed the benefits provided. Songdo City in Korea is widely considered the first smart city is still a "work in progress" and has resulted in many environmental externalities (Yigitcanlar & Kamruzzaman, 2018). This means that if the smart city trend is bound to continue, municipalities should best understand what they need to implement and how to implement it. This report provides an analysis of the social, technological, economic, environmental, and political implications of implementing a smart city program in what is referred to as a Social, Technological, Economic, Environmental and Political (STEEP) analysis.

Two years ago, the US department of Transportation announced a smart city challenge for mid-sized US cities to win a grant for $40 million. While the city of Portland was one of the seven finalists, the ultimate winner was Columbus, Ohio. The top seven cities represent a subset of US cities that could be seen as incubators for smart city innovations and should be closely monitored over the next few years to determine which cities were best able to meet their objectives and which ones did not perform as well as expected. Although the cities are roughly the same sizes, the differences in geography, climate, infrastructure, culture and governance systems mean that a successful innovation in one city may not translate well to another city. Just as the definitions for a smart city are countless, so are the interpretations from city to city. This report will conclude by providing some recommendations about how to best manage a smart city program. Given limited resources, managers must determine investment priorities amid increasing uncertainty in such areas of technology development, private-sector business models, and the desires of city residents.

2 Literature review

The research method for this report includes a review of relevant academic literature as well as practical implementation-related documentation produced by city governments and other institutions. Research was conducted via interviews and outreach with representatives from the City of Portland Bureau of Transportation as well as review of published materials on city government websites, USDOT Smart City Challenge grant applications and other public information sources.

Since the mid-twentieth century, numerous environmental, social and economic crises on a global scale have significantly affected our societies (Yigitcanlar & Lee, 2014). Especially during the last two decades, metropolitan areas around the world have been engaged in various initiatives to improve urban infrastructure and services, aiming at having a better environment, social and economic conditions, improving the attractiveness and competitiveness of cities (Trindade et al., 2017). These efforts brought up the concept of intelligent cities (Komninos, 2012), which became the predecessor of the smart cities (Yigitcanlar, 2015). According to Deakin and Al Waer (2011), the smart cities concept arises due to the intelligent use of digital information in areas such as human health, mobility, energy use, education, knowledge transfer and urban governance.

More than 50% of the global population is now urbanized according to the United Nations report of 2012 (United Nations & Affairs, 2013). Thus, it is safe to say that the concept of a smart city is fairly new and can be seen as the successor of information city, digital city and sustainable city (Yigitcanlar, 2006). Despite the discussions about its concept in recent years, there seems to be a lack of consensus on what a smart city really is. Even though, a number of authors find it difficult to conceptualize, their definitions do not contradict, but overlap (Scheel & Rivera, 2013; Cocchia, 2014).

Generally, it is perceived that smart cities make use of Information and Communication Technology (ICT) to conceptualize a model where development is achieved through the use of human, collective and technological capital (Angelidou, 2014). The term smart city is, therefore, an umbrella concept that contains a number of sub-themes such as smart urbanism, smart economy, sustainable and smart environment, smart technology, smart energy, smart mobility, smart health and so on (Lara, Moreira Da Costa, Furlani, & Yigitcanlar, 2016).

Examining smart cities is an expanding field in which academic researchers and collaborative organizations such as partnerships between universities and cities seek to assist stakeholders in understanding how to navigate the increasingly complex intersection of city operations and planning, technology development and community engagement. Portland State University recently launched the Digital City Testbed Center, which intends to leverage interdisciplinary research teams to evaluate responsible technology adoption ("Portland State Inside PSU | Digital City Testbed Center," 2018).

The Mobility Innovation Center and Technology Policy Lab hosted by the University of Washington were formed to address specific challenges faced by cities, finding in 2017 that autonomous vehicles are one of the largest potential disruptors of city transportation systems and should be incorporated in city planning activities in a proactive fashion ("Driverless Seattle - Tech Policy Lab," 2018). A 2018 study of seven U.S. cities sought to understand efforts underway in these jurisdictions to manage smart city technology innovations, recommending that key aspects of an innovation framework include establishing clear and specific goals and in turn defining clear expectations about what is expected of project participants ("Innovation frameworks for smart cities - Mobility innovation center," 2018).

Some cities that have appropriated the concept of smart cities have applied themselves to enjoy their benefits so that the needs of the city are met. For instance, Barcelona defines smart city as a high-tech intensive and advanced city that connects people, information and city elements using new technologies in order to create a sustainable greener city, competitive and innovative commerce and an increased life quality. Meanwhile, the city of Amsterdam addresses the issue as an innovative technology and is willing to change people's energy-related behavior to tackle climate challenges (Lee, Hancock, & Hu, 2014). In the case of Doha, smart city practice is more of an interaction of urban technologies and knowledge economy activities (Thierstein, Wiedmann, & Salama, 2013), whereas in the case of Brisbane, Australia, the practice is to integrate smart technologies into good urban and space design practices (Pancholi, Yigitcanlar, & Guaralda, 2015).

Research conducted in 2016 states that similar to "smartphones", a smart city is a futuristic approach to alleviate obstacles created by ever-increasing population and fast urbanization to benefit both governments and masses (Joshi, Saxena, Godbole, & Shreya, 2016). The ecosystem as a whole is experiencing economic turmoil, a high rate of urbanization, climate variation and vast population growth as mentioned by a Cisco report from 2013 (Jesner Clarke, 2013). It is factors like these that prohibit growth and exacerbate problems such as traffic, pollution, scarcity of resources and poor infrastructure. According to a report in 2011 by Pike, it was estimated that globally the Smart City market will spend about $16 million by the year 2020 (Enbysk, 2013). These funds should be directed as efficiently as possible to achieve the greatest return on investment in the community as a whole.

In order for a city to determine if a new technology or innovation will make a difference in solving existing problems, a measurement needs to be taken before implementation. The city of Boston has introduced an application that allows the citizens to score the city and provide real time information so the various agencies can more quickly address concerns (Barns, 2018). While a true apples-to-apples comparison between smart cities would be very difficult, a Cities in Motion Index (CIMI) was introduced to scrutinize 77 city indicators covering 10 dominant categories in urban life, including, the economy, technology, human capital, social cohesion, international outreach, environment, mobility and transportation, urban planning, public management, and governance. The results showed New York City and London at the top position, although it ranked them extremely poor at the social cohesion parameter (Silva, Khan, & Han, 2018).

Kern and Bulkeley propose three governance mechanisms available to city networks: information and communication; project funding and coordination; and, recognition, benchmarking and certification (Kern & Bulkeley, 2009). All three aim to encourage cities to convert commitments into action. Palomo-Navarro and Navío-Marco carried out a PEST (Political, Economic, Social and Technological) analysis of the Spanish Network of Smart Cities (RECI) to assess the impact of the smart city network at the local, national and international level. They discovered that cities need a framework for establish smart city policies and regulations or modify existing rules that may hinder implementation. They could achieve this goal by collectively learning from each other to yield general lessons for the circumstances in which specific strategies are (Palomo-Navarro & Navío-Marco, 2017).

3 Steep analysis

Although Palomo-Navarro and Navio-Marco carried out a PEST analysis, the environment is a significant factor that merits a separate consideration. For this reason, a STEEP (Social, Technological, Economic, Environmental and Political) analysis will be performed. The results should represent a more holistic view of how to implement a smart city program.

3.1 S – social

The social aspect under smart city initiative is based on smart communities, whose citizens can play an active part in its design. Today, cities are deprived of some vital elements, one being “quality of life” which can be improved with smart city innovations. With some complexities of social ecosystem in the cities has increased making sustainability an important factor (Deakin & Al Waer, 2011). In fact, cities that are smart only with respect to their economy are not smart at all if they disregard the social conditions of their citizenry. A smart city initiative should be sensitive in balancing the needs of various communities (Deakin & Al Waer, 2011). Any smart city project has a direct impact on the quality of life which further aims to foster more aware, informed and educated citizens. Therefore, the rate of engaging people from various communities to actively participate in initiating the project can influence the success or a failure of any effort made. A lot of cities have successfully used real time data to educate the public about their choices and harnessed the power of the competitive spirit to encourage people to experiment with their own habits of travel, work, civic participation and consumption (Spinak, A. Chiu, D. & Casalegno, 2008).

