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André Presse
Orestis Terzidis *Editors*

Technology Entrepreneurship

Insights in New Technology-Based Firms, Research Spin-Offs and Corporate Environments

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Foreword

The quality of life that is taken for granted in developed countries has not simply come about. It is the result of decades and, in certain cases, centuries of focus on inclusive development and creating products that created the greatest value and institutionalising the skills and knowledge into teachable competences. The greater value, or perception of value, was reflected in the higher amounts that customers were willing to pay for goods of services. This value in turn resulted in a virtuous cycle of improving quality of life. With time, this created societies that began to focus on the higher levels of the value chain, since these provided ever-increasing revenue per hour of effort. The increased productivity and quality of life also came at a price. It became clear that growth had limits, in the resources but even more in the environment. Our atmosphere is too small to absorb all the greenhouse gases, and our oceans are limited if it comes to pollution. The constraints in many cases led to new regulations, but again hard work in innovation was necessary to square the circle and allow for sustainable growth.

Over the past few decades, the world has become interconnected as never before. Goods and services found markets around the world, as ever more countries opened their markets to international trade and commerce. This further spurred the specialisation that had earlier given rise to products with higher perceived value, since the number of consumers who had the wherewithal to purchase them increased.

Commoditisation of manufacturing capabilities made the world more flat and smaller, since specialisation could be automated if the demand was high enough. This resulted in the West outsourcing to Japan, then South Korea and Taiwan, and ultimately to China. The result of this was that product manufacturing went to the cheapest location in the world. There was a belated realisation that with the outsourcing of manufacturing, the raison d'être of manufacturing that could be done in lower-cost countries was not adequate to sustain the wealthier Western economies.

The only way to sustain the existing quality of life was by way of innovation that countered commoditisation with higher perceived value. This innovation had to find its way from technology research and development to established companies as well as startups. It is this technology transfer and commercialisation, its impact, challenges and bottlenecks that the authors have captured.

The efforts by the authors in capturing the relevance of, and challenges in, sustainable technology management in this context are both topical and highly relevant. Technology management is relevant in established firms since over time, all existing technology can become replicable, resulting in price-based competition. With developing countries having the lowest cost of manufacture, companies in developed countries cannot compete on cost. A focus on technology management can enable established companies to continue competing on value, resulting in a value-driven, rather cost-based, competitive advantage. The topic is also on the agenda for universities and research centres: the traditional mission of research and teaching is complemented in many institutions by the third pillar of innovation.

The different perspectives of entrepreneurship from researchers from across the globe provide fascinating insights on what afflicts startups and reasons why technologies succeed, or more importantly, fail, en route to commercialisation.

Technology startups fail because of many reasons. Chief among them include low-value recognition from customers, delivery failure resulting from underestimating the logistics of manufacturing and delivery, the inability to monetise since competing solutions are ‘free’ like e-mail or simply the inability to identify and focus on beachhead customers.

The authors have elegantly encapsulated the challenges that young technology firms face, have theorised on business models for technology ventures and have showcased how to convert value to sustained revenue, which ultimately ensures scale and profitability. Intellectual property (IP), which includes patents and trademarks, is an important method to provide competitive advantage, which ultimately results in impressive profits. The impact of student densities on IP creation and subsequent venture capital availability, which is a critical requirement for successful entrepreneurship, has also been discussed.

In particular, the authors have evaluated new technology-based firms (NTBFs) across Europe and analysed the impact of grants. The negative implications of state grants, in contrast to private funding, are that grants are often not ‘smart’, where they open doors to the market or prepare the ground for the next round of funding. These are critical to the subsequent success of NTBFs. Another impact of grants and other forms of state funding is that NTBFs continue to do more of the same; instead of focusing on go-to-market strategy that results in quick and replicable revenue and reaching scale, they focus on technology. These startups use the funds to do what they’re already good at, rather than developing the business and sales channels.

In spite of the limitations of state funds and grants, it is undeniable that this funding is much needed and can have a huge positive impact at a time when there is a paucity of other funding sources due to the early stage of the NTBFs. The greatest impact of such funding is that it enables NTBFs to align closely to markets, so that their solutions become more driven by market pull rather than technology push. These have been extensively discussed and provide a valuable perspective, not only to NTBFs but also as cornerstones to state policymakers, to maximise impact of state funding.

Since the authors are primarily academicians from premier institutions in Europe, their perspective on important elements such as the impact of the eminent role that entrepreneurship programs play in universities is driven by objective analysis of large and comprehensive data sets. Indeed, this is distilled from their involvement in such programmes, providing a unique insight into the role that these programmes play. Further, and more importantly, these authors are actively involved in supporting entrepreneurship much before the startup comes into being—they help evolve the thinking of the would-be entrepreneurs. The book reflects several of their learnings as they continue to hand-hold and drive the future of entrepreneurship and competitive advantage of Europe.

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Part I
Business Models, Business Architecture and Business Planning of NTBFs

The Semantics of Entrepreneurial Learning in New Technology-Based Firms

Evaluating NTBFs' Entrepreneurial Progress Using Content Analysis of Business Plans

Marc König, Christina Ungerer, and Guido Baltes

Abstract New Technology-Based Firms (NTBFs) learn their business in the early-stages of their life-cycle. As a central element of the entrepreneurial learning process, the business model describes the value-creation functions that are conceptualized in different stages of the NTBF's life-cycle. Transaction relations connect the model with the business reality and ideally mature in strength over time to a functioning value-network. This chapter describes the development of a research design that determines, extracts, and evaluates semantics constructs of this entrepreneurial learning out of a convenient sample and three cohorts of business plans submitted to a business plan award between 2008 and 2010. The analysis shows empirical evidence for the survival and growth of those NTBFs that exhibit a balanced status of entrepreneurial learning in the maturity of the value-network that can be characterized as early startup-stage. The empirical findings of the network theory based business plan analysis will allow for a better explanation of the performance in the entrepreneurial process that is discussed for NTBFs based on theory of organizational learning.

Keywords New Technology-Based Firms (NTBFs) · Network theory · Organizational learning · Value network · Transaction relations · Business plan

1 Introduction: Relevance of the Entrepreneurial Status

NTBFs are of specific relevance when it comes to solving the problems of our modern society. They are seen as the carrier to bring new knowledge to the market that solves a certain problem in an innovative manner (Ferguson & Olofsson, 2004). NTBFs get started based on technologies that are underestimated or ignored as

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business opportunities by incumbent companies (Fontes & Coombs, 1996). Due to their liability of newness, however, they evince a high possibility of failure (Aaboen, Lindelof, & Lofsten, 2008).

In order to successfully manage the transition towards growth, NTBFs undergo massive changes in their early life-cycle (Sexton, Upton, Wacholtz, & McDougall, 1997). This especially due to the fact that they represent a new organization with a new product, which requires NTBFs to gain legitimacy (Ferguson & Olofsson, 2004). Failures in developing NTBFs through these transition stages are mainly due to the human factor and not due to technology or system failures (Longbotham & Longbotham, 2006). Many NTBFs simply do not manage to survive as they do not know what they are doing (Wille & Schulte, 2011). Particularly in their early life-cycle stages, they need to bring in immense knowledge into the organization (Franco & Haase, 2009; Øystein Widding 2005).

During this process NTBFs are embedded in an innovation system that helps them to learn their business and which highly impacts their survival and growth. In the inter-organizational environment of the innovation system, NTBFs gain information from intermediaries such as investors, institutionalized networks and consultants (von Nell & Lichtenthaler, 2011). They gain further distinctive resources to build up their business (Katzy, Sailer, Holzmann, & Turgut, 2011) which in the early-stage of the NTBFs' life-cycles in particular requires the facilitation of the ego centric value-network (McAdam & Marlow, 2008; Vanderstraeten & Matthyssens, 2012).

Stakeholders and intermediaries can help NTBFs and thus often represent parts of their early information-network. In their interactions, NTBFs rely on the business plan or presentations thereof to communicate their innovative business and receive education (Honig & Karlsson, 2004). This presentation of the business model represents the first "barrier" for NTBFs to get access to needed resources, since groups such as banks, corporates (investing money and often offer early business relations) and venture capital investors as well as incubators use it to prioritize the allocation of their scarce resources (Doganova & Eyquem-Renault, 2009; Karlsson & Honig, 2009; Kirsch, Goldfarb, & Gera, 2009; Mason & Stark, 2004). Although the business plan is commonly used as an education tool and selection document in the NTBF innovation process, little is known about predictive performance indicators and their empirical proof (Castrogiovanni, 1996; Simón-moya & Revuelto-taboada, 2016; Simon, 2012).

Therefore this article contributes to the understanding of the entrepreneurial process embedded into the innovation system based on analyzing the artifact 'business plan' from a network theory perspective and discussing the empirical findings in the context of organizational learning (Hoang & Antoncic, 2003; Tam & Gray, 2016). Transaction relations described in the text of NTBFs' business plans are discussed as indicators providing insight into the organizational learning status. As measurement instrument and an analyzing process are provided, which allow the status of entrepreneurial learning to be related to the NTBF performance. In the context of entrepreneurial learning the discussed findings will help practitioners of an innovation system to improve their evaluation and decision making process for prioritizing their support measures based on analyzing NTBFs' business plans.

2 Literature Review: Organizational Learning in the Early-Stages

Organizational learning (OL) has been discussed in the context of existing companies by many scholars since the early 1990s (Franco & Haase, 2009; Tam & Gray, 2016). The theory of organizational learning describes the interaction between the individual, the organization and its environment (Tam & Gray, 2016). It further tries to capture the dynamic process of creating, retaining, and transferring knowledge in the context of the organization in order to achieve a positive impact on the organization as a whole (Zgrzywa-Ziemak, 2015).

Thereby, the impact of organizational learning on the performance of the organization is specifically discussed in many studies. Against expectations, learning is not always positively related to an organization's performance, which leads to the assumption that learning may leads to specific results, as nonproductive learning also accrue (Zgrzywa-Ziemak, 2015). This necessitates an understanding of the concrete result of organizational learning to measure organizational performance.

As the NTBF creation is built on the identification and exploitation of a new technology-based business opportunity, it becomes crucial that the funding entrepreneur accumulates relevant knowledge within the NTBF (Fontes & Coombs, 1996). In this knowledge acquisition process the identification of the business opportunity requires explorative learning in the beginning of the NTBF's life-cycle, which enables acquiring new competences and technologies as well as extending relevant existing ones. Exploitative learning on the other hand aims at continuously improving the value creation system that caters to the respective opportunity. Keeping the balance of exploitation and experimentation is the key to system survival and growth (March, 1991; Tam & Gray, 2016; Zgrzywa-Ziemak, 2015).

Based on the innovative nature of NTBFs, learning in such NTBFs requires the involvement of many sources and interveners rather than a single process. In this context, the learning process depends on the surrounding innovation system that moderates the performance of the organization (Fontes & Coombs, 1996). Accordingly, Tam and Gray identified that inter-organizational learning plays a vital role during the early-stages characterizing NTBFs (Tam & Gray, 2016). Only constant inter-organizational learning will allow the NTBF and the surrounding innovation system to learn the innovative business model (Fontes & Coombs, 1996).

Inter-organizational learning can create knowledge that represents a competitive advantage (Graham & Muyia Nafukho, 2007). Following Chrisman and McMullan, NTBFs show knowledge gaps in four categories: know-why, know-what, know-how, and know-who. Know-why represents scientific knowledge, and know-what certain techniques and facts. Both are typically explicit knowledge and thus may not form the basis for competitive advantage. Tactical knowledge of know-who and know-how may be regarded as more heterogeneously spread and thus likely to enable a competitive advantage. Know-how usually integrates know-what and know-why into a process of "learning by doing". Know-who represents the development of business relations emerging from this process (Chrisman & McMullan, 2004; Widding, 2007). Successful tactics of NTBFs are usually based on experience from prior startups, management or industry specific experience (Huovinen & Tihula, 2008).

Developing successful tactics stemming from know-how and know-who is characterized as entrepreneurial knowledge in literature (Franco & Haase, 2009). Entrepreneurial knowledge in a certain sector allows NTBFs in the entrepreneurial functions of a business to convert resources from the market place to a higher yield by combining (innovation) and marketing them in a new value combination. Entrepreneurial knowledge leads to new ways of managing NTBFs. Therefore, the ventures need to interact with their partners surrounding the envisioned business model (Widding, 2007; Xiu-qing & Li, 2013).

Strategies for learning a new business—such as the widely used discovery driven planning, critical assumption planning, and the lean startup approach—describe adaptive learning strategies as fundamental for entrepreneurial survival and success (Hart, 2012; Mcgrath & Macmillan, 1995; Sykes & Dunham, 1995): NTBFs in their very early-stage sort through their ideas in an experimental attempt to adapt to outside needs. In the course of these attempts the NTBF learns which relations to build and which to avoid (Greve, 1995; Sullivan & Ford, 2014).

For NTBFs, business models play a vital role in the inter-organizational learning process. They are used in different steps during the early-stages of NTBFs' business life-cycles. The presentation is often done in the form of one-pagers, pitch decks and business plans describing the business model. Business models are used to explore the respective business opportunity and to build the value network, i.e. documents help NTBFs to get feedback on the core assumptions of their business case and at the same time to convince external partners (Danna & Porche, 2008; Doganova & Eyquem-Renault, 2009; George & Bock, 2011).

3 Research Question: Determining the Status of Entrepreneurial Learning

Despite the broad theoretical understanding of inter-organizational learning necessities, little is known about the entrepreneurial learning patterns of NTBFs. Even more, there is little understanding of NTBF interactions (when? with whom?) in the innovation system from a life-cycle perspective. This is in particular due to the integral challenge of lacking methodologies to investigate NTBFs in a sufficiently large number and in different life-cycle stages (Hoang & Antoncic, 2003; Tam & Gray, 2016). In this context the most frequently available and semantically rich artifact of NTBFs' entrepreneurial learning about their business model is the business plan (Honig & Karlsson, 2004; Karlsson & Honig, 2009).

Despite its vital role, neither the innovation systems practices (Hindle & Mainprize, 2006; Mason & Stark, 2004) nor academic discussion offer commonly accepted and reliable methods to objectively evaluate NTBFs' status of entrepreneurial learning that is relating to performance (Castrogiovanni, 1996; Fernández-Guerrero, Revuelto-Taboada, & Simón-Moya, 2012; Simon, 2012). No research is found that looks at the semantic of business plan texts. This chapter aims to shed light on the sematic of NTBFs' business plans by answering the following research question:

> *Can the semantic constructs of entrepreneurial learning extracted from NTBFs' business plans allow for an empirical analysis and evaluation of the NTBF performance as well as the chance for survival and growth?*

The business plan provides a snapshot model of the NTBFs' status of entrepreneurial learning in the form of described transaction relations. Using a network theory lens to look at the NTBF merging, these transaction relations are considered an indicator for the extent to which this snapshot model of the NTBF—distorted by inaccuracy and uncertainty—is anchored into the business reality of the NTBF's business environment. Validity of this indicator is assumedly based on principal agent theory and the assumption that NTBFs are unlikely to "cheat" or lie with respect to the transaction relations described in their business plan, due to the high risk of ruining the relationship building process, if discovered (Kang & Zheng, 2009)—thereby losing trust of and access to their innovation system's closed network (Dewatripont, Legros, & Matthews, 2003; Yan & Lu, 2008).

Proposition 1 NTBFs' business plans represent snapshot models of the business reality with high validity in the described relationships.

Network theory explains the relationship building by investigating the NTBF's interaction with the external environment (Carpenter, 2011; Kilkenny & Love, 2014; Trimi & Berbegal-Mirabent, 2012). Here, it is argued that around the "ego," the business entity of interest, transaction relations are accumulated to human resources, financial resources, and suppliers on the input as well as to customers on the output-side (Carnovale & Yeniyurt, 2015). These transaction relations determine the NTBFs' integration into a broader value network (Carnovale & Yeniyurt, 2015; Kilkenny & Love, 2014). The ego thus represents a focal point of the NTBF's value-creation function as complemented by a broader value network that produces an output for satisfying customer needs (Carnovale & Yeniyurt, 2015; Elfring & Hulsink, 2007; Greve, 1995).

Proposition 2 Transaction relations determining the value network of an NTBF can be identified and classified from the business plan text in which they are described.

Taking a longitudinal perspective on NTBFs, network theory argues that transaction relations are changing significantly in type, strength and motivation over the NTBF's life-cycle stages. Initially, transaction relations may be more identity-based, which is strongly related to the founder(s) of the NTBF: the motivation to commit to the relation focuses more on committing to interact with the individual person than on committing to the economics of the NTBF's current business stage (Hite & Hesterly, 2001; Oksanen, Hallikas, & Sissonen, 2010; Ostgaard & Birley, 1996;

Sullivan & Ford, 2014; Witt, Schroeter, & Merz, 2008). In later stages, in particular for setting the NTBF on a growth path, transaction relations need to be built more on an economic rational and benefit in order to reliably provide access to increasingly needed resources, a growing number of customers etc. (Hite, 2005; Hite & Hesterly, 2001; Sullivan & Ford, 2014). Such maturing relations lead to an intensified and increasingly stable embedding of the NTBF into the broader value network, which reduces the NTBF's risk of failure (Katsamakas, 2014; Lusch, Vargo, & Tanniru, 2010; Oksanen et al., 2010).

Proposition 3 Well-performing NTBFs' transaction relation based embedded value network increases in strength over time.

The context in which a NTBF is born results in specific patterns in the described transaction relations that relate to NTBF performance. These patterns are fingerprints of the process an innovation system learned to support NTBFs in its regional context. They are defining the path performing NTBFs follow in order to become successful (Fontes & Coombs, 1996; Tam & Gray, 2016). Initial research on transaction relations in business plans shows clear empirical evidence on different patterns connected to the performance of NTBFs (Konig, Baltes, & Katzy, 2015).

Proposition 4 NTBFs can be clustered based on the patterns in the transaction relations and their performance.

4 Research Design Development: A Multistage Purification Process

We applied a multistage process to develop a research design that allows accessing and empirically comparing NTBF performance based on business plan texts following our propositions. The research technique of content analysis enables objective, systematical, and empirical research on business plans (Bos & Tarnai, 1999; Kassarjian, 1977; Murphy & Ciszewska-carr, 2005; Rourke & Anderson, 2004). Symbols can be interpreted in intersubjective comprehensible cultural forms, while the text in business plans describes our social reality to some extent. Research using content analysis requires the classification of text through counting and accessing words, symbols, themes, characters, paragraphs, sentences, grammatical units, etc. by certain value concepts (Bos & Tarnai, 1999).

Analyzing a quantity of business plans based on our propositions required the combination of qualitative and quantitative content analysis techniques to ensure empirical and theoretical grounding (Bailey, Johnson, & Daniels, 2000; Elo & Kyngäs, 2008). The resulting research design aims at identifying, categorizing and evaluating transaction relations described in NTBF business plan text. Following this multi-step procedure allowed us to build an infrastructure for coding large numbers of business plans in the long run.

Content analysis, whether quantitative or qualitative, is always based on an imperfect data basis and thus can never be considered as being fully reliable (Kassarjian, 1977; Krippendorff, 2004). Research designs such as the one used for our research building on a measurement instrument can only deliver trustable results in qualitative study approaches, when the underlying measurement instrument is purified by conducting a rigorous test and measurement series based on coder reliability (Bailey et al., 2000; Kemal Avkiran, 1994; Murphy & Ciszewska-carr, 2005).

The Sample

The research team has access to a database containing a total of 837 business plans that had been submitted to the most prominent technology-oriented business plan award of southwestern Germany (CyberOne) between 2000 and 2016. bwcon, leading business association for fostering high-tech and innovation in the region, organizes the CyberOne award. The sample of 837 business plans was supposed to be investigated with a research design allowing for qualitative scalability. Consequently, an infrastructure has been developed that enables applying the research design to further business plan samples in later research stages.

Starting at the core of the research sample, the CyberOne data, a network sampling technique was used. Network sampling is particularly helpful for the identification of hard-to-reach populations (Johnston & Sabin, 2010). Collecting data through network sampling adheres to the idea that some organizations can be referred to peers with certain characteristics (Biernacki & Waldorf, 1981). Since properties of the network affect the sample, and the referred peers may ask for an unlimited number of companies (Johnston & Sabin, 2010), the generalizability of the population of NTBFs in the state of Baden-Württemberg is limited. However, comparing the data with a study of the Centre for European Economic Research (Egeln et al., 2012), an average of 300 F&E intensive companies were founded between 2001 and 2010. Looking at the founding hotspots in both data samples, most companies were clustered around cities with universities engaging in research. Furthermore, due to the high-tech focus of the CyberOne (the award represents a central platform for venture capital in the region), our data seems highly comparable to the ZEW data. Thus, representativeness for the population of NTBFs in the state of Baden-Württemberg can be assumed to some extent.

This assumption is not delimited by the fact that the plans were submitted in various stages of the NTBFs' business life-cycle and not only once when they were founded: the planning for innovative business concepts is not necessarily connected to the legal foundation of a NTBF. Rather, this is elementary for our research as business plans submitted in different stages that are defined as the early-stages in the life-cycle of NTBFs will enable identifying specific semantic constructs relating to the respective life-cycle stages.

In order to statistically analyze the sampled NTBFs' performance, external information has been added using secondary data sources. The aim was to allocate NTBFs to the categories 'non-survived', 'survived' and 'growth'. For this purpose, we defined a structured process to identify the NTBFs described in the business plans in the internet and subsequently in the official German commercial register. To further validate and enrich performance data with information such as the development of staff and turnover as well as the industry, a data service provider has been involved.

To guarantee comparability, only one provider has been selected. Analyzing a subsample, the company bisnode has been identified as the provider with the best data quality. Turnover data and the number of staff are information companies often do not want to make public. Bisnode attempts to access this data through official sources such as the German Federal Register, then contacts the companies directly and asks for the data. If no information is found, an estimation is made based on scientific modeling using the most reliable data that is available in the respective case.

Although the categories of non-survivor, survivor and growth are applied in several research projects related to NTBF performance, quite heterogeneous definitions with respect to the time period and the growth of turnover as well as employees are found in literature (Coad, Daunfeldt, Hölzl, Johansson, & Nightingale, 2014; Moreno & Casillas, 2007; Parker, Storey, & van Witteloostuijn, 2010). We defined survived startups as firms documented in the official registers for more than 5 years after the submission of the business plan. We allocated firms to the category growth when their turnover (as specified in the business plan) reached at least 100,000 euros and had been tripled when below and doubled when above 500,000 euros within 5 years after submission.

Research Design Development

First, a convenience sample of business plans encompassing 20 survivors and 20 non-survivors was used to operationalize the network theory based semantic construct "transaction relations" for early-stage NTBFs' business plans using qualitative structured content analysis. The subsequent quantitative analysis showed that the business plans of survivors exhibit a significantly higher number of (described) transaction relations. Furthermore, survivors evince transaction relations in several dimensions of outside markets and in different strength (scores) levels (Konig et al., 2015).

The results of the convenience sample analysis have been used to develop a multidimensional measurement instrument that identifies transaction relations by employing a well-structured, formalized method of content analysis. Transactions relations are categorized into market dimensions of suppliers, financiers, human resources and customers. Theoretical and empirical findings support the instrument that is based on the following equation describing value network maturity and thus the status in the entrepreneurial learning process:

$$\text{Maturity} = (\text{customers}; \text{financiers}; \text{human resources}; \text{suppliers})$$

In each of the four dimensions, transaction relations are classified according to their strength (maturity) using a 5-point-scale referring to the business-life-cycle stages early-seed, late-seed, early-startup, late-startup, and growth. An example for a transaction relation template in the dimension customer growth stage could be the following: *"We sold 20 products for 500,000 euros to the following customers…"* This transaction relation is significantly stronger than the transaction relation: "*We got positive feedback from 3 potential customers…*" which we classified as late-seed stage in the customer dimension.

To achieve quality of the research design in terms of objectivity, reliability and validity, a well-structured purification has been applied for employing the recommended "expert judging" (Kassarjian, 1977; Krippendorff, 2004; Zhou, Yim, & Tse, 2005). This purification was conducted using two tryout cycles: the first tryout was designed to identify interpretative differences in the application of the multi-dimensional instrument by the researchers with in-depth expert knowledge in comparison to interchangeable, non-expert coders. For this purpose, each business plan of the convenient sample was coded by students 25 times on average.

The second tryout builds on the first tryout's results and was designed to improve the overall research design and quality based on inter-coder agreement as an indicator. In this tryout, 136 additional business plans from the years 2008 to 2010 including new types of transaction relations were coded. For the new research design, the complexity of the measurement instrument application process was reduced by breaking it down into two steps: first identifying and categorizing transaction relations, then evaluating them according to their strength in a separate procedure. Moreover, the workload per coder was reduced to increase motivation and the coding was conducted in an organized, supervised setting to provide maximum assistance.