The term Social Equity means that there are different levels of fairness. According to Wiftachel and Hedgecock (1993) and Polese and Stren (2000), an environment for human interaction, communication and cultural development with improvements in the quality of life, creates a condition for social sustainability (Yiftachel and Hedgcock, 1993; Polese and Stren, 2000). Cities have always facilitated human gatherings and they are actually the social search engines that help like-minded people to find each other and collaborate. The more efficient a smart city infrastructure becomes, the greater the urban footprint can become. The added dimension of digital communication allows for travel further while maintaining a high level of communication.

"Many of the plans talk a lot about social-equity goals, but these goals are not translated into clearly specified objectives—and it's not at all clear how the goals are incorporated into decision-making," says Kevin Manaugh, assistant professor in McGill University's department of geography and School of Environment. That is mainly due to the fact that traffic speed is easier to measure than social-considerations such as balancing the interests of pedestrians or cyclists with those of motorists.

Transportation projects cover a range of infrastructure projects including sidewalks, highways, bicycle paths or suburban rail system. A few cities—notably Boston, San Francisco, San Diego and Chicago—have managed to build in clear, measurable indicators for achieving social-equity goals, according to Manaugh Chipello-McGill, 2015). Some of these measures can be included in urban planning to better address social equity objectives including; improvements in accessibility to desired destinations, particularly for disadvantaged groups, difference in travel times, to work and to essential services, between car and public transit, difference between top and bottom income quintiles in the proportion of household expenditures spent on transportation and difference between car users and pedestrians or cyclists in traffic injuries and deaths, on a per-trip basis.

3.2 T – technology

From a technological perspective, the smart city ecosystem is a complex one comprising many technology areas. Major players operate in several areas, providing solutions that complement other players, but may sometimes overlap. The growing smart city market has a number of broad ICT trends that enables some key segments such as energy, transportation and urban planning, Thus, to exploit new technologies and deliver smart solutions to cities and citizens for the upcoming challenges, many technological impacts have been analyzed.

Networking and communication infrastructure helps cities to connect devices, people, gather data and deliver services to myriad endpoints. One of the major needs is monitoring the citywide transport system. Some critical technology trends that will affect future smart city developments include - low power WAN technologies, Bluetooth LE, ZigBee and Wi-Fi; licensed cellular networking such as existing 3/4G and the evolution to 5G; sit technologies such as LoRaWAN and the evolving 802.11ah (Lea, 2017). These technologies use unlicensed spectrum and focus on low power and cost. One major appeal driving city adoption is the ability to offer a citywide service, for free, at a relatively low capital cost.

One of the ultimate goals is to be able to provide free Wi-Fi in all aspects of public transportation such as subways, light rails, buses and its stops etc. Board any city bus in Portugal's second-largest municipality, Porto and you've got free Wi-Fi. More than 600 city buses and taxis have been fitted with wireless routers, creating what's touted as the biggest Wi-Fi-in-motion network in the world (Frayer, n.d.). The service not only provides commuters with free Internet connections but also helps collect data that make the municipality run more efficiently. In Silicon Valley, the light rail service that runs from Mountain View to San Jose uses 4G cellular to provide Wi-Fi service to all its trains. In places like Seattle and on Caltrain in the San Francisco Peninsula, early experiments with Wi-Fi services were abandoned when they couldn't provide services that stood up to user demand (Kapustka, 2012). Portland has not taken any initiatives for free Wi-Fi system in local buses yet.

Cyber-physical systems and the IoT is generally defined as the connection and virtual representation of physical devices to the Internet. Many parts of the traditional city infrastructure have been monitored for many years, such as for traffic, water and electricity which often used proprietary technologies and maintained as individual silos (Lea, 2017). The IoT is changing that situation radically. The city infrastructure is now being connected by using open standard protocols such as IP and HTTP which are being made accessible through web technologies such as REST. The cost and accessibility of IoT technologies is allowing private companies to instrument physical infrastructure and to use devices, including the smartphones that many citizens now carry. For example, auto manufacturers are increasingly sensing not only the car itself but its surroundings, traffic conditions and even providing sensed data in the case of accidents. Civil engineering firms are deploying sensors to monitor stress in structures such as tunnels and bridges or the quality of road surfaces (Mair, 2015). Citizens are getting involved by deploying low-cost sensors to track air pollution (Schiller, 2014) and noise levels or just employing their smartphones as mobile sensor platforms.

Cloud and edge computing are generally defined as the delivery of computing as a service, which has offered cities ways to reduce costs and increase efficiency. But, due to legal and privacy concerns, cities have been reluctant to exploit the full benefits of public cloud services for core services, one such city, Portland, is still hesitant to fully use the cloud and edge computing services, but many have used private cloud services and some have experimented with public/private or a hybrid cloud infrastructure. A secondary factor driving the adoption of cloud solutions for smart cities is the massive increase in data being generated, captured and analyzed by cities as they start to deploy and exploit IoT technologies. New infrastructure sensing, combined with private data sources and citizen data, means that cities now have access to a multitude of high-volume real-time data sources. While there are many examples of this use of cloud infrastructure in cities, intelligent transportation is a lead use-case. Taiwan has exploited cloud computing to handle the high data volume from its intelligent transportation systems (ITS) ("Intel Inside®. Efficient and Smart Traffic Outside.," 2016).

In an initiative, a collaboration initiative between the Bureau of Planning and Sustainability and Portland State University has produced the concept of an "Open Data Cloud", which recently received funding for an initial pilot. This Open Data Cloud Pilot project will collect, store, and integrate Smart Cities related data from a variety of sources including new sensor deployments, autonomous and connected vehicle pilots and existing city internal data sets and regional data sources. The integrated data platform will provide standardized access to these data sources for public sector agencies and local innovators, while respecting privacy and security needs and developing data user agreements (Christine Kendrick, 2017).

Smart cities, by their very nature, generate significant amounts of data in their daily operations. The trends identified such as IoT and Open Data are driving the cities to collect and make available significant amounts of data, some of it is static but a major portion is real-time. This data exhibits the classic characteristics of big data; high volume, real time (velocity); and extremely heterogeneous in its sources, formats and characteristics (variability) (Lea, 2017). The evolving technology that captures, manages and analyses this big data leverages technology trends such as cloud computing. Cities are now able to access and use massive computing resources that were too expensive to own and manage only a few years ago. Boston in the United States for instance, is using big data to better track city performance against a range of indicators but also to identify potholes in city streets and improve the efficiency of garbage collection by switching to a demand-driven approach ("How cities score," 2016) and Singapore tracks real-time transportation and runs a demand-driven road pricing scheme to optimize road usage across the island (Land Transit Authority, 2018).

Autonomous vehicles (AVs), also known as driverless vehicles, are able to make decisions independently of human interference, in the face of uncertainty and are set to revolutionize the transport industry. It is emerging as a potential solution to modern day transport problems. The major benefits stem from AVs' connected nature, which enables them to communicate with other vehicles and critical infrastructure to optimize traffic and maximize all associated benefits for sustainable and smart cities (Petit & Shladover, 2015). Since the introduction of AVs in 2010, their development and appeal has increased significantly. However, the successful operation of AVs and their impact on society depend significantly on their management and on addressing risks associated with them. A few of these risks are privacy, cybersecurity, increased vehicle miles travelled (VMT), worsening congestion, reduced transit ridership and privatization of public transit. AVs have the potential to bring positive impacts, such as more flexible transportation options that address some of the issues related to unequal access to affordable transportation outside of Portland's inner core for example.