Breaking down the coding process into these stages allowed for the reduction of the complexity inherent in the coding process for the judges, and in addition for classifying the identified transaction relations based on single sentences as semantic units. Consequently, one sentence could be evaluated separately by two non-expert coders (students) plus an expert coder's judgment. This further offered the possibility to adapt the research instrument in a later step based on the learnings gained from identified and analyzed sentences and to scale such improvement over the entire sample.

Quality and Data Preparation of the Sample 2008–2010

High reliability of quantitative content analysis is assumed if coding by trained coders results in a reliability of 66–95% (Kassarjian, 1977). Thus, although coders producing systematic errors have not been excluded from our coding, the resulting agreement of 64.69% in the highest classification across all dimensions suggest a nearly acceptable quality. Looking at each dimension, the following agreement was reached: customer 69.66%, supplier 45.52%, financier 48.28%, and human resources 73.79%. The systematic process produced an absolute agreement of 56% for the total of all described transaction relations and allowed to identify poor coding performance ("systematic errors") as well as misinterpretations that could be traced back to the research design and in particular to the code book (König, Ungerer, Büchele, & Baltes, 2016).

Additional data enhancement was realized by conducting researchers' judgments in order to obtain a data sample with trustable results (Murphy & Ciszewska-carr, 2005). For the planned cluster analysis, we decided to consider only the highest-rated transaction relations per dimension the coders agreed upon in each business plan. We further looked at each single transaction relation with disagreement. To reduce context-related misjudgment of the coders—who had to evaluate sentences without knowing the whole business plan context in the second process step—we further investigated the transaction relations in each business plan with a context perspective. This also allowed the identification of outliers in the highest classification. Because of these adjustments, 33.75% of the business plan ratings (highest classification per dimension) were changed. The judgment made by the researchers only led to moderate changes: in the majority of cases, the difference between ratings was only ± 1. Therefore, it is assumed that the final coding of the sample evinces sufficient quality for further analysis. It is thus used as input data in the cluster analysis: the four dimension represent independent variables determined by the expert-adjusted highest rating.

5 Results: Seven Clusters of NTBFs' Learning Patterns

To examine the 2008–2010 sample in a first explorative approach, a cluster analysis has been performed. Cluster analysis summarizes different methodologies that allow grouping cases based on independent data structures (Backhaus, Erichson, Plinke, & Weiber, 2011). With this suggestive segmentation task, we aimed at grouping NTBFs based on the strength of transaction relations described in their business plans. Distinguishing between the three performance categories, the analysis has the potential to provide insights and directions for further research on venture survivability.

Hierarchical clustering is considered suitable for the relatively low sample size of 136 observations. Since we aim at obtaining homogenous clusters, the "Complete Linkage" algorithm is utilized. As usual, the optimal number of clusters is associated with the last clustering step before two highly dissimilar clusters are merged. Moreover, we divided the analysis into the performance categories of survived, non-survived, and growth, as we are searching for patterns regarding the level of transaction relations that characterize a successful NTBF and patterns within the NTBFs that failed. We further assessed the clusters in the context of the firms' industry.

When looking at the survived NTBFs as depicted in Table 1, the optimal number of clusters turns out to be three. The first cluster achieves a high score in all categories and more than half of the NTBFs assigned to the first cluster are growth NTBFs. The second cluster is characterized by NTBFs having low scores in every dimension, and only 18% of them can be labeled as growth. Concerning the industry, we cannot draw a clear conclusion, as it seems as if all kinds of NTBFs are represented in that cluster. The NTBFs in cluster three are similar to the first cluster

Table 1 Survived NTBFs

Complete linkage		HC customers	HC financier	HC human resources	HC suppliers	Growth
1	Average	3.838	3.000	3.405	3.081	0.568
	N	37	37	37	37	37
	Deviation	0.8665	0.9718	0.6855	0.7593	0.5022
2	Average	1.353	2.000	2.529	1.941	0.176
	N	17	17	17	17	17
	Deviation	0.6063	0.7071	0.6243	1.2485	0.3930
3	Average	4.154	2.692	3.462	0.538	0.462
	N	13	13	13	13	13
	Deviation	0.8006	1.4367	0.9674	0.7763	0.5189
Total	Average	3.269	2.687	3.194	2.299	0.448
	N	67	67	67	67	67
	Deviation	1.3771	1.0900	0.8209	1.3373	0.5010

regarding the percentage of growth NTBFs, the financiers score, and the human resources score. However, they are characterized by an extremely high customer and an extremely low suppliers score. The NTBFs of the third cluster are mainly from the chemical industry.

Since the scores of the second cluster are significantly lower (mostly at the 1% level) than the scores from the first and third cluster, and due to the fact that they survived, the NTBFs from the second cluster seem to have submitted their business plan in quite an early stage. Further investigation of cluster two will be necessary to understand the performance.

When analyzing the non-survived NTBFs, the optimal number of clusters is two, which is illustrated in Table 2 below. In the table we see that to the first cluster (4), the algorithm assigns 13 NTBFs, which obtain mediocre scores for financiers and suppliers, but very high scores for customers and human resources. These NTBFs are mostly rooted in the software industry. The remaining question is: Did they achieve too little of scores in financiers and suppliers, or did other reasons cause their failure?

Further analysis of the data provided by bisnode, combined with additional secondary research, a typical exit scenario (merger with a larger company) was identified in 5 of the 13 cases. Consequently, these NTBFs showed decent performance, as an exit is a frequent objective in high-tech industries. In the other cases we were not able to identify the reasons for non-survival, i.e. a deeper case analysis would allow for a better understanding. Hence, the analysis strengthens the quality of our elaborated model of value network maturity as an indicator for entrepreneurial learning.

Regarding the second cluster of the non-survivors (5), their failure appears to be well explained by the low scores in each dimension. For every dimension except that of suppliers, the first cluster achieves significantly higher scores at the 1% level. The NTBFs in the second cluster stem from different industries and no clear cut can be drawn.

Table 2 Non-survived NTBFs

Complete linkage		HC customers	HC financier	HC human resources	HC suppliers	Growth
4	Average	4.769	2.923	3.923	2.308	0.077
	N	13	13	13	13	13
	Deviation	0.4385	0.9541	0.7596	1.2506	0.2774
5	Average	1.982	2.125	2.661	2.196	0.054
	N	56	56	56	56	56
	Deviation	1.0356	0.6892	0.7693	1.1508	0.2272
Total	Average	2.507	2.275	2.899	2.217	0.058
	N	69	69	69	69	69
	Deviation	1.4514	0.8023	0.9098	1.1615	0.2354

Table 3 Growth NTBFs

Complete linkage		HC customers	HC financier	HC human resources	HC suppliers
6	Average	3.882	3.176	3.529	3.471
	N	17	17	17	17
	Deviation	0.9275	1.0146	0.7174	0.6243
7	Average	3.231	2.538	3.385	1.385
	N	13	13	13	13
	Deviation	1.4233	1.1266	0.7679	0.8697
Total	Average	3.600	2.900	3.467	2.567
	N	30	30	30	30
	Deviation	1.1919	1.0939	0.7303	1.2780

Exploring the growth NTBFs as a sub-sample of the survived ones, we can again identify two clusters as shown in Table 3. In the first cluster (6), relatively high scores are reached in all categories, whereas in the second cluster (7) the partner dimension is rated significantly lower and the average financier score is lower as well. Nearly half of the NTBFs from this cluster are located in the software industry; all of them provide services rather than physical products. The low partner and financier rating could be explained by the fact that software companies can potentially realize turnovers relatively quickly, and typically do not need many partners to realize their product or service: the development is rather human resources intensive.

6 Discussion, Limitations, and Conclusion

Inter-organizational learning is the key for successfully transferring new knowledge from research to the market in an entrepreneurial learning process. Described transaction relations in NTBFs' business plans, which are an expression of the status of entrepreneurial learning, have been analyzed in an explorative approach based on cluster analyses. Discussing the results, one NTBF cluster among the survivors exhibits a balanced status in each transaction relation dimension, scoring on average the learning status we defined as early-startup. These firms did not only survive, but also showed a good chance for growth with 57%. Only in the business plans of seven non-survived NTBFs (cluster 4), could a similar pattern be detected. Hence, one could hypothesize that ventures crossing the maturity stage of an early startup have learned the essentials of the functionality of their business and thus survive with a high potential for growth.

This result suggests that the entrepreneurial learning status of early-startups, as described in the business plan in terms of the value network maturity, is characterized by addressing an initial pilot market or having pre-contracts for the supply of their product or service. Furthermore, these NTBFs usually realize first turnovers of up to 20,000 euros. Regarding financiers, they are funded by a third-party investor, such as a business development bank or an initial business angel. Looking at the human resources dimension, the NTBFs on average evinced a functional team of more than four founders. Moreover, they implemented first professional partnerships to suppliers.

In cluster 3, we identified a group of NTBFs that grounded their survival on strong transaction relations on the customer side, while being significantly weaker on the partner and financiers interface. The data leads to the assumption that these companies learned, in particular from the market, how to create sustainable value for their customers and consequently were able to survive. Circa 46% of these even generated growth. The average score derived from their business plans implies that the firms realized a turnover exceeding 20,000 euros and were already cooperating with a distribution partner. Hence, we assume that these clusters primarily represent NTBFs that are focused on internal growth, based on own cash flows. An explanation for the low partner rating could be that the mere existence of a cooperation does not imply the quality or supportive power of the relation.

Exploring cluster 2 and 5, we hypothesize that there is only a small number of NTBFs scoring as early and late-seed stage that can survive and grow. This finding is congruent with life-cycle research suggesting that failure rates for NTBFs are higher the earlier they are in the life-cycle (Eloranta, 2014). When showing such a low level of entrepreneurial learning in a business plan, the probability of survival is quite low. One alternatively, one could assume that some founders fail in entrepreneurial learning from the beginning.

Attempting to contribute to a better understanding of the entrepreneurial learning status, the results of this research are subject to limitations. These are primarily a consequence of the content analysis research design. Quality could be improved by further developing and standardizing the analysis process and by constantly adding new knowledge on new transaction relationships in the coding manual. Moreover, data quality improvements could be reached by detecting coders that produce systematic errors in the coding process, as well as by applying computer-assisted coding procedures.

A further source of limitation lies in the business plan sample data collection. Objectivity could have been distorted by the network sampling approach. Moreover, environmental factors of the innovation system may greatly influence the success of NTBFs. Sample representativeness may be further limited by failures in identifying successful startups that are not found in the bisnode database. Comparing the results to similar data from other regions and applying the research design to larger samples could add to concluding on the sample representativeness.

The results seem quite promising for conducting analyses to predict survival and growth based on the status of entrepreneurial learning with a larger sample. A follow-up study will use either discriminant analysis or artificial neuronal networks (ANN) as structure testing procedures for predicting performance group allocation (Backhaus et al., 2011). Once the model is estimated based on a large dataset, new business plans can be allocated to the predefined groups. Qualitative analysis of the clusters could identify more detailed reasons for performance by looking at individual characteristics. Finally, management recommendation on how to support NTBFs in different stages could be derived.

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Architecture of Technology Ventures: A Business Model Perspective

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Abstract This chapter develops a framework for analyzing the architecture of technology ventures. The framework is based on the concept of business model-how the venture creates and captures value. Application of the business model concept in the technology venturing literature results in four theoretical postulations which explain how and why technology ventures differ from other ventures. In summary, we propose that: (1) business model of technology ventures has a complex technological core and a flexible marketing periphery. (2) Because of this core-peripheral architecture, business model of technology ventures is technology-driven and market-driving (3) market driving-ness makes these business models disruptive and (4) versatile, able to tap into multiple emerging markets. Supportive empirical evidence from three technology ventures substantiates this framework and its implications.

Keywords Technology ventures · Theory of the firm · Business models · Core-Periphery model · Market driving

1 Introduction

Technology ventures defined as small (less than 50 employees) and young (less than 10 years old) firms driven by high-technologies (technologies that require advanced and sophisticated knowledge base such as ICT, biotech and nanotech) have made and continue to make significant contributions to the world economy (Caridi-Zahavi, Carmeli, & Arazy, 2016; Gruber, Heinemann, Brettel, & Hungeling, 2010; Roure & Maidique, 1986; Zhang, Baden-Fuller, & Pool, 2011). Despite the importance of this type of business firms, little is known about the architecture of their business models and why they differ from other ventures. The extant literature is largely based on the assumption that technology ventures are formed around novel technologies which

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give them a potentially phenomenal capacity to exploit untapped markets (Deeds, DeCarolis, & Coombs, 2000; Li & Atuahene-Gima, 2001; Voudouris, Dimitratos, & Salavou, 2011; Zahra, 1996). Given this realization, one would naturally ask, if technology ventures differ from ordinary ventures why there is no specific theory for the architecture or design of their business models? This chapter seeks to answer this question by synthesizing work on technology venturing (Li & Atuahene-Gima, 2001; Voudouris et al., 2011) and business model design (i.e. Massa, Tucci, & Afuah, 2016; Wirtz, Pistoia, Ullrich, & Göttel, 2015).

The primary objective of this chapter is, hence, to outline a theory for the business model of technology ventures based on a synthesis of the literature on theories of the firm and the business model concept. The core argument of the chapter builds on two points: (1) current theories of the firm including the resource-based views and transaction costs are too simplistic and generic; falling short in providing a complete explanation for why technology ventures differ from other ventures. (2) The process of designing a business model based on new technologies to tap into unexplored markets (Najmaei, 2014; Najmaei, Rhodes, & Lok, 2015) is a potential yet relatively neglected perspective which can address the shortcomings in the theories of the firm for technology venturing.

We propose a framework, suggesting that, the emergence and growth of technology ventures are best explained by looking at the dynamics of their business models. Business models create the momentum that drives a high-tech venture by linking its technologies to different markets. This momentum originates from an opportunistically developed flexible orchestration of core technological know-how and complementary assets which generates a steady demand for the technology of the venture.

In addition, our theory posits that the business model of technology ventures is different from general business models employed by non-technology ventures in two fundamental ways: (1) they are nested dual systems composed of a core technology system nested in a periphery market focused system. The business model is technology based hence the venture is technology driven not market driven. This technological driven-ness enables technology ventures to become market driving. (2) This technological core and marketing periphery provides the technology venture with a superior versatility to commercialize its core technology in multiple markets and disrupt existing ones (Najmaei, 2012).

Considering the above, this chapter is organized as follows. The first section overviews the design and structure of technology ventures. This section establishes that a technology ventures is essentially a firm and the current view of the emergence, scope, boundaries and growth of the firm and consequently technology ventures is largely shaped by the economic theory of the firm. The second section elaborates the business model concept and the business modeling theory. It suggests that the business model concept is an alternative and perhaps new perspective to study technology ventures. The third section synthesizes the concept of technology ventures with the business model concept and proposes an architecture for the business model of technology ventures with its primary features. Section 4 substantiates the proposed model using three case studies. The last section discusses the implications of this theory for the theory and practice of technology venturing and outlines several directions for future research.

2 Technology Venturing

To understand the concepts of 'technology ventures' and 'technology venturing' let's define two terms of 'technology' and 'venturing' respectively. A technology in its simplest term is an application of knowledge to solve problems. In this regard, economic theory represents technology as a given set of factors' combination, defined (qualitatively and quantitatively) in relation to certain outputs such as tools, products and machineries (Dosi, 1982). Some outputs require relatively simple technologies while other require use of more advanced, sophisticated and complex technologies. Example of the former technologies are agricultural, carpentry, and cooking tools. Whereas nanotechnology, bio-technologies, and information technologies exemplify the latter type also known as high or advanced level technologies.

Technological progress in this respect is driven by the development of theoretical know-how and practical knowledge, expertise and embodiment of technical knowledge over time. Such progress, hence, follows certain paradigms which serve as patterns of solution of selected technological problems (Dosi, 1982). Each paradigm evolves through normal problem solving activities which shape technological trajectories along which various tools, machineries and products are developed until a revolutionary solution changes the paradigm. Technological progress, hence resembles that of scientific knowledge in a preparadigmatic, paradigmatic and post-paradigmatic phases (Dosi, 1982; Teece, 1986).

A venture, on the other hand, is simply an organization which brings a technology to the market in the form of a value offering encapsulated in products or services (Byers, Dorf, & Nelson, 2011). The act of venturing is the process through which a technological idea is brought to the market or simply commercialized. Taken together, the process of technology venturing involves conversion of technological know-how into market offerings within a technological paradigm along a specific technological trajectory (Abernathy & Utterback, 1978; Dosi, 1982; Teece, 1986). Having discussed the notion of technology venturing, let's see how economic theory explains emergence of technology ventures.

2.1 Two Polar Views: The Problem of Exogeneous Perspectives

The extant literature reflects two broad polar views on the nature of technology ventures. The first one points to market forces as the main determinant of technological advances and hence creation of ventures (Abernathy & Clark, 1985; Dosi, 1982; Schumpeter, 1942). This view, known as 'demand-pull', is an exogenous one in which consumers' unmet needs and preferences signal opportunities for venturing to be enacted by alert entrepreneurs (Dosi, 1982). Here, "consumers (or users) express their preferences about the features of the goods they desire (i.e. the features that fulfill their needs the most) through their patterns of demand" (Dosi, 1982, p. 149). The main shortcoming of this view is its treatment of technology as a "freely available black box" (Dosi, 1982). That is, it assumes that, "there generally exists a possibility of knowing a priori (before the invention process takes place) the direction in which the market is "pulling" the inventive activity of producers" (Dosi, 1982, p. 149), hence ignoring the creativity of technologists and scientific breakthroughs.

The second view is in clear contrast to the market pull view. It suggests a technology push approach in which scientific advances backed by heavy investments in R&D result in technological breakthroughs which are pushed to the market via the process of technology venturing. Schumpeter (1934) is broadly recognized as the pioneer of this view. According to Schumpeter (1934), large firms with considerable market power, capital and R&D investments develop new technologies. This creative pattern destructs established norms, giving the inventor more competitive power to secure greater share of the market.

To Schumpeter technology venturing is a process of creative destruction done by large firms and smaller firms, if initially successful, will be eventually absorbed by larger corporations (Abernathy & Utterback, 1978). Furthermore, as Dosi (1982, p. 147) states, the 'technology push' view proposes a one-way causal determination (from science to technology to the economy) which fail to consider the intuitive importance of demand factors in shaping the direction of technical progress.

Despite their apparent differences and shortcomings, both market pull and technological push have informed our understanding of the ecology of technological venturing (Anderson & Tushman, 1990; Tushman & Romanelli, 1985). That is, they rest on exogenous assumptions which rather than explaining the internal mechanism which makes technology ventures different from other ventures, consider interactions between markets and technologies in a population of firms.

2.2 Transactions and Resources: Endogenous Views on Technology Venturing

As previously discussed, an endogenous view is required to understand factors and specify the internal structure of the technology ventures, their management, resources, capabilities and organizational processes. There are two pivotal endogenous views within the literature on technology venturing; the transaction costs and the competency or resource-based views. Both views posit that internal factors have more explanatory power than external technological and market exigencies in explaining the nature of technology ventures.

2.2.1 Technology Ventures: Transactions Costs and Resources

The transaction cost theory (TCT) (Coase, 1937; Williamson, 1975, 1979) is a powerful endogenous theoretical tool which explains how technology ventures work by looking at the governance and mode of transactions inside the ventures and between ventures and markets for technologies. A transaction refers to the exchange of goods, services, and information within and between firms in markets or from the providers to the users (Williamson, 1979).

TCT suggests that optimal choices are made when internal and external costs of transacting are minimized (Williamson, 1979). Internal costs include costs of managing, monitoring and controlling personnel and productive activities to develop and use technologies in creating market offerings. Whereas external costs include costs of selecting, contracting and monitoring performance of parties involved in transactions such as suppliers of materials and distributors (Williamson, 1979). In this regard a technology venture is a unit or mode of governance capable of performing transactions that are based on the use of technologies markets cannot perform (Williamson, 1991). Three attributes of such technology-driven and technology-intensive transactions determine how a venture performs them: (1) uncertainty involves in them, (2) their frequency, and (3) the nature of assets or resources required to perform them (Williamson, 1981). Uncertainty has two types. Internal uncertainty refers to the difficulty in evaluating performance of internal mechanisms, elements, and assets. External uncertainty refers to the environmental unpredictability, complexity as barriers of effective adaptation (Williamson, 1981). With respect to the frequency of transactions, Williamson (1981) states that only recurrent transactions (i.e., routines) are important because they make strategic and economic sense for the firm. Finally, asset specificity is whether the asset used in executing the transaction is tailored to the user and specialized to a transaction (Williamson, 1981). Asset specificity has three forms. Site asset specificity refers to the location of plants and systems that are specialized to a key transaction or set of transactions. Physical asset specificity refers to transaction-specific and specialized materials, tools, machineries, equipment, and technologies. Human asset specificity refers to the specific and specialized knowledge, skills, and abilities of staffs that is mainly developed through learning by doing (Williamson, 1981).

Given these attributes, the main purpose of the transaction cost analysis is to "align transactions, which differ in their attributes, with governance structures such as various organizational forms, markets, joint ventures, etc. which differ in their costs and competencies in a discriminating way" (Williamson, 1991, p. 79). A key task of managers is to find and execute the most efficient economizing alignments. Economizing alignments are not always obvious and/or sometimes are at variance with managerial personal attitudes and preferences (Williamson, 1991).

Applying transaction costs theory in the context of technology ventures suggests that, technology ventures are performers of technology-intensive transactions which cannot be performed in markets. Hence, the process of technology venturing involves the process of using technological know-how to perform a set of transactions which are riddled with uncertainty in markets for technologies and internal the venture due to their complexity and lack of prior market testing. Such transactions are usually performed frequency using a complex configuration of specialized technological and human assets and involves higher than usual external and internal uncertainty. What transaction cost theory does not explain is the configurations of resources with which transactions are performed and management of these configurations.

The above shortcomings led to the formation of the resource-based or the competency view (Barney, 1991; Wernerfelt, 1984). The competency view treats a technology venture as a bundle of resources mainly technological know-how managed by executives who have different worldviews about technologies, markets and resources at their disposal (Barney, 2001). Resources here, are defined broader than assets in the transaction cost view. Organizational resources in this view refer to all those specific physical (e.g., specialized equipment, geographic location), human (e.g., expertise in chemistry), and organizational (e.g., superior sales force) assets that can be used to implement value-creating strategies (Eisenhardt & Martin, 2000, p. 1107). Hence, similar ventures in terms of resource endowments can use their resources in uniquely different ways to perform market transactions differently (Eisenhardt & Martin, 2000). Furthermore, the competency view suggests that market offerings (i.e., products and services) are results of transactions performed by resources utilized by managers. Success of a venture's market offerings (i.e. products and services), is a function of the way the venture acquires, uses and develops its resources and competencies (Deeds et al., 2000; Siegel, Siegel, & Macmillan, 1993).

Finally, the competency view suggests that resources which are valuable, rare, inimitable and organized in a firm-specific structure (e.g. innovative product development, networking, alliance management) can shape competitive competencies which drive sustained market success of technology ventures (Najmaei, 2016a; Park & Tzabbar, 2016; Tzokas, Kim, Akbar, & Al-Dajani, 2015).

At the heart of both transaction cost theory and the competency view—and departing from the exogenous views as previously discussed—rests the concept of value and how internal factors are assembled to create and capture value.

2.3 *Value Concept: The Foundation of an Endogenous View of Technology Venturing*

Both transaction costs and competency views suggest that a technology venture succeeds only when it creates and captures value. The transaction cost view considers value creation and capture in terms of the venture's ability to economize transactions or minimize overall economic costs (Williamson, 1991). The competency view takes a slightly different stand by considering value as the difference between the totality of customers' perceived benefit by acquiring the firm's products or services and the full economic costs of these products and services (Barney, 2001).

For the purpose of this research and to align transactions and competency views on the notion of value, the conceptualization of value proposed by Bowman and Ambrosini (2000) is used. According to Bowman and Ambromani, value in general can be divided into 'use value' and 'exchange value'. Use value is defined as the "customers' perceptions of the usefulness of the product on offer, equivalent to 'total utility'" and exchange value is "the amount paid by the buyer (customer) to the seller (business enterprise) for the use value".