In April of 2017, the Portland Bureau of Transportation launched a Smart Autonomous Vehicles Initiative (SAVI) through City of Portland Resolution No. 372964. The purpose of SAVI is to develop best practices for the testing of AVs and to create AV policies that spur innovation, advance the City's Vision Zero goals to eliminate traffics deaths by 2025, reduce congestion, significantly decrease CO2 and other transportation pollutants and make travel more affordable for Portland's low and moderate-income residents. The ultimate goal of SAVI is to maximize the public benefits of AVs to Portland residents and businesses and to minimize the risks and potentially negative outcomes of this new technology (Christine Kendrick, 2017).

3.3 E – environmental

The leading cities in the deployment of smart cities solutions across the world have announced ambitious objectives to increase their energy efficiency and correspondingly decrease their CO2 emissions to attempt to contain climate change.

UITP (International Association of Public Transport) has demonstrated that a shift towards public transport would contribute very significantly to achieving this objective. With the deployment of new electromobility solutions in public transport**,** smart cities are enabling the connection between transport and the energy system.

In Vienna, electric buses are able to charge en-route using the overhead tramway electricity network, thus reducing battery weight and costs. With their network of substations, tramway networks, under certain conditions, offer interesting perspective for the deployment of other types of electric vehicles. Through these interfaces and connections, energy and transport management will be increasingly integrated in the future. ICT will provide the data and the tools to enable this management. Portland is also planning on bringing the electric busses starting from 2023 on pilot project and is expected to invest approximately $500 M to replace all diesel busses with electric busses by 2040.

Some of the positive impacts of implementing Autonomous vehicles or AVs will significantly decrease CO2 and other transportation pollutants and make travel more affordable for Portland's low and moderate-income residents.

The initiatives to keep environment clean and green, City of Portland is initiating an urban instrumentation project which is a multi-vendor, low-cost, climate and air quality sensor pilot funded by a Replicable Smart Cities Technologies Cooperative (RSCT) grant from the National Institute of Standards and Technology (NIST). This project will deploy 9 sensors total: 3 Argonne National Laboratory/University of Chicago Array of Things nodes, 3 SenSevere RAMP devices and, 3 Apis SensorCell nodes. Each device will take 5-minute mean measurements of carbon monoxide (CO), nitric oxide (NO), nitrogen dioxide (NO2) and ozone (O3) gas concentrations, temperature, and relative humidity. The RAMP devices will also measure carbon dioxide (CO2) and the Array of Things nodes will also measure particulate matter with diameters < 2.5μm (PM2.5). The air quality devices will be deployed in three phases beginning with a laboratory deployment at PSU to compare the sensor measurements with known concentrations of pollutants. Next, the devices will be deployed at the Oregon's Department of Environmental Quality (DEQ) urban background monitoring site to collocate the sensors with each other and with reference instruments used for regulatory purposes, to assess their accuracy. During the final deployment, the validated sensors will be placed on the roadway at three different signalized intersections where one sensor device from each vendor will be deployed (3 unique sensors per intersection) and co-located with City operated Curbside Labs for Emissions and Atmospheric Research (CLEAR) cabinets for two of the intersections (Christine Kendrick, 2017).

3.4 E – economic

The access to free wi-fi at locations such as cafes, clubs, parks, libraries, barber shops and churches, has resulted in the emergence of urban social settings or surroundings that provide a social experience outside the home or work/school. This new form of "third space" has been coined a "makerspace" and is creating new opportunities for entrepreneurs to pursue their dreams. As a city begins to invest more funds into becoming more innovative, it can foster makerspaces, which promote sharing practices, exercise community-based forms of governance and utilize local manufacturing technologies (Niaros, Kostakis, & Drechsler, 2017).

If properly implemented to ensure equitable distribution of the information system, the access to these resources will serve the marginalized in society and create an entrepreneurial ecosystem. A finding from the studies of biological and social ecosystems is that there is a strong, positive relationship between the diversity of an ecosystem's elements and its resilience (Manson, 2001). The tensions in the ecosystem between diversity and coherence of components is akin to the tension that organizations, as open systems, must balance between the differentiation and integration of their sub-units. Both entities must incorporate unique actions that effectively respond to changing market and environmental conditions. These differentiating actions individual departments, the ecosystems necessitate a melding of new activities among the various ecosystem components, such as incubators and funding sources (Roundy, Brockman, & Bradshaw, 2017).

As cities shift their focus from large scale projects that cost millions of dollars to funding several smaller programs, many of them will fail, but the ones that are successful will be very successful. During a guest lecture by Jim Coonan, he mentioned that a similar trend is occurring with start-ups in respect to venture capitalists. The previous approach was to find a start up with strong potential, inject a large number of funds and hope to a significant return on investment. With a very high failure rate of most start-ups, a large investment carries an equally large amount of risk. Since the upside of success seemed to negate the risk, investors were willing to bet big. A reinterpretation of this model reveals that investing in many small start-ups will result in mostly failures, but the successful ideas will outweigh the overall losses.

Smart city projects at least partially translate into more business opportunities for local companies joining public procurement. This is expected to thicken local markets thus contributing to the city's performance. Additionally, innovation processes are also expected to be fostered, mainly through a general improvement of local knowledge production functions, as well as through the positive fallout from the generation of location solutions for international smart city projects (Caragliu & Del Bo, 2018).

3.5 P – political

The governance of a smart city is often mentioned as a key component of the program's success or failure.

In the context of smart cities, open data refers to public policy that requires or encourages public agencies to release data sets and make them freely accessible. Typical examples are citywide crime statistics, city service levels and infrastructure data. Many governments and leading cities now run open data portals, e.g., the UK and Canadian data portals, (data.gov.uk and open.canada.ca) and city portals such as San Francisco (dataSF.org) and London (data.london.gov.uk). The evolution of open data represents a broadening of the information available related to city operations. Its primary goal is transparency, but a significant subsidiary goal is to make information available to third parties that can be exploited to improve city services and foster innovation around new services. San Francisco and London have led efforts to exploit open data with local companies creating mobile applications based on park data (Franks, 2013), tourism, parking and transportation (City of London, 2018).

In May 2017, Portland City Council enthusiastically adopted an Open Data Ordinance (No. 1883562) to establish an Open Data Policy and Open Data Program for the City of Portland. This action built upon earlier efforts from a 2009 Resolution (No. 367353), led by the City's

Bureau of Technology Services (BTS), when Portland became the first city in the United States to declare its commitment to Open Data and to develop an Open Data portal (Christine Kendrick, 2017), The five summary goals for City of Portland's Open Data Policy and Program: 1. Increase transparency and improve public trust; 2. Build civic participation and engagement; 3. Improve access to data to inform and improve decision making; 4. Reduce staff time devoted to responding to requests for City data; 5. Grow the likelihood of data-driven innovations in the private sector that increase the social and commercial value of City assets and improve the delivery of City services (Christine Kendrick, 2017).

Smart city policies should have a bottom-up, demand driven component and should be closely monitored by municipalities and local governments and many more efforts in evaluating the impacts of these programs should be undertaken (Caragliu & Del Bo, 2018). A study looking into the emergence of smart cities in Europe has established a list of items that should be undertaken by cities interested in implementing smart city innovations (Papa, Gargiulo, & Galderisi, 2013):

- Adopting models of multi-level governance through the distribution of responsibilities between different government and institutional levels;
- Promoting integrated urban policies by adopting a holistic and strategic approach;
- Focusing on new ICT in order to provide citizens for new media opportunities and easier access to the public and cultural contents;
- Ensuring a sustainable territorial development based on the efficient use of resources.

4 Comparison of cities

In 2015, the US Department of Transportation (USDOT) launched a transportation focused program, the Smart City Challenge, enticing mid-sized cities to compete for a $40 million grant by submitting their Smart City vision. A total of 78 cities submitted their work, 7 cities; Austin, Columbus, Denver, Kansas City, Pittsburgh, Portland and San Francisco were chosen as finalists. Columbus (Ohio) won the challenge and was awarded the grant (US Department of Transportation, 2017). Though this program has served as a catalyst for the implementation of Smart City technology and principles and these 7 cities have continued to pursue the visions they laid out, they have been challenged in doing so without access to the funding that they all pursued. Since these cities were all in the category for the same prize, it seems appropriate to discuss and compare the directions that they have taken following the competition.

4.1 Portland, Oregon

The UB Mobile PDX user interface would have provided a valuable service to Portland residents and visitors by enabling them to access a mobility marketplace wherein the growing range of transportation modes that are available in Portland could be optimized and connected with the user such that faster, lower cost trips across the city could become available. A cornerstone of the design of this application was, as called out in its title, the ubiquity of availability and utility to all Portland residents. While the USDOT grant funding sought by Portland did not become available, several aspects of the proposal ultimately led to projects that are underway.

While Portland's UB Mobile PDX application and transportation marketplace have not yet moved forward, other components of USDOT proposal formed the basis for initiatives that the City of Portland and stakeholders continued to pursue by including modifications to reflect the lower level of funding available to operate pilot programs. These programs include initiatives to responsibly manage the growing quantities of data that are being generated by new technologies that are being deployed, such as multiple roadway instrumentation pilot projects. These programs may be seen as an outgrowth of components of the USDOT proposal, but tailored more closely to meet the Portland's needs, rather than those of the grant criteria and adjusted in scope to reflect currently limited budgets.

One of the main areas of focus identified by the City of Portland is the ability of smart city technologies and approaches to improve outcomes for all communities, especially low income and disadvantaged communities that may face disproportionate challenges to access the new benefits and services as they become available. Our literature review and interviews with city representatives served to emphasize the overarching equity lens through which both an overall smart city strategy and specific program implementation actions are viewed (Christine Kendrick, 2017). Activities after the USDOT grant proposal served to further tailor Portland's approach to an equitable smart city by seeking to further understand the needs of residents and including greater levels of community involvement.

For example, an April 2018 assessment conducted by Portland State University, OPAL Environmental Justice and Forth Mobility found that significant differences exist in preferences, technology adoption gaps and transportation options among Portland's communities, particularly in East Portland (Golub, 2016). One of the main findings of the report that Portland intends to use to inform certain aspects of its mobility strategy is that some communities experience limited access to data services (such as Wi-Fi) and therefore could face difficulties in using smartphone-based transportation applications.

As a result of these findings and other factors including the general trend toward greater data transfer requirements driven by the larger number of communicating devices that are expected to be deployed in both stationary and mobile applications and the increasing desire of telecom companies to attach equipment to city-owned infrastructure, the City of Portland is now placing new emphasis on its role in communications. Portland is only beginning to develop an overarching communications strategy, but it is becoming clear that wireless communications will be a central component to a smart city, especially as some cities find themselves at the cusp of rolling out 5G networks and ongoing uncertainty about how and where 5G sites may be deployed (Fung & Shaver, 2018).

In addition to ensuring ubiquitous access to the connectivity required to participate in emerging transportation options, Portland is also planning to develop ways to ensure that these services offered by private sector companies are reasonably available to all residents. For example, Portland's Shared Electric Scooter Pilot included requirements of the scooter companies that a certain number of them be deployed in East Portland neighborhoods to ensure a greater level of equitable access than may be the case in absence of this requirement (Portland, 2018c). Because similar trends could present themselves with the introduction additional technologies, such as autonomous vehicles, Portland is planning ahead to ensure that when they become available, they are available to all residents. To accomplish this, the Smart Autonomous Vehicles Initiative (SAVI) was launched in 2017 to address several aspects related to their deployment, one of which is adoption of a set of policies that set forth a clear preference for "fleet-owned fully-autonomous vehicles that are electric and shared," or "FAVES." These types of vehicles would have lower greenhouse gas emissions impact and would be more likely to provide adequate service to low income and disadvantaged communities than non-shared vehicle configurations.

Finally, governance of smart city decisions is addressed by the formation of the Smart City Steering Committee (SCSC), which brings together 13 city bureaus and offices and representatives from the City Council and Mayor's offices (Portland, 2018d).

Included in the Appendix is additional detail on two examples of initiatives Portland currently has underway that have roots in the USDOT proposal and are being pursued on a pilot basis.

4.2 Denver, Colorado

Denver's challenges include traffic congestion caused by rapid population growth, an inability to keep up with the demands for increased infrastructure, ozone levels that are out of compliance with federal standards, a lack of affordable housing within a reasonable commuting distance and a lack of services in areas with higher poverty rates. To meet these challenges, Denver approached the USDOT Smart City Challenge with several guiding principles: establishing mobility and freedom for all; improving connectivity; leveraging public and private partnerships to boost funding levels; and collaboration with public, private, academic and community members. The technical components of Denver's proposed Smart City program included Mobili-ty on Demand, Transportation Electrification and Intelligent Vehicles.

Denver was awarded a $6 million U.S. Department of Transportation Advanced Transportation and Conges-tion Management Technologies Deployment Program federal grant. This grant money, along with city and county of Denver funds, will be used to initiate the implementation of intelligent vehicle technology. A Con-nected Traffic Management Center (TMC) will be implemented to support current and future Connected Vehicle (CV) applications. In addition, Denver is installing dedicated short-range communications (DSRC) in 1,500 City fleet vehicles to jumpstart technology adoption (City of Denver, 2016). In 2016, Denver re-leased the GoDenver app, fulfilling the promise of Mobility on Demand. Denver had an existing bike-share program, the first in the country and a strong public transit system, the RTD, which they leveraged to gain a partnership with Xerox for development and testing of the new program (Badzmierowski, 2016). In its initial release, the GoDenver app supports trip planning using various transportation and parking options, however payment for third party services, such as Lyft, is not supported (City of Denver, 2018).

4.3 Austin, Texas

Austin is the fastest growing city in the US, with a population that has doubled in the past 30 years and continual job growth, even during the recession of 2018. All of this growth, however, has led to a growing economic divide, with many service and public workers unable to afford close in housing. Austin's response to the USDOT Smart City Challenge focused on addressing this economic divide through improved access to transportation with an eye towards increasing access to jobs and resources while adhering to Austin's guiding principles; equity, economic opportunity and environmental stewardship. To achieve these goals, Austin proposed implementation of transit access hubs, known as Smart Stations; Connected Corridors which link Smart stations with new transit services; a mobility marketplace which connects travelers to the best packaged mobility options; and ladders of opportunity initiatives, which combines the preceding three systems to provide access to jobs, education, healthcare, healthy food and other areas of need (Austin, 2016a).

After failing to obtain the USDOT Smart Cities Challenge grant, Austin shifted their focus to more traditional Smart City initiatives; Shared-Use Mobility, Electric Vehicles and Infrastructure, Autonomous Vehicles, Data and Technology and Land Use and Infrastructure (Austin, 2016b), as laid out in Austin's Smart Mobility Roadmap. Austin is seeking public/private partnerships to move forward with these initiatives.

4.4 Kansas City, Missouri

Kansas City Missouri entered the USDOT Smart City Challenge with a head start in deploying Smart City Technology. As the first city to be equipped with Google Fiber, Kansas City achieved cutting edge neighborhood connectivity. A new 2.2-mile-long streetcar corridor was equipped with public Wi-Fi, smart lighting and information kiosks. Kansas proposed implementing a Prospect Corridor, which would serve underserved communities with Smart transportation technology; Automated, Connected and Electric Vehicles; and an extension of the existing 2.2-mile-long streetcar corridor to connect with underserved communities.

Kansas City has an impressive existing Smart Corridor, as highlighted in their grant proposal, which demonstrates many of the cutting-edge technologies' cities are striving for. They have not moved forward with further development since their failed application for the USDOT Smart Cities Challenge Grant. A Request for Proposals (RFP), "Comprehensive Smart City Partnership with Kansas City, Missouri", was recently closed. With this RFP, Kansas City is seeking a public/private partnership to continue development of their Smart City initiative (City, Kansas, 2018).