As noted, a venture succeeds when it creates and captures value. Value creation in this regard is the activation of the firm's tangible and intangible resources (through the actions of organizational members) as inputs of procedures that combine and transform use values the firm has acquired into new use values (Bowman & Ambrosini, 2000, p. 5). Or simply, creation of competitively superior products and services. Then, the use value must be captured.

Value capture is the realization of 'exchange value' by economic actors including firms, customers, resource suppliers and employees (Bowman & Ambrosini, 2000, p. 15). Value is realized when buyers are convinced and enticed to pay for the use value (Teece, 1986). Both creation and capturing of value are driven by a venture's ability to use its resources to perform technology-driven transactions in a competitively superior way relative to other firms in the industry. Taken together, technology venturing is the process of using a technology to create 'use value' and developing an organization around it to capture this value by generating 'exchange value'. As next section shows, capturing value is more difficult than creating it.

2.4 How Can Technology Ventures Capture Value?

To capture value from technological innovations, innovators should generate revenue in excess of the total cost of their resources and convert it into profit (Teece, 2006). Not every firm can capture the entire profit generated by a technological offering because this profit is distributed among the firm and its suppliers, imitators, followers and customers (Teece, 1986). Teece (1986) argues, an innovator needs to take three factors into considerations to maximize its share of the profit, (1) appropriability regime. That is "the environmental factors, excluding firm and market structure, that govern an innovator's ability to capture the profits generated by an innovation. The most important dimensions of such a regime are the nature of the technology (its complexity, design, knowledge-base), and the efficacy of legal mechanisms of protection (existence of patents, copy rights, trademarks, trade secrets, etc.)." (p. 287). (2) Stage of the technology in the industry life cycle and its dominant design. According to Teece, once a dominant design emerges, competition shifts to price and away from the design. Competitive success then shifts to a whole new set of variables. Scale and learning become much more important, and specialized capital gets deployed as incumbents seek to lower unit costs through exploiting economies of scale and learning (p. 288). Hence, innovative designs accrue more profits faster. (3) Complementary assets involved in the creation and commercialization of the technology. These assets are different from specific assets discussed in the transaction costs view in that they complement assets used in performing core technological transactions. Teece further argues that, a technology is based on a complex system of knowledge components (i.e. specific assets in transaction costs). In almost all cases, the successful commercialization of an innovation requires that the know-how in question be utilized in conjunction with other capabilities or assets. Services such as marketing, competitive manufacturing, and after-sales support are almost always needed. These services are often obtained from complementary assets which are either generic, specialized or co-specialized (p. 288).

Teece defines three forms of complementary assets as follows: "Generic assets are general purpose assets which do not need to be tailored to the innovation in question. Specialized assets are those where there is unilateral dependence between the innovation and the complementary asset. Co-specialized assets are those for which there is a bilateral dependence" (Teece, 1986, p. 289). Ceccagnoli and Rothaermel (2008) offer the following examples for these three types of complementary assets: General purpose manufacturing equipment are an example of generic complementary assets. GE Medical System's stellar reputation for quality and service in hospital equipment is considered a specialized complementary asset, whereas specialized repair facilities for Mazda's rotary engine would be a co-specialized complementary asset.

A technology venture succeeds in maximizing its share of profit (i.e. capturing value from its innovation) when, (1) the design its technological offerings is different from the dominant design either by creating a new technological trajectory or progressing along an emerging one within a new paradigm where the dominant design is not well-established and entrenched yet. Under such circumstances, the competition is not on price hence allowing the venture to charge a premium for its design. (2) It has access to well-defined and developed sets of complementary assets to deliver its technological offerings to the market place and capture its value faster than competitors in a more economic was. (3) It can only manage these two conditions when strong regimes of appropriability exist in the ecosystem where it operates.

Considering the above, Teece (1986)'s model offers a precise understanding of how the structure of resources in the form of complementary and transaction specific assets and nature of transactions in presence of strong appropriability regimes help technology ventures capture value from technological offerings. What is missing from these theoretical models is the logic or the model by which resources (complementary and specific) are managed to optimize both the creation of superior value offerings and capturing of their value in the market. In what follows, it will be argued that the business model concept can cover this void. It not only integrates and complements these models into a complete view of what technology ventures are, but also explains how they work and how they differ from other ventures.

2.5 *The Business Model Concept: Logic of Creating and Capturing Value*

It is now a well-established fact that all technology ventures have business models: "Every company has a business model, whether they articulate it or not" Chesbrough (2007, p. 12). "Whenever a business enterprise is established, it either explicitly or implicitly employs a particular business model that describes the design or architecture of the value creation, delivery, and capture mechanisms it employs" Teece (2010, p. 172). Therefore, the question is how the business model concept fits into the endogenous theories of technology venturing and specifically models of value creation and capture. To address this question, lets briefly discuss what a business model is.

2.5.1 What Is a Business Model?

The extant literature offers three interpretations of the business model concept. The first one is the industry view. Per this view business models define how firms in an industry work. For instance, the social networking business model represents Facebook, twitter, Instagram, etc. Whereas the e-commerce business model refers to the general style of operation used by eBay, Amazon, Alibaba and other similar firms. In other word, ventures which operate in one technological paradigm and evolve along similar technological trajectories by adding common technological problems in different ways (Dosi, 1982; Dosi & Marengo, 2007) are expected to have similar business models and vice versa.

The second view is the cognitive view. According to this view, business models are cognitive representations of the reality of business, how it works and is expected to work in the mind of founders or managers of technology ventures (Malmström, Johansson, & Wincent, 2015;Najmaei, 2016a). Markides (2008) uses the strategic thinking model of Abell (1980) and conceptualizes business models as encompassing three sets of assumptions about who customers are, what they want and how the value offerings should be created and delivered to them. Similarly, Teece (2010) argues that this mental model encompasses assumptions about who customers are, what products are offered to them, how these offerings are created and delivered to customers and how customers are enticed to pay for them (Fig. 1).

The last view is the reified or enacted view. In this view, a business model represents what the firms actually does. Hence, giving scholars and practitioners a sense of the business in action (McGrath, 2010). Some also argue that business models are, in fact, ventures' realized strategies (Casadesus-Masanell & Ricart, 2010), or a system of interconnected boundary-spanning activities performed by the venture to create and capture value (Zott & Amit, 2010). Osterwalder and Pigneur (2010) consider this system as being composed of nine interrelated components: customer segments, value propositions, customer relationships, distribution channels, revenue systems, key resources, key activities, key partners and cost

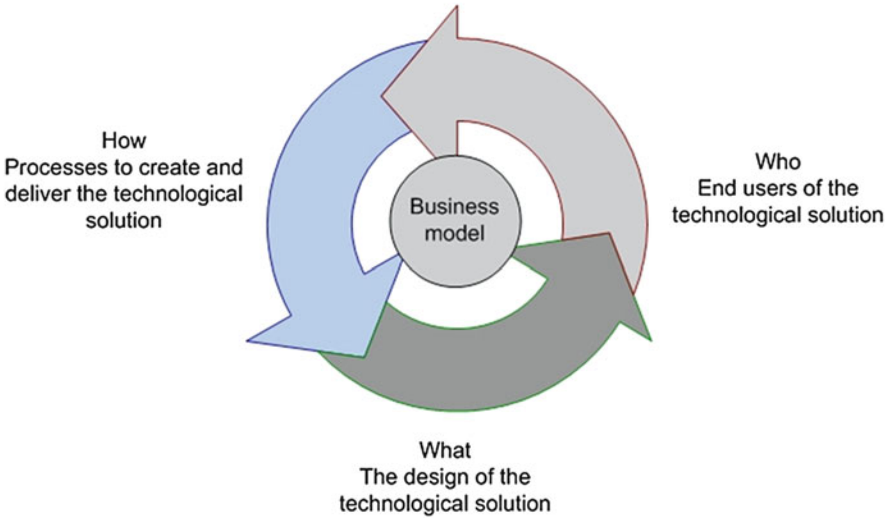

Fig. 1 Business models involves assumptions about who to serve, what to offer and how to develop, deliver and market it

structure.[1] Similarly, Al-Debei and Avison (2010) argue that business models have four interconnected dimensions: value network, value architecture, value propositions and value finance.[2]

From this perspective, a business model defines how resources are configured, bundled and utilized (George & Bock, 2011) to perform various transactions with its business partners and customers (Zott & Amit, 2010). Per this view, a venture with a well-designed business model outperforms its rivals because such a business model enables the venture to perform key activities better than other ventures (Patzelt, Knyphausen-Aufse, & Nikolw, 2008; Zott & Amit, 2007, 2008).

Recent studies (e.g. Foss & Saebi, 2016; Massa et al., 2016) suggest that these three interpretations are neither mutually exclusive nor are they separated. In fact, they must be thought of as complementary descriptions of the same entity. Specifically, managers use industry templates, norms and assumptions or rules of the game to develop their own views of the business. This is the adoption of the industry recipe or how firms in an industry work. Then, once this recipe is adopted, managers try to customize it for their businesses. In this stage managers modify the recipe to contemplate how their own business should work, what it should deliver and how it can be differentiated from other businesses. This phase results in the formation of business models as mental models. When managers adopt these models, they start to acquire necessary resources, and configure them to enact recognized opportunities (Najmaei, 2016a). Figure 2 schematically summarizes these complementary phases.

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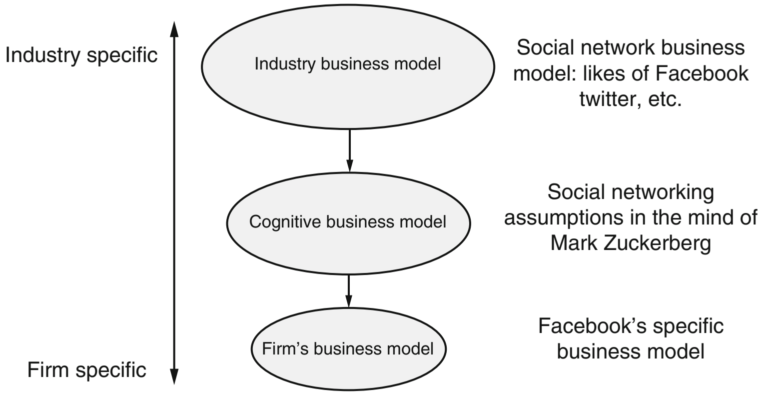

Fig. 2 Development of a business model from an industrial recipe to mental model to a business model

All ventures including technology ones start within a technological paradigm with a set of agreed upon and shared assumptions about how technologies work and can be commercialized. Then each venture adopts a tailored version of these assumptions and uses limited resources which are both core and complementary, specific to the firm's business model to create a unique position by offering various value propositions to customers in the market place (Osterwalder & Pigneur, 2010). This reasoning leads us to ask what exactly business models do to make this market positioning happen.

2.5.2 What Do Business Models Do?

A business models performs several functions to convert an idea into a venture. First, it is a narrative tool which helps a venture's founder describe his businesses and highlights its uniqueness to secure funds and other resources from key resource owners such as technology partners, banks, venture capitalists and government authorities (Magretta, 2002). This process also helps ventures gain legitimacy specially in emerging trajectories and technological paradigms where suppliers, clients and customers are uncertain about the credibility and legitimacy of new ventures (Zimmerman & Zeitz, 2002). Secondly, like 'negative' and 'positive' heuristics in scientific paradigms which inform scientists about which research directions to take and which ones to avoid to help a paradigm progress (Lakatos, 1978), business models guide managers' resource development and acquisitive behaviors by showing which resources are relevant to the business, hence should be invested in and which ones are not (Najmaei, 2013). Finally, the most important function of a business model is to determine how resources should be structured and configured to perform value creating and capturing transactions in a cohesive manner (George & Bock, 2011). In other words, business models articulate the logic of the business, show the blue print of its resource configurations and elaborate

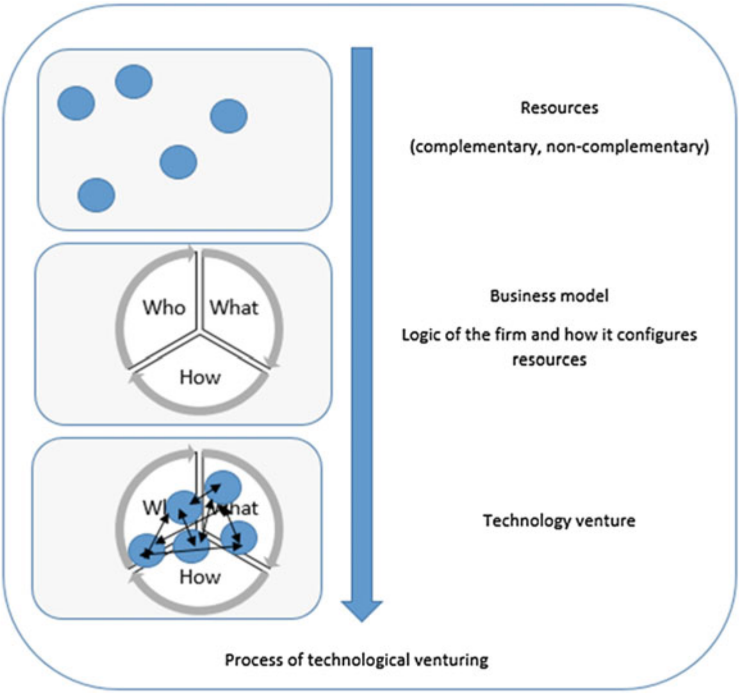

Fig. 3 Business models as the logic of resource configurations in technology ventures

formulas for creating and capturing value. As Zott, Amit, and Massa (2011) put it, business models emphasize a system-level, holistic approach to explaining how firms "do business" by seeking to explain how value is created, not just how it is captured.