4.5 Pittsburgh, Pennsylvania

Pittsburgh was nearly decimated with the collapse of the US steel industry. Revitalization of the city was achieved through a shift towards education, healthcare and advanced industries. Pittsburgh's USDOT Smart City Challenge proposal was geared towards enhancing this new foundation by improving safety, enhancing mobility, addressing climate change and enhancing ladders of opportunity. Pittsburgh proposed expanding an existing test bed of real time traffic controls along a safety corridor with the addition of connected vehicle technology and other safety enhancements; installing EV charging stations and solar canopies to demonstrate clean energy technology; and connecting smart spine corridors to low- and medium-income areas to enhance economic opportunities (Pittsburgh, 2016a).

Pittsburgh has built a unique public private partnership organization, the SmartPGH Consortium, which includes representatives from government, public authorities, utilities, universities, community organizations, philanthropy and corporations. This consortium has enabled Pittsburgh to continue progressing with Smart City projects without having won the USDOT grant or other federal grant funding (Pittsburgh, 2016e).

Pittsburgh's existing test bed of real time traffic controls is in the process of being expanded from the original installation of a handful of intersections to now cover 50. This Smart Spine system will connect several areas of the city, including lower income areas (Pittsburgh, 2016c). Existing street lights in Pittsburgh are being converted to energy saving LED light fixtures which also include sensors that can be used to monitor traffic conditions and air quality. This real-time data will used in conjunction with the smart intersection technology to adjust for traffic events (Pittsburgh, 2016d). An 'Electric Avenue' project is underway in Pittsburgh with budget allocated to increase the city's electric vehicle fleet and to install DC charging stations that receive power from a solar canopy tied into the local district energy microgrid (Pittsburgh, 2016b).

4.6 San Francisco, California

The challenges San Francisco proposed addressing with the USDOT Smart City Challenge grant were a lack of affordable housing, increased pedestrian deaths, high levels of greenhouse gas and expected population growth. To address these issues, San Francisco proposed a multi-tiered approach that combines neighborhood, citywide and regional solutions to meet their goals of a 10% reduction in each of these categories: single occupancy vehicle trips, transportation emissions, pedestrian deaths, cost of transportation for low income households as a percentage of their household income and freight delays and collisions. To achieve this, San Francisco proposed implementation of various shared transportation related improvements, electric vehicle related improvements, connected vehicle technology and automated transportation (S. Francisco, 2016a).

Though San Francisco did not win the USDOT Smart City Challenge grant, it was awarded a grant of $11 million USDOT Advanced Transportation and Congestion Management Technologies Deployment grant. With this grant, San Francisco has been able to move forward with several of the items originally proposed (S. Francisco, 2016b). Among them are a Smart Carpool pilot which includes designation of HOV lanes, special pick up and drop off zones, as well as an app for carpool matching (C. of S. Francisco, 2016); and the installation of smart traffic signals, which include sensors for pedestrians and bicycles as well as emergency vehicle prioritization (Figure 1).

Figure 1: San Francisco's smart city timeline (S. Francisco, 2016b).

4.7 Columbus, Ohio

Columbus Ohio, the winner of the USDOT Smart City Challenge grant pitched their proposal as one that could be scaled nationwide. They proposed 4 separate Smart City districts that would be representative of many cities across the country: residential, commercial, downtown and logistics. Columbus's proposal emphasized providing access for lower income parts of the community, including transportation improvements that would enable better access to neonatal care for low income expectant mothers; access to jobs; connecting visitors to transportation options; safe, reliable transportation that can be accessed by all and environmentally sustainable solutions. To achieve these goals, Columbus proposed implementing a connected transportation network that combines traffic and other sensors with access to kiosk-based trip planning information; a multi-modal trip planning app; and the installation of EV infrastructure (Columbus, 2016).

As the recipient of the USDOT Smart City Challenge, Columbus is preparing to implement the most ambitious suite of Smart City technologies yet. The technologies being actively planned include: a connected vehicle environment, which would improve pedestrian, bicycle and automotive safety; a multimodal trip planning application, which bridges together all potential modes of transportation into one interface for a seamless trip planning experience; Smart Mobility hubs at bus stops, which provide kiosk-based multimode trip planning and public wi-fi access to allow app based planning on personal devices without data plans; a mobility assistance app designed to meet the needs of people with cognitive disabilities; prenatal trip assistance for mothers using Medicaid-brokered transportation services, which would reduce Columbus' infant mortality rate; event parking management, to reduce the congestion caused by inefficient traffic management during large events; a connected electric autonomous vehicle fleet designed to carry visitors safely the first and last mile from a parking area; and truck platooning, which uses connected vehicle technology to move multiple trucks through intersections efficiently (Columbus, 2018).

Columbus's proposal emphasized the idea that they would serve as a national model for Smart City planning. To fulfill this promise, Columbus is publishing the details and results of their Smart City projects. The Smart Columbus Playbook includes contracts, program materials, presentations, white papers, videos, webinars and data. These assets are available to any city and can be used and modified freely as aid in developing Smart City technology across that nation (Columbus, 2018).

5 Conclusions and recommendations

The USDOT Smart City Challenge grant program spurred many cities to think about and plan for a smart future. Of the top 7 finalists, aside from the winner, Columbus, the cities that were most successful at moving forward with their original vision were those who were awarded an alternate grant, the USDOT Advanced Transportation and Congestion Management Technologies Deployment grant. Among the cities who did not obtain any federal grant funding, some are actively working with or seeking public/private partnerships and some are taking no action at all. Columbus Ohio, the recipient of the grant, is moving forward with a very ambitious set of initiatives and is sharing their process and results, a valuable resource for any city implementing smart technology. Cities around the country recognize that technology can be used to better the lives of their citizens, but as is the case for any public infrastructure improvement, funding is a significant challenge. Adding technological improvements to the slate of federally funded transportation infrastructure could go a long way towards moving the US into the next generation of transportation, one which is environmentally friendly, shared equally regardless of income and provides a safer environment for everyone.

Following a thorough literature review, STEEP analysis and comparison of seven US cities, it is evident that the implementation of smart city innovations should have a significant impact on the community. Since the agency primarily responsible for the smart city implementation is the city itself, there is an inherent responsibility to first approach addressing the need of the society. In the city of Portland, there has been a strong push to focus on pedestrian and bike safety, so all projects must first address this safety concern.

Beyond safety, Portland has placed strong emphasis on promoting equity in the smart city projects. As such, during the pilot run for the electric scooters in the summer of 2018, the company was required to provide a minimum number of scooters on the east side of Portland, which has a high percentage of marginalized citizens. At the end of the pilot program, a fine was assessed to the scooter company for not providing the minimum 100 scooters a day on the east side of town (Portland, 2018a). The ability to issue fines as a means to maintain policy is effective and should be used to ensure that regulations are properly followed. It is crucial to have effective community outreach programs to determine the core of what the city aspires to be and the corresponding values. Further outreach will help to define the means by which a city achieves its goals. In the last 30 years, the rate of violent crime has been cut in half ("Reported violent crime rate in the United States from 1990 to 2017," 2018), but some cities still experience high rates of gun violence, so they have adopted sensors to detect gunshot locations. While this may have the veneer of a new tool to fight crime, a negative consequence could be the impression of the community that they are second-class citizens that need additional supervision and control. Conversely, Portland has adopted a philosophy that a community is more prone to positive growth when the marginalized are empowered, not controlled.

A common theme with cities that have been able to effectively implement smart city innovations is that their system of governance is bottom-up, with a strong city council, as opposed to top-down, where the mayor would have great authority and the ability to select commissioners based on personal preference over qualifications. Additionally, projects that become too politicized will result in unnecessary obstacles that would prevent a beneficial innovation from being implemented. Conversely, an unchecked administration would have an authority to implement programs that would only benefit a small subset of the population at a considerable cost to the city as a whole.

Appendix

Open data management

Regardless of the specifics of the communications networks that transmit data, the city of Portland will find itself in a position where it will be the recipient of increasing quantities of data and a much more complex set of data privacy and sharing requirements and constraints that it must develop and implement. The Open Data Cloud component of Portland's USDOT proposal has since been repurposed and titled the Portland Urban Data Lake (PUDL). Image Source (Portland, 2018b).

One of the key responsibility's cities have in data management is responsible sharing it with the correct parties. Cities will be in possession of data that is confidential and must be protected with appropriate privileges, e.g., sharing with other government agencies, but not with the general public. On the other hand, cities have an obligation to make many types of information publicly available, in some cases in an anonymized fashion. As a result, many cities are developing data management platforms such as the PUDL. The City of Portland's defined PUDL project goals are included below (Portland, 2018b):

Create Urban Analytics products to demonstrate effective use of Smart Cities data, including data from new sensor installations.

Explore technologies and architectures for providing standardized, documented access to Smart Cities data sources for public sector agencies and local innovators.

Collect and store and data from a variety of sources, including new sensor deployments, PBOT and BPS data sources as well as other regional data sources, while respecting privacy and security needs.

With PUDL, Portland seeks to both develop analytics that stand to improve city operations and assist third party developers that are also developing analytics and service offerings that may not be possible without a basis the availability of rich data. One of the initial use cases for the PUDL is managing the data steam from several types of sensors that are currently being deployed on a pilot basis.

Roadway instrumentation

Portland is currently deploying multiple types of sensors to gather a range of information that is intended to ultimately assist several city functions. Two sensor types were selected for an initial rollout on a pilot basis, including air quality sensors and a new type of multipurpose sensors deployed initially to support Portland's Vision Zero to promote pedestrian safety. The Traffic Safety Sensor Project was launched by Portland in 2018 and will use sensors that will be deployed via a partnership agreement with GE, Intel AT&T and PGE. The sensors, which are CityIQ type manufactured by GE, will assist transportation planners in understanding where pedestrians and bicyclists commonly walk and ride. In turn these patterns may be used by transportation planners to redesign intersections and other areas of the roadways and sidewalks to increase safety.

The CityIQ sensors can also do many other things. The presence of many types of additional capabilities that are currently not enabled naturally leads to the future possibility that the monitoring services provided by these sensors could be expanded in the future.

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Appendix-A

List of Publications by Cornelius Herstatt

International, reviewed journals

M.Marwede/C. Herstatt: No innovation for the elderly? The influence of cognitive distance in corporate innovation, in: Creativity and Innovation Management (CIM) 2019, 1-13

M. Zaggl/T. Schweisfurth/C. Herstatt: The Dynamics of Openness and the Role of User Communities: A Case Study in the Ecosystem of Open Source Gaming Handhelds, in: IEEE Transactions on Engineering Management PP(99), March 2019

K. Sourav, T. Daim, C. Herstatt, Technology Roadmap for the Single-Aisle Program of a Major Aircraft Industry Company, IEEE Engineering Management Review, Vol. 46., 2018

F. Geyer/J. Lehnen/C. Herstatt: Customer Need Identification Methods in New Product, what works best, in: International Journal of Innovation and Technology Management, (12) 2018

K. Eling/C. Herstatt: Managing the Front End of Innovation – Less fuzzy, yet still not fully understood, in: Journal of Product Innovation Management, 34 (6), 2017

F. Kohlbacher/C. Herstatt: Silver Product Development: The Concept of Autonomy as the Common Denominator in Innovations for older Users, in: Gereontechnology: Research, Practice, and Principles in the Field of Technology and Aging, 2016

J. Lehnen/T. Schmidt/C. Herstatt: Bringing agile project management into lead user projects, in: International Journal of Product Development, Vol. 21, Issue 2-3, 2016

C. Hansen/ T. Daim/ H.Ernst/ C. Herstatt: The future of rail automation: A scenario-based technology roadmap for the rail automation market, in: Technological Forecasting and Social Change, Vol. 110, 2016

T. Weyrauch/C. Herstatt: What is Frugal Innovation? in: Journal of Frugal Innovation, Vol. 1, 2016

T. Schweisfurth/C. Herstatt, C.: "How internal users contribute to corporate product innovation: the case of embedded users", in R&D Management, Vol. 46 No. S1, 2016

Göldner/C.Herstatt/F.Tietze: The emergence of care robotics - A patent and publication analysis, in: Technological Forecasting & Social Change, 92, 2015

F. Tietze/T. Pieper/C. Herstatt: To own or not to own: How ownership impacts user innovation - An empirical study, in: Technovation 2015

C. Herstatt/R. Tiwari: Frugale Innovation, in WIST (Wirtschaftswissenschaftliches Studium), Heft 11., Jg. 44, 2015

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R. Tiwari and S. Buse (eds.), *Managing Innovation in a Global and Digital World*, https://doi.org/10.1007/978-3-658-27241-8

T.Schweisfurth/C.Herstatt: Embedded (Lead) Users as Catalysts to Product Diffusion, in: Creativity and Innovation Management, January 2015

T. Schweisfurth/C. Herstatt: How internal users contribute to corporate product innovation: the case of embedded users, in: R&D-Management Journal, November 2014

K. Wellner/C. Herstatt: Determinants of User Innovation Behaviour in the Silver Market, in: International Journal of Innovation Management, (18), 6, 2014

F. Kohlbacher/C. Herstatt/N. Levsen: Golden Opportunities for silver innovation: How demographic changes give rise to entrepreneurial opportunities to meet the needs of older people, in: Technovation (5) 2014

R. Tiwari/C. Herstatt: Changing Dynamics of Lead Markets: A new Role for Emerging Economies as Innovation Hubs, in: The European Financial Review, April-May 2014

Herstatt/M.von Zedtwitz: Global products from innovation labs in emerging countries, in: International Journal of Technology Management, Vol. 64, Nos. 2/3/4, 2014

K. Balka/C. Raasch/C. Herstatt: The Effect of Selective Openness on Value Creation in User Innovation Communities, in: Journal of Product Innovation Management, Volume 31, Issue 2, 2014

F. Tietze/T. Schiederig/C. Herstatt: Firms´ transition to green product service systms innovators: cases from the mobility sector, in: International Journal of Technology Management, Vol. 63, Nos.1/2, 2013

C. Raasch/V. Lee//S. Späth/C. Herstatt: The rise and fall of interdiscliplinary research: The case of open source innovation, in: Research Policy, 1/2013

M. Grothe/C. Herstatt/H.-G. Gemünden: Cross-Divisional Innovation in the large cooperation: Thoughts andevidence on ist value and the role oft he early stages of innovation, in Creativity and Innovation Management (CIM), Vol. 21, Issue 4, 2012

R. Tiwari/C. Herstatt: Assessing India´s lead market potential for cost-effective innovations, in: Journal of Indian Business research (Emerald), Vol. 4 Issue 2, 2012

T. Schiederig/F. Tietze/C. Herstatt: What is Green Innovation? An exploratory literature review, in: R+D-Management Journal, Vol.42, 2, 2012

L. Janzik/C. Raasch/C. Herstatt: Online communities in mature markets: Why join, why innovate, why share? in: International Journal of Innovation Management, Vol.15, No. 4 (August) 2011

R. Tiwari/C. Herstatt/M. Ranawat: Benevolent Benefactor or Insensitive Regulator? Tracing the Role of Government Policies in the Development of India´s Automobile Industry, in: East-West Centre Policy Studies, No. 58, 2011

C. Raasch/ C. Herstatt: How companies capture value from open design, International Journal of Information and Decision Sciences 3, 1, 2011

T. Schweisfurth/C. Raasch/C. Herstatt: Free revealing in open innovation: A comparison of different models and their benefits for companies, International Journal of Product Development 13, 2, 2011

K. Balka/C. Raasch/C. Herstatt: How open is Open Source? – Software and Beyond, in: Creativity and Innovation Management (CIM), Vol. 19 (3), 2010

L. Janzik/C. Raasch/C. Herstatt: Warum Kunden in Online-Communities innovieren: Ergebnisse einer Motivanalyse, in : ZFB, Zeitschrift für Betriebswirtschaft (Vol. 81, Nr. 5), 2011

S. Buse/R. Tiwari/C. Herstatt: Global Innovation: An Answer to mitigate Barriers to Innovation in Small and Medium-Sized Enterprises? in: International Journal of Innovation and Technology Management, Vol. 7, No. 3, September 2010

M. Grothe/C. Herstatt/ H.G. Gemünden: Geschäftsbereichsübergreifende Innovationen: Wie lässt sich die Entstehung bereichsübergreifender Produkte und Dienstleistungen in multidivisionalen Unternehmen systematisch fördern? In: ZFO (Zeitschrift für Organisation), 5/2010.