Founders of technology ventures use their assumptions about who, what and how to looks for ways to develop or acquire core and complementary assets required to commercialize their technological know-how. Then using these assumptions, they bundle, link and structure resources in the form of an organization which creates and captures technology-driven value. Figure 3 depicts application of this function in the process of technology venturing.

Thus far, we established that the business model concept offers novel insights into how resources and transactions are performed in technology ventures. Before we go further to develop a more specific theory of business models for technology ventures', its seems logical to compare three endogenous views which shaped the core of this research, namely the transaction costs, resource-based or competency view and the business model view. Table 1 illustrates a summary of these three.

As depicted in Table 1, the business model view takes business model of the venture as the unit of analysis. This allows us to look at the venture as a coherent system rather than a bunch of isolated transactions or a bundle of resources in silos. Furthermore, seeing a venture as a system of activities from the lens of its business

Table 1 A comparison of three endogenous views of technology venturing

Questions	Transaction cost view	Resource-based (competency) view	Business model view
Unit of analysis	Transactions within firms and between firms and markets	Resources and capabilities	Business models
Why do technology ventures emerge?	Technology-based ventures offer more economic ways than markets to solve specific users' technological problems	Technology-based ventures can develop a unique set of resources and capabilities to tap into market niches	Technology-based ventures use novel business models which enable them to create and capture values not possible otherwise
How do technology ventures compete & grow?	Growth and competitiveness are driven by the ability to minimize costs of transactions low	Growth and competitiveness are driven by the ability to acquire, develop and configure strategic resources better than competitors	Growth and competitiveness are driven by the ability to design and constantly manage novel business models to do business in a superior way to competitors
How do technology ventures differ from non-technology ones?	Transactions are technology-driven	Resources and capabilities are technology- centered and driven	Business models are designed to make use of advanced technologies

model enables us to explore and investigate interconnections between and within value creating (i.e. design of products and services) and value capturing (i.e. profit formula and use of complementary assets such as marketing and logistics capabilities) activities.

Furthermore, although transactions and resource-based views attribute the emergence of technology ventures to the existence of ventures as an efficient governance mode to perform technology-intensive transactions and bundle of technological competencies within specific organizational structures respectively, they neglect the importance of the entrepreneurial logic which underpins the structures of resources and transactions performed through these structures. The business model view addresses these shortcomings by adding the notion of business models (i.e. sets of coherent and specific assumptions about who, what and how within a technological paradigm converted into activities carried out by resources) to the picture to clarify how resources are configured to perform various transaction.

Finally, the business model view adds to the explanations offered by the other two views about the competitiveness, growth and architecture of technology ventures. It posits that, the growth and competitiveness of technology-ventures are driven by their technology-intensive business models rather than efficient transactions and superior resource structures because without having a business model that delineates a clear logic to manage resources and perform transactions, a venture fails to create and capture value. Recent study of Gassmann, Frankenberger, and Michaela (2014) shows that ventures with strong technological capabilities but weak business models did not survive the competition Therefore, business models not only convert technologies into value-creating machines but also add technology-specific value capturing capability to them to ensure that the venture captures value to survive and grow.

3 Proposing an Architecture of the Business Model of Technology Ventures

Considering the above, this section offers an architecture of the business model concept for technology ventures. Several studies have used the notion of business models to explain how and why technology ventures differ from other ventures but layout of a general architecture for the business model of technology ventures remains to be worked out. Table 2 illustrates a summary of a selective list of research applying the concept of business model in technology ventures.

We propose that the architecture of the business model in technology ventures is what makes them different from other ventures. The main dimensions of this architecture have not been empirically explored nor have they been conceptually studied. Deriving from the literature on technology venturing and embedded in the business model literature as discussed above, we deduce four primary dimensions of the business model of technology ventures. In what follows, it will be illustrated that, business models of technology ventures have a unique orchestration of technological know-how and complementary assets resembling a nested structure with a core and a periphery. This core-periphery architecture brings about some unique capacities in the business model of technology ventures which makes them behave in different ways than other ventures.

3.1 Business Models and the Core-Periphery Imagery

The so-called core-periphery imagery has been an important conceptual tool to describe structure of different organizations including technology ventures (Hannan, Burton, & Baron, 1996). Hannan et al. (1996) argue that “a feature forms part of the organizational ‘core’ if changing it requires adjustments in most other features of the enterprise. A feature lies at the periphery if it can be changed without imposing changes on other features.” (P. 506). Fiss (2011) adds that, the core elements are essential and the peripheral elements are less important and perhaps even expendable or exchangeable.

An important aspect of the core-periphery imagery is its ability to describe an organization’s capacity to change. Hannan et al. (1996), pp. 506–507) further add that, “coreness means connectedness, elements in the core are linked in complicated

Table 2 A selective list of research using the business model concept in the context of technology ventures

Authors	Description	Key findings
Reymen, Berends, Oudehand, and Stultiëns (2016)	A qualitative study of the design of business models in four high technology ventures in Netherlands	The design of business models is a fundamental phase in technology venturing. Executives use different decision making modes to execute this phase. The effectual logic is used to generate a value proposition for a specific customer segment. Causal logic is then used to define the other business model components in relation to the value proposition and customer segment
Najmaei (2016b)	A qualitative study of the process of business model development in five high-tech ventures in the Australian cloud-computing industry	Developing a business model involves three phases. (1) business modelling ideation (BMI) in which various ideas for a viable business model are generated and the most viable one is chosen. (2) The "business modelling strategic commitment" (BMSC) in which the strategic consensus and commitment are generated and (3) the "business model actualization" (BMAC) in which the model is reified or actualized
Najmaei (2016a)	A quantitative study of 87 Australian manufacturing technology ventures	Technology ventures who adopt process modularity gain a competitive capacity to convert modular processes to innovative business model designs which in turn result in better market performance
Raphael Amit and Zott (2015)	A qualitative study of the antecedents of business model design in nine technology ventures in the USA's peer to peer lending space	Goals (in terms of both creating and capturing value) , managerial and industrial templates, stakeholder activities, and environmental constraints are four common components of a design model which explains how business models for technology ventures are designed as system of boundary-spanning activities
Doganova and Eyquem-Renault (2009)	Single case study of the role of business models in innovative activities of a technology venture	Business model is a key market device for a technology venture. In addition to its narrative role, it has a calculative device that allows entrepreneurs to explore a market and also plays a performative role by contributing to the construction of the techno-economic network of an innovation

(continued)

Table 2 (continued)

Authors	Description	Key findings
Zott and Amit (2008)	A quantitative study of the fit between the business model design and product-market strategies of 300 e-commerce ventures in the US and Europe	Novelty-centered business models, coupled with product market strategies that emphasize differentiation, cost leadership, or early market entry enhance firm performance
Zott and Amit (2007)	A quantitative study of the associations between business model design and performance of 190 technology ventures in the US and Europe	Novelty-centered business model design enhance performance. This positive relationship is stable across time, even under varying environmental regimes. Additionally, entrepreneurs' attempts to incorporate both efficiency- and novelty-centered design elements into their business models could be counterproductive
Chesbrough (2007)	Conceptual analysis of the importance of novel business models to the growth and competitiveness of technology ventures	A better business model often will beat a better idea or technology. Technology-ventures need the capacity to adopt novel business models and constantly sharpen the value creating and capturing edges of their business models
Calia, Guerrini, and Moura (2007)	A qualitative study of the role of business model in the management of the innovative network of a Brazilian Metallurgy Venture	Technology ventures use a more outward oriented R&D which is guided by their business model. Such an outside-in approach helps them manage a sequence of innovative activities which not only provide the venture with a competitive product technology, but also provided the necessary resources for the venture to reformulate its business model as markets change
Morris, Schindehutte, and Allen (2005)	A conceptual analysis of the application of the business model concept in entrepreneurial Technology venturing	A business model has three levels, the foundation level which shows what components are included in the operation of the venture. The proprietary which includes a firm-specific unique combination of these building blocks and the rules level which involves a set of operating rules which link the business models to ongoing strategic actions of the venture
Zimmerman and Zeitz (2002)	A conceptual analysis of the role of legitimacy in the growth of technology ventures and how business models enhance achievement of legitimacy	Technology ventures can use four strategies (conformance to the existing rules, selecting a favorable environment, manipulating rules in creative ways and developing new

(continued)

Table 2 (continued)

Authors	Description	Key findings
		social contexts and norms to achieve legitimacy and their business model is a core component in the successful execution of these four strategies
Chesbrough and Rosenbloom (2002)	Single case study of the role of business models in technology venturing activities of the Xerox corporation	New ventures which span off the Xerox have unique business models which enabled them to successfully commercialize their products and services because a successful business model creates a heuristic logic that connects technical potential with the realization of economic value
Amit and Zott (2001)	A qualitative study of the value-creating logic of 59 high tech ventures in the US and Europe	High-tech ventures use business models as the source of value-creating logic. Business models in e-commerce sector can have four generic design themes: novelty, efficiency, complementary and lock-in, each imposing different rules with regard to the creation of value from the technological innovation used by the venture

webs of relations with each other and with peripheral elements. Because dense webs of connections retard change, core features are more inert than peripheral ones (Hannan & Freeman, 1984).” Analogously, peripheral elements are more flexible, fluid and agile. The core-periphery view also suggests that a set of interconnected elements in a core-periphery view cannot have more than one core (Borgatti & Everett, 1999) but more than one constellation of different peripheral elements may surround the core. These permutations of peripheral elements are equally effective in the performance of the system (Fiss, 2011). All in all, a set of core factors can be used in conjunction with multiple sets of peripheral factors to create multiple flexible configurations which are different in periphery but relatively similar in core. Teece (1986) used this notion to conceptualize how technological innovations are commercialized. He proposed that technological innovations have a core technological know-how and a set of peripheral complementary assets which are tailored to make the technology fit into markets. Winter and Szulanski (2001) extended this view and added that, technology ventures may fail to replicate their core technological know-how because reproducing business models with a core and a periphery is riddled with structural challenges caused by the complex and sticky knowledge at core. In view of this, since business models encompass the structure of all resources owned and used by the firm, we propose that:

Proposition 1: Technology ventures are based on business models which have a technological core and a marketing periphery.

Proposition 2: Having a technological core and a marketing periphery gives technology ventures a degree of stiffness and rigidity at core and versatility at periphery which enables them to be flexible to tap into new markets quickly.

3.2 From Market-Driven to Market Driving Business Models

The technological core and marketing periphery implies a complementary relationship between technological and marketing knowledge base of technology ventures. Burgers, Van Den Bosch, and Volberda (2008) show that a fit between the creation of this technological and market knowledge is a fundamental challenge faced by managers of technology ventures. They further argued that, although the two types of knowledge are intertwined, their management in the wider organizational context (i.e. business mode) could substantially differ. Najmaei, Rhodes, and Lok (2014) studied this difference and found a set of complementary relationships between marketing and technological knowledge acquired by managers. They argued that differences in these relationships result in different mental models hence business model designs. More recently, Najmaei (2016a) showed that founders of technology ventures proactively seek to find and combine new marketing ideas with their technological core to commercialize their technologies in novel ways. All in all, technology ventures exhibit tendencies to use their technologies to proactively seek for new markets or develop new structures in markets by carving out niches (Jaworski, Kohli, & Sahay, 2000). These tendencies are consistent with market driving rather than market driven orientations (Kumar, Scheer, & Kotler, 2000; Mele, Pels, & Storbacka, 2015).