K. Kalogerakis/C. Lüthje/C. Herstatt: Developing Innovation Based on Analogies: Experience from Design and Engineering Consultants, in: Journal of Product Development Management (27), 2010

C. Raasch/C. Herstatt/K. Balka: On the Open Design of Tangible Goods, in: R+D-Management, Volume 39 Issue 4, 2009

K. Balka/C. Raasch/C. Herstatt: Open source beyond software: An empirical investigation of the Open Design phenomenon, First Monday 14, 11, 2. Nov.

F. Skiba/C. Herstatt: Users as sources for radical innovations: Opportunities from collaborations with service lead users, in: International Journal of Services Technology and Management, Vol. 12, No. 3, 2009

P. Spethmann/C. Herstatt/S. Thomke: The Impact of the Tool Crash Simulation on Productivity and Problem-Solving in Automotive R&D, in: International Journal of Product Development Management, Special Issue on "Automotive Product Development, Design and Engineering Process and Applications", Vol. 8, No. 3 2009

B. Verworn/D. Schwarz/C. Herstatt: Changing workforce demographics: the strategies derived from the resource-based view of HRM, in: International Journal of Human Resources Development and Management, Vol.9, Nos.2/3, 2009

F. Tietze/E. Reula/C. Herstatt: The relation of patent ownership and firm success: Cases from the LCD Flat-Panel-Display industry, in: International Journal of Technology Intelligence and Planning, Vol. 5, No. 1, 2009

B. Verworn/ C. Herstatt/ A. Nagahira: The fuzzy front end of Japanese new product development projects: impact on success and differences between incremental and radical projects, in: R&D Management 38, 1, 2008

C. Stockstrom/ C. Herstatt: Planning and Uncertainty in New Product Development, in: R&D Management 38, 12, 2008

V. Braun/C. Herstatt: The Freedom-Fighters: Why incumbent corporations are attempting to control user-innovation, in: International Journal of Innovation Management, Vol.12, No. 3 (Sept, 2008)

C. Raasch/C. Herstatt: The dynamics of user innovation: Factors sustaining innovation activity, in: International Journal of Innovation Management, Vol.12, No. 3 (Sept, 2008)

V. Braun/C. Herstatt: Barriers to User-Innovation: Moving towards a Paradigm of "License to Innovate", in: International Journal for Technology Policy and Management, Vol.7, No.3, 2007

C. Herstatt/F. Tietze/D. Probert/A. Nagahira: The Chief Technology Officer (CTO) in Theory and Practice: A literature review and results from field research in Japan, in: International Journal of Innovation and Technology Management (IJITM), September 2007

A. Nagahira/S. Sugiyai/C. Herstatt/B. Verworn/C. Stockstrom: "Impact Analysis of Front End Practice in Japanese companies", Nihon University Journal,Vol.1,No.2, 2007

C. Lettl/C. Herstatt/H.-G. Gemünden: User´s contributions to radical innovation: evidence from four cases in the field of medical equipment, in: R&D Management, Volume 36, June 2006

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C. Herstatt/A. Baumgarten: Die Zusammenarbeit mit dem lokalen Produktmanagement bei der internationalen Markteinführung von neuen Produkten, Ergebnisse einer empirischen Untersuchung in der Konsumgüterindustrie, in: Zeitschrift für Organisation (ZfO), 2006

C. Lettl/C. Herstatt/H.-G. Gemünden: Learning from Users for Radical Innovations, in: International Journal of Technology Management, Vol. 33, No.1, 2006

G. Trauffler/C. Herstatt/H. Tschirky: How to transfer discontinuous technology into radical innovation – Some evidence from three nanotech case, in: International Journal of Technology Intelligence and Planning (IJTIP), Vol.1, No.4, 2006

R. Tietz/P. Morrison/C. Lüthje/C. Herstatt: The process of user-innovation: A case study in a consumer goods setting, in: International Journal of Product Development Management, Volume 2, No. 4, 2005

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C. Lüthje/C. Herstatt/E. von Hippel: User-innovators and "local" information: The case of mountain biking, in: Research Policy (Volume 34), No. 6, 2005

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Chr. Müller/C. Herstatt/T. Fujiwara: Sources of Bioentrepreneurship: The Cases of Germany and Japan, in: Journal of Small Business Management (JSBM), Vol. 42, No. 1, 2004

C. Lüthje/C. Herstatt/C. Lettl: Knowledge Distribution among Experts: A closer look into the Efficiency of Information Gathering for Innovation Projects, in: International Journal of Technology Management, Vol. 25/26, August, 2003

C. Herstatt: Search fields for radical innovations involving Innovation, International Journal of Entrepreneurship and Innovation Management, Volume 2 (I) 2002

C. Herstatt/H.Geschka: Need Assessment in Practice – Theory, Methods and Experiences, in: International Journal of Entrepreneurship and Innovation Management, Volume 2 (6) 2002

C. Herstatt/Chr. Mueller: Interfirm cooperation: a brief overview of current theoretical findings and issues for future research, in: International Journal of Human Resources Development and Management, Volume 1, No.1, 2001

C. Herstatt/H. Geschka/D. Guggisberg/J. Geis: Innovationsbedarfserfassung in der Schweiz - Methoden, Erfahrungen und Tendenzen, in: Die Unternehmung (3) 1999

C. Herstatt/E. v. Hippel: From Experience: Developing New Product Concepts Via the Lead User Method: A Case Study in a „Low-Tech“ field, in: Journal of Product Innovation Management (9), 1992

C. Herstatt/T. Sommerlatte: F & E-Benchmarking, in: Die Unternehmung (3), 1995

International, refereed conferences

Fahnenmüller, L., Heinz, M. and C. Herstatt, 2018, Managing Cross-Disciplinarity for Sustainability – The Case of Cradle-to-Cradle Innovation, 25th International Product Development Management Conference (IPDMC), Porto, Portugal, June 2018.

Fahnenmüller, L. and C. Herstatt, 2018, The Cross-Disciplinary Implementation of Cradle-to-Cradle Innovation – Current State and Future Outlooks, C2C Science Symposium, Lüneburg, September 2018.

Goeldner, M., Kruse, D. J., Herstatt, C. (2018), One Size Does Not Fit All – An Empirical Study on Identifying Social User Innovation Using the Lead User Method, JPIM Research Forum, Chicago, USA

Heuschneider, S./Herstatt, C. (2018), Uniting distributed research streams: Reviewing the field of external search, in: 25th IPDMC Conference, Porto, Portugal

Krohn, M./Herstatt,C. (2018), The question of Frugal mindset in MNCs – Framing an emerging phenomenon with a systematic literature review, in: 25th IPDMC Conference, Porto, Portugal

Krohn, M., Herstatt, C. (2018), Managers' Perspectives in the Face of Global Economic Developments - Recognition of Opportunities for Frugal Innovation, Cognitive Perspective in Entrepreneurship Research Conference, Paris, France

Moschner, S.-L. and Herstatt, C. (2018) Analysis of the Influence of Symbolic and Substantive Actions on the Open Innovation Collaboration Between Incumbents and Startups in Corporate Accelerators, 16th International Open and User Innovation Conference, New York, USA

Heinz, S./Fahnenmüller, L./Herstatt,C. (2018), Managing cross-disciplinarity for sustaianability – The case of cradel to cradle innovation, in: 25th IPDMC Conference, Porto, Portugal

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Tiwari, R., Buse, S., Kalogerakis, K., Scheitza, J., and Herstatt, C. (2018): Relevanz und Potenziale frugaler Innovationen für Österreich: Studie im Auftrag des Rates für Forschung und Technologieentwicklung, Hamburg: Institute for Technology and Innovation Management.

Morimura, F., R. Tiwari, C. Herstatt, and S. Buse (2018): "Potential Role of Frugal Innovation in Home Energy Management Systems", ISPIM Connects Fukuoka conference, Fukoka, Dec. 2-5 (forthcoming).

Goeldner, M., Kruse, D., Buse, S. and Herstatt, C. (2017), Identifying Social Innovation using the Lead User method – An explorative case study in Indonesia, 24th IPDMC Conference, Reykjavik, Iceland

Heuschneider, S., Ehls, D., Herstatt, C. (2017): The Field of External Search and the Search for External Knowledge: A Co-Citation Analysis, 77th Annual Meeting of the Academy of Management (AOM), Atlanta, GA, USA.

Heuschneider, S., Ehls, D., Herstatt, C. (2017): The Field of External Search and the Search for External Knowledge, 15th International Open and User Innovation (OUI) Conference, Innsbruck, Austria.

Kruse, D., Goeldner, M. and Herstatt, C. (2017), Linking user innovation and social innovation - an explorative case study on Lead User identification in the humanitarian sector, 15th International Open and User Innovation Conference, Innsbruck, Austria

Moschner, S.-L. and Herstatt, C. (2017) Corporate-funded incubators and accelerators as a field of interaction - How incumbents can obtain knowledge from entrepreneurial ventures, 24th IPDMC Conference, Reykjavik, Iceland.

Moschner, S.-L. and Herstatt, C. (2017), Entrepreneurial ventures as sources for innovation? How incumbents (under)utilize corporate incubators and accelerators as an open innovation approach, 15th International Open and User Innovation Conference, Innsbruck, Austria.

Denker, F., Eling, K. and Herstatt, C. (2016), The Role of Individuals' Domain Knowledge in Evaluating Radical New Product Ideas, R&D Management Conference, Cambridge, UK.

Drabe, V. and Herstatt, C. (2016), Why and how companies implement Circular Economy concepts – the case of Cradle to Cradle innovations, R&D Management Conference, Cambridge, UK.

Drabe V., Hübner R. and Herstatt, C. (2016), Analyzing Barriers to Corporate Implementation of the Circular Economy Concept – An Exploratory Approach, 1. interdisziplinäre Konferenz zur Zukunft der Wertschöpfung, Hamburg, Deutschland.

Goeldner, M., Herstatt, C., Canhão, H. and Oliveira, P. (2016), With a Little Help from My Friends – How Patients and Caregivers Become User Entrepreneurs in the Medical Device Sector, 14th International Open and User Innovation Conference, Boston, USA.

Goeldner, M., Herstatt, C., Canhão, H. and Oliveira, P. (2016), Patients and Caregivers as User Entrepreneurs – A Case Study Analysis in the Healthcare Sector, R&D Management Conference, Cambridge, United Kingdom.

Heuschneider, S. and Herstatt, C. (2016), External search for exploration of future discontinuities and trends as a driver for innovation: a co-citation and content analysis, 14th International Open and User Innovation Conference, Boston, USA.

Lehnen, J. and Herstatt, C. (2016), Thirty years lead user research - an empirical study of its implementation level in business practice, 14th International Open and User Innovation Conference, Boston, USA.

Marwede, M. and Herstatt, C. (2016), Product development for distant target groups – An experimental study, R&D Management Conference, Cambridge, UK.

Moschner, S.-L. and Herstatt, C. (2016): Overcoming the Innovator's Dilemma by Keeping Your Enemies Close – How Incumbents Can Learn from Entrepreneurial Ventures, R&D Management Conference, Cambridge, UK.

T. Pieper, F. Tietze, C. Schultz, C. Herstatt (2016), To share or not to share – Exploring the impact of sharing behavior on user innovativeness, R&D Management Conference, R&D-Mgmt. Proceedings, Cambridge, UK.

Tiwari, R., Kalogerakis, K. and Herstatt, C. (2016), Frugal Innovations in the mirror of scholarly discourse: Tracing theoretical basis and antecedents, R&D Management Conference, Cambridge, UK.

Weyrauch, T. and Herstatt, C. (2016), Frugal innovation – What is it? Criteria for frugal innovation, R&D Management Conference, Cambridge, UK.

Goeldner, M. and Herstatt, C. (2015), Patients and relatives as user entrepreneurs? A case study analysis in the healthcare sector, 13th International Open and User Innovation Conference, Lisbon, Portugal.

Kalogerakis, K., Drabe, V., Paramasivam, M. and Herstatt, C. (2015), Closed-Loop Supply Chains for Cradle to Cradle Products, HICL Conference, Hamburg.
von See, B. and Kalogerakis, K. (2015): "Innovation Contests in Logistics", HICL conference, Hamburg.

Lehnen, J. and Herstatt, C. (2015), The lead user approach in innovation practice: Nice-to-know or must-have?, 13th International Open and User Innovation Conference, Lisbon, Portugal.J. Lehnen/C. Herstatt: The lead user approach in innovation practice: Nice-to-know or must-have?, in: OUI-Conference 2015, Lissabon July 2015

R. Tiwari/K. Kalogerakis/C. Herstatt: Frugal innovation and analogies: some propositions for product development in emerging economies, in: R+D-Management Conference 2014 (proceedings)

D.Ehls/C. Herstatt: Attracting Participants in Open Innovation Communities: Revealing Joining Preferences, in: ISPIM Conference, Dublin 2014 (proceedings)

D. Ehls/C. Herstatt: Joining Open Source Com- munities under Alternatives, in: Academy of Management Conference, Philadelphia 2014 (proceedings)

M. Göldner/C. Herstatt: Are patients a valuable source of innovation for R&D of medical devices? The case of medical smartphone applications, in: UOI-Conference, Boston 2014 (Proceedings)

J. Lehnen/D. Ehls/C. Herstatt: How is the lead user approach implemented in practice?, in: R+D-Management Conference, Stuttgart 2014 (proceedings)

K. Wellner/C.Herstatt: Determinants of User Innovator Behavior in the Silver Market, in: ISPIM-Conference, Dublin 2014 (proceedings)

V. Nedon/C. Herstatt: R&D Employees' Intention to Exchange Knowledge within Open Innovation Projects, in: ISPIM-Conference, Dublin 2014 (proceedings)

V. Geng/C. Herstatt: The Cradle-To-Cradle (C2C) Paradigm in the Context of Innovation Management and Drivin Forces for Implementation, in: IPDMC-Conference, Limerick 2014 (proceedings)

F. Tietze/T. Pieper/C. Herstatt: To own or not to own: How ownership affects user innovation - An empirical study in the German rowing community, in: Acadamy of Management Conference, (AOM-Proceedings), Orlando 2013

A. Ramdorai/C. Herstatt: BoP-Innovations in the Medical Industry, in: : Acadamy of Management Conference, (AOM-Proceedings), Orlando 2013

D. Ehls/C. Herstatt: Open Source Participation Behaviour – A Review and Introduction of a Lifecycle Model, in: 35th DRUID Celebration Conference (DRUID-Proceedings), Barcelona 2013

N. Stoermer/C. Herstatt: Exogeneous versus endogeneous governance in innovation communities: Effects on motivation, conflicts and justice, in: Academy of Management Conference (AOM-proceedings), Boston 2012

D. Ehls/C. Herstatt: Open source software and open content: Some same but different, in: DRUID (conference proceedings), Copenhapen 2012

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