Market driving is a unique feature of highly innovative firms. Kumar (1997) observed that rapidly growing retailers embrace high technologies like ICT to drive markets. Technological intensiveness enables these firms to look for and even create new market space for their expansion. Further work on market driving-ness by Kumar et al. (2000) suggests that market driving companies, are generally new entrants into an industry like high tech ventures, who can gain a more sustainable competitive advantage by delivering a leap in customer value through a unique business system. Market driving strategies entail high risk, but also offer a firm the potential to revolutionize an industry and reap vast rewards (Jaworski et al., 2000) hence appealing to ventures with technological innovations.

More specifically, although all ventures need to monitor changes in the marketplace and adapt to customer needs to enhance firm performance, high tech industries necessitate firms to drive markets by choosing minimal adaptation to local market trends in favor of introducing proprietary value propositions that satisfy customers' latent needs(Ghauri, Wang, Elg, & Rosendo-Ríos, 2016; Kumar et al., 2000). Therefore, instead of reactively responding to players and following the existing structures, market driving firm influence the structure of the market and/or the

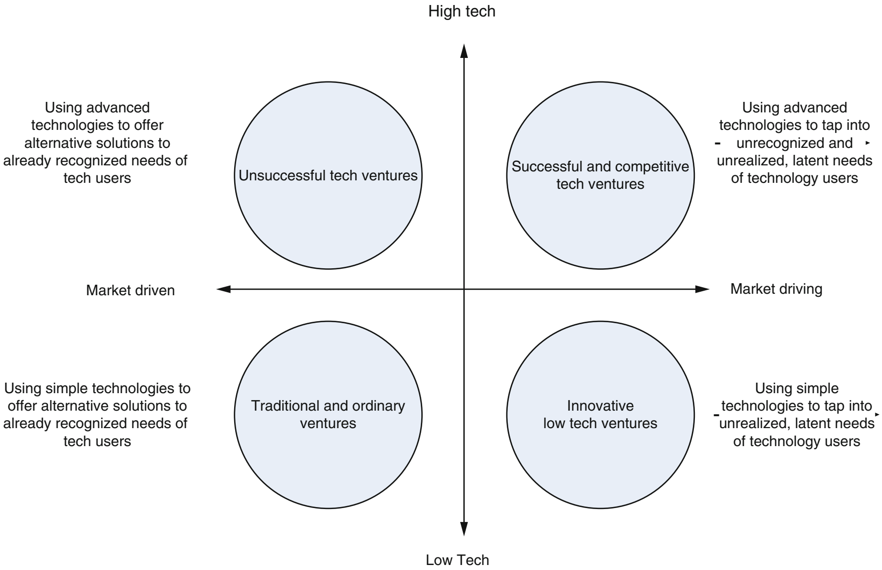

Fig. 4 Technological driven and market driving nature of the business model of technology ventures

behavior (s) of market players proactively in a direction that enhances the competitive position of the business. (Jaworski et al., 2000). Market driving-ness, hence, requires business models with the capacity to proactively search for customers' latent needs and cater for them via disruptive value offerings (i.e. revolutionary products and services). Taken together, the intersection of two forces: creative power of high-technologies and the need to be market driving creates a space for technology ventures to design their business models. This is perhaps a fundamental difference between technology ventures and other ventures (Fig. 4). The growth of disruptive ventures such as Uber, Airbnd, Menulog, and Cochlear exemplifies this fact. The following two propositions summarize this line of reasoning:

Proposition 3: The core-periphery structure of technology ventures enables them to be technology driven and market driving.

Proposition 4: The market driving business model of technology ventures makes them proactive and disruptive.

All in all, technology ventures have business models with a technological core and a marketing periphery. This core-periphery structure enables technology ventures to (1) tap into emerging markets quickly (2) proactively drive markets and (3) disrupt industries. These features distinguish technology ventures from ordinary ventures and explain how and why they make greater contributions to local and international economies. Figure 5 synthesizes these points into a simple framework.

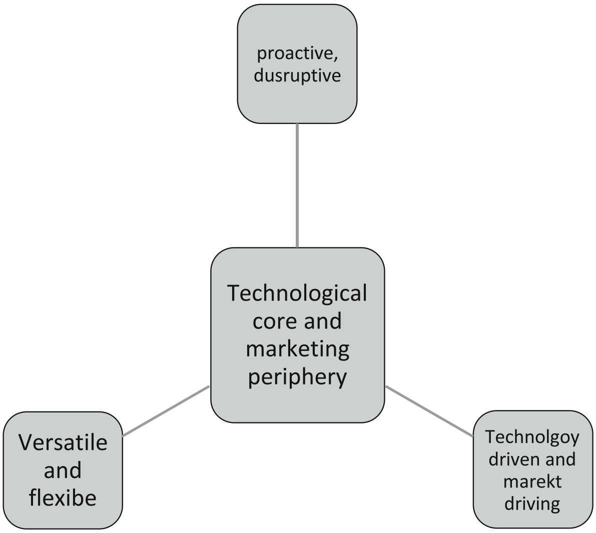

Fig. 5 Four characteristics of the architecture of the business model of technology ventures

On the ground that any theoretical deduction needs empirical support and as a step further, a preliminary empirical study was conducted to explore the extent to which these theoretical predictions hold in a sample of technology ventures. The next section reports the design and results of this study.

4 Empirical Illustrations from Three Technology Ventures

4.1 Design: Data and Sample

To substantiate the proposed framework, a qualitative hypothesis-testing approach was adopted (Hak & Dul, 2010). Unlike theory-building case studies (Eisenhardt, 1989), this qualitative approach seeks to confirm rather than explore theoretical postulations. As Hak and Dul explains, a theory-testing case study involves "the process of ascertaining whether the empirical evidence in a case or in a sample of cases either supports or does not support a given theory." (p. 937).

Five technology ventures were chosen from a sample of technology ventures based in Sydney Australia. Founders of the ventures were contacted and asked to participate in a short interview about their ventures, business models and technological and marketing capabilities. Five entrepreneurs from three ventures (one pharmaceutical, one cloud computing processing and one biotechnology) agreed to participate in the research and consented to interviews. Interviews were scheduled in September, October and November 2016. Each interview was tape recorded and transcribed for analysis. Descriptions of interviews are given in Table 3.

Table 3 Types and mode of data collection

	Pharmaceutical venture	Cloud computing venture	Biotechnology venture
Interview 1	• 25 min • Face to face • 3 pages of transcript		
Interview 2		• 15 min • Face to face • 3 pages of transcript	
Interview 3		• 18 min • Phone interview • 3.5 pages of transcript	
Interview 4			• 12 min • Skype • 2.5 pages of transcript
Interview 5			• 20 min • Face to face • 4 pages of transcript

Table 4 Content analysis if interviews regarding theoretical propositions

	Proposition 1	Proposition 2	Proposition 3	Proposition 4
Interview 1	3	3	3	2
Interview 2	2	2	2	2
Interview 3	3	2	2	2
Interview 4	2	2	2	3
Interview 5	3	2	3	3

4.2 Analysis and Results

Since the purpose of the empirical part of this research is to explore if four theoretical propositions can be validated in a sample of technology ventures, a content analytic approach was used in which the content of interviews was analyzed for conforming or disconfirming evidence (Hak & Dul, 2010; Hillebrand, Kok, & Biemans, 2001). All four propositions received considerable support. The number of confirming statements for each proposition was counted (Table 4) and mapped (Fig. 6) to graphically visualize how different venture founders see their business model and venture as theoretically proposed in this research.

Finally, to better illustrate evidence gathered to validate our theoretical propositions, a set of support and proof quotes from interviews was selected to demonstrate how each proposition is supported by at least two statements from executives of technology ventures. Table 5 illustrates these quotes.

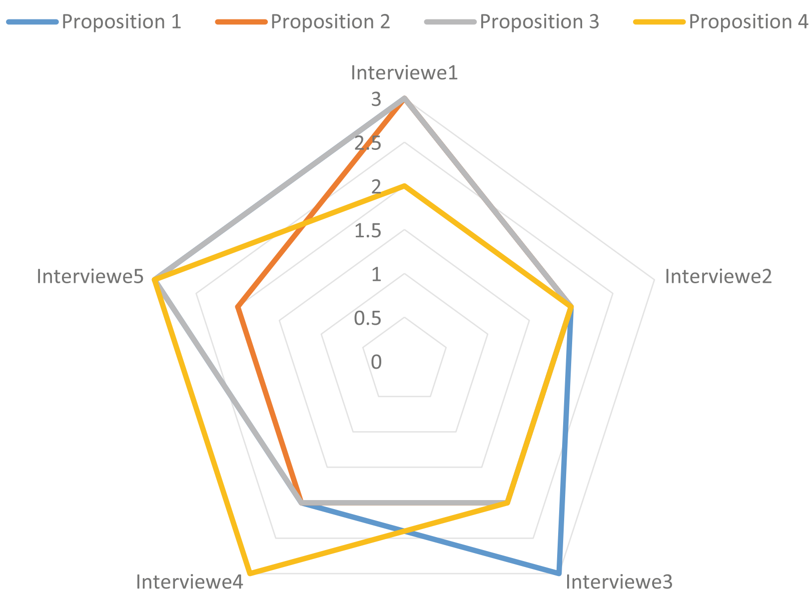

Fig. 6 Visualization of the content analysis of interviews

Table 5 Support and proof quotes for theoretical propositions

	Support quote	Proof quote
P 1	"Our business is based on a unique proprietary tool which can be used ibn different ways depending on what our clients want" (Interviewee 1)	"It is our core technology which drives our business. It is basically our only source of revenue" (Interviewee 4)
P 2	"Using our technology and marketing potential of our business we have constantly sought for emerging markets domestically and internationally" (Interviewee 5)	"Our business has used its core technology to create a wide range of solutions for diverse clients in different markets" (Interviewee 2)
P 3	"Since we started this business, we have, pretty much, defined our markets. It is the uniqueness of our technology that let us create markets for our products" (Interviewee 3)	"Our business model is like our motto to be the frontrunner in this emerging industry. Our core knowledge makes us a pioneering venture with a potential to shape future markets" (Interviewee 1)
P 4	"Our business is to discontinue old technologies and help the industry to transit to the way we do the business" (Interviewee 2)	"Traditional IT is becoming increasingly obsolete but business models like ours. By very nature of our technology we disrupt markets while generating new ones" (Interviewee 3)

5 Discussion and Conclusion

Technology ventures are expected to run different modes of value creation and capture from other ventures. Building on this premise, it was argued that business models of technology ventures is different from that of other ventures in that they have a technological core which determines the operational scope of the venture and a flexible marketing periphery which enables the venture to tap into multiple markets. Furthermore, the core-periphery architecture enables these business models to be proactively market driving and disruptive.

To substantiate these theoretical deductions, we case studied three ventures and found supportive evidence for this theorization. We believe, the core-periphery imagery is a useful conceptual tool to develop this theoretical perspective. In fact, "cognitive researchers have argued that the human mind's ability to classify is better understood in terms of a conceptual structure consisting of core and peripheral categories" (Fiss, 2011, p. 397). Thus, the proposed view is expected to help readers of this work, in both academic and business worlds, better classify ventures into high and low tech and distinguish high-tech ventures by their technological core and marketing periphery. As such, our approach is a theoretically different and somewhat novel way to speculate about, explain and observe the behavioral dynamics of technology ventures. In this way, this view extends previous work on the applications of core-periphery imagery in technology ventures. Importantly, our model adds to the insights developed by Fiss (2011) who showed that technology ventures have a strategic core and tactical periphery which enable them to adopt different strategic paths some of which lead to high performance while others result in poor performance and Hannan et al. (1996) who attributed the inertia of technology ventures to the imprinting process in which founders' models of the employment relation affect the core of the firm hence limiting its capacity to change. Additionally, although technological ventures are usually thought of as engines of economic growth and drivers of new markets (Jaworski et al., 2000; Kumar et al., 2000), factors behind this orientation is less understood. Our model proposes the architecture of their business models as a plausible force behind market driving-ness of ventures, hence shedding new light of the theory of market driving firms (Mele et al., 2015).

Finally, our model has several implications for practicing managers. First, an overemphasis on the technological core could have detrimental effects on the venture's capacity to grow and adapt because the technological core is relatively rigid and difficult to change whereas the marketing periphery is a key complementary component of a venture's business model necessary for its commercialization (Teece, 1986, 2006). This component is also flexible, making the business model adaptive and resilient. The way Uber is using its technology to deliver foods (via the Uber food model) in addition to its usual passenger-transporting model is an example of how a balanced emphasis on both the technological core and marketing periphery enables technology ventures to tap into multiple markets.

Secondly, technology ventures are market driving. Executives can harness the power of market driving-ness in multiple ways. As outlined by Jaworski et al. (2000)

technology ventures can either eliminate traditional players in a market like Uber and taxi driving industry or build a new or modified set of players in a market like the collaborations between multiple biotechnology firm or syndications of nanotechnology firms and bio technology firms to create injectable nanomachines to cure diseases or attack cancerous tumors or change the functions performed by traditional players as in the case of Airbnb and the hotel industry and the Cochlear and traditional hearing aid devices. To perform these strategies, we echo Kumar et al. (2000) who encourage executives of technology ventures to be forward sensing to detect new markets and constantly try to explore new applications of their core technologies.

5.1 Moving Forward

Although, the model presented in this chapter sheds new light on the nature and anatomy of technology ventures form the business model vantage point, much more research is needed to fully validate and extend the business modelling view of technology ventures. As noted by Borgatti and Everett (1999) "any formalization of an intuitive concept needs to identify, in a precise way, the essential features of a particular concept." (p. 376). In this sprit, one way to move forward is to develop more precise explanations for the nature of core-periphery relationships which define technology ventures. The case study methodology has a long tradition of enabling scholars to explore complex and dynamic relationships within organization (Eisenhardt, 1989; Eisenhardt & Graebner, 2007). Therefore, more focused case studies on the business models of technology ventures aimed at exploring dynamics of relationships between their technological cores and marketing peripheries seem to be a promising direction to advance this line of thinking.

In addition, although much is known about key characteristics of technology ventures (e.g. Byers et al., 2011; Li & Atuahene-Gima, 2001; Roure & Maidique, 1986; Zahra, 1996; Zhang et al., 2011) and their business models (e.g. Chesbrough & Rosenbloom, 2002; Zimmerman & Zeitz, 2002; Zott & Amit, 2008), relatively little work has been done on typologies or configurations of factors which shape business models of technology ventures. Fuzzy Set Qualitative Comparative Methods (FSQCM) represent a promising direction to advance this line of thinking because they help researchers develop better configurational and typological organizational theories (Fiss, 2011).

Finally, although it was not the initial objective of the paper, but we documented some preliminary empirical support for our theoretical predictions and propositions. This is by no means a definitive proof for our theoretical model. More confirmatory and perhaps replicating qualitative work is necessary to confidently establish the empirical accuracy and consistency of our work. Such work should provide a more detailed analysis of the core-periphery architecture from a broader range of cases across industries and contexts (Pratt, 2009).

5.2 Concluding Remarks

The question of what technology venture are and how and why they differ from other ventures is multifaceted, encompassing a wide range of theoretical perspectives generally stemming from the theory of the firm. However, there is by no means a singular, unified normative articulation of the essence and nature of technology ventures. This chapter pushed for a systematic, integrative and comparative approach that recognizes the unique role of technology-based business models in the anatomy and architecture of technology ventures. It argued that the business model concept is a useful theoretical means to generate integrative theories which enrich our understanding of technology venturing. While this approach is promising, it is only a starting point toward more complete theories of technology ventures. Hence many important questions remain and thus there is much work yet to be done to fully understand technology ventures and their business models. It is hoped that, the ideas presented here encourage scholars and practitioners to continue this line and add to a cumulative body of knowledge on the design and architecture of business models in technology ventures.

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The Role of Business Models in the Development of New Technology-Based Firms

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Abstract In the process of development of new technology-based firms (NTBFs), the crucial role belongs to establishing an effective and efficient business model to deploy the focal technology in a sustainable way. As such, it becomes clear that the business model design and testing/validation become the essential parts of a startup process; yet, so far, the topic of the business model in the context of NTBFs has received insufficient attention in the literature. Drawing on the basic theoretical and empirical insights from entrepreneurship and strategy research, this chapter scrutinizes the topic of the ontological nature of a firm's business model within the NTBF context, and its relatedness and distinction from strategy, technology, and innovation. From definitional issues, we proceed to discussing the role of the business model in the process of development of NTBFs. Then, we summarize the available empirical material to formulate the most frequently occurring problems with new ventures' business models that prevent their development, paying particular attention to ways of preventing and dealing with such problems. The developed conceptual framework of business model-related NTBF challenges is illustrated and corroborated with the mini-cases of technology ventures.

Keywords Business model · Key customer · Business model innovation · Technology-based firms · Business value · Customer value · Value matrix · Efficiency · Effectiveness

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1 Introduction

The construct of a business model has recently gained substantive attention in management literature and practice (Al-Debei & Avison, 2010; DaSilva & Trkman, 2014; Foss & Saebi, 2016; Massa, Tucci, & Afuah, 2016; Morris, Schindehutte, & Allen, 2005; Zott, Amit, & Massa, 2011). In its essence, a firm's business model is a system of organizational routines for creating economic value for the firm's stakeholders and capturing a part of this value for the firm itself and its shareholders (Osiyevskyy & Dewald, 2015a; Osiyevskyy & Zargarzadeh, 2015). In a narrower sense, a business model determines how the enterprise creates and delivers value to customers and then converts payments received into profits (Osterwalder & Pigneur, 2009). However, the customers and investors are not the only significant constituents of a business model. The recent managerial thinking stresses the crucial role of internal (e.g., employees) and external stakeholders (e.g., partners), particularly in creating the customer value. For example, Gassmann, Frankenberger, and Csik (2014) point out that "in addition to customers, other important actors such as suppliers, distributors, solution providers, or those participating indirectly such as researchers, consultants or associations, contribute in some significant way to creating value for customers. Such partners can inspire new ideas in much the same way as customers can, and may also be frequently instrumental in actually realising new concepts" (p. 121).

In other words, a business model refers to what the company offers, to whom it is offered, and how it can accomplish its goals on a routine basis. The business model is hence a predominantly internally looking construct (Massa et al., 2016), analytically independent of competitors and the current state of the market, which is where strategy comes in (Norén & Wang, 2010). The business strategy, on the other hand, describes how the company will engage with competitors, identify and segment customers, and respond to the market environment (Norén & Wang, 2010). The business strategy focused on creating and sustaining the competitive advantage determines the profit potential, yet this potential gets implemented through a properly established business model (Biloshapka, Osiyevskyy, & Meyer, 2016). A business model in itself can become a capability underpinning the firm's competitive advantage (Casadesus-Masanell & Ricart, 2010; Markides & Charitou, 2004), provided that a set of conditions are met (e.g., the VRIN framework of Barney, 1991). Thus, a company's strategy and business model are distinct yet obviously related constructs (Massa et al., 2016), each determining the ultimate financial performance through setting its potential (strategy) and realizing it with different degrees of effectiveness and efficiency (business model). In addition, the strategies of new technology-based firms set up their dynamic capabilities, determining by this means the dynamic boundaries for their business models; then, the companies implement their business models in the market (DaSilva & Trkman, 2014). Finally, the ability to scale up and/or internationalize a new venture has been shown to be determined predominantly by the characteristics of its business model (Hennart, 2014; Osiyevskyy, Troshkova, & Bao, 2018; Verbeke, Zargarzadeh, & Osiyevskyy, 2014).

Therefore, similarly to other enterprises in the market economy, in the process of development of new technology-based firms (NTBFs), the crucial role belongs to establishing an effective and efficient business model to deploy the focal technology in a sustainable way. As such, it becomes clear that the business model design and testing/validation become the essential parts of a startup process; yet, so far, the topic of the business model in the context of NTBFs has received insufficient attention in the literature—with the notable exception of Osterwalder and Pigneur (2009). To address this gap, drawing on the basic theoretical and empirical insights from entrepreneurship and strategy research, we discuss the nature of a business model construct and the developmental processes of business models' emergence in new ventures and startups. For the technology ventures research, we intend to provide essential insights regarding the role of firms' business models for securing Schumpeterian rents. Then, we will provide a summary of the available empirical material to formulate the most frequently occurring problems with new ventures' business models that prevent their development, paying particular attention to ways of preventing and dealing with such problems. The developed conceptual framework of business model-related NTBF challenges will be illustrated and corroborated with the mini-cases of technology ventures.

2 Business Models in New Technology Ventures

The essential characteristic of all technology ventures (either NTBFs or corporate ventures) is the primary focus on technological innovation. The key goal of a firm organized around an innovation is to find the right business model and, most importantly, the architecture of the revenue to capture value from that novelty (Teece, 2010; Zott et al., 2011). Hence, the role of a business model in profiting from an innovation is to ensure that the technological core of the innovation is embodied in an economically viable enterprise (Chesbrough & Rosenbloom, 2002). Firms can capture the value from a new technology in two basic ways: through incorporating it into their current business model, or through launching new ventures that exploit the technology in new business arenas (Chesbrough & Rosenbloom, 2002). A successful business model unlocks latent value from a technology, but constrains the following search for new, alternative models for other technologies later: consider, e.g., the rigidity problem of the established Xerox Corporation (Chesbrough & Rosenbloom, 2002) or General Electric before Jack Welch (Welch & Byrne, 2003).

Now, when we understand the primary role of a business model in NTBF development, it becomes clear that the business model design (Amit & Zott, 2015) and test/validation become the essential part of the startup process. Ultimately, the value of a new venture stems from a well-developed and validated business model, executed by a suitable founding team. A new venture's raison d'être is in offering a unique customer value proposition (or, more broadly, the value proposition to all key stakeholders), and then delivering on this promise. Only a differentiated, technologically feasible, and economically viable offer will allow the new player to take part in the race on a par with the leaders.

From a design perspective, a new venture's business model is composed of three inter-related dimensions (George & Bock, 2011; Osiyevskyy & Dewald, 2015b): the value dimension (value proposition to key stakeholders); the transactive dimension (system of activities); and the resource dimension (approach to resource orchestration). To create a successful business model for a new technology-based firm, it is critically important to interlock the value of the product, market reaction, and capabilities of the company not only in the close, but in the future perspective.

Despite all the turbulence in today's business environment, the traditional understanding of a firm's strategy to achieve above-average returns remains unchanged: selecting target a market, defining products, services, and branding tactics to differentiate from competitors, with the ultimate goal of creating a clear and compelling customer value proposition. However, it is the business model that allows the firm to capitalize on that strategy. The business model is where the rubber hits the road and a strategy is transformed into revenue, operating profit, and ultimately customer and shareholder satisfaction.

3 Business Models: The Effectiveness/Efficiency Characteristics

The two key dimensions that describe how well a business model functions are customer value (effectiveness) and business value (efficiency) (Biloshapka et al., 2016). The 'customer value' dimension reflects the utilitarian views of the customers ('does the company actually deliver what is important for me?')—driven by an objectively attractive value proposition and full subjective appreciation of the benefits. The 'business value' dimension reflects the potential profitability of the business model, allowing the owners to benefit from the fair, above-the-average profit streams derived from delivery on the promise of the customer value proposition. The innovator trying to design a business model must also realize that the answers to the efficiency/effectiveness questions—how much business value and how much customer value is in the business model—are not always correlated. A firm can have a great customer value proposition that simply makes no money—an effective yet not efficient state. Conversely, it can squeeze profits from customers for only so long until they realize they are being used—an efficient but not effective state.

Juxtaposing these two dimensions yields the Value Matrix: a practical tool for diagnosing the current state of the affairs in the firm's business model (see Fig. 1).

The Loser quadrant includes the business models of those firms that fail to deliver either customer or business value; they create neither happy customers nor sufficient ROI. *The Taker quadrant* includes the business models of the companies that are hanging on to their prominent, profitable market position without actually providing

Customer value			
	High	**Giver** *(established customer value yet failing in translation to business value)*	**Winner** *(the aspired situation)*
	Low	**Loser** *(failing in both)*	**Taker** *(high business value yet short-changing customer value)*
		Low	**High**
		Business value	

Fig. 1 Business model value matrix. Source: adapted from: Biloshapka et al. (2016)

or securing outstanding customer value, thanks to their high brand value, reputation based on past successes, or prohibitively expensive customer switching costs. This is a fragile position, likely leading to the Loser situation. Only market anomalies, such as a government-secured monopoly or other market distortion can allow a company to maintain this position profitably enough. The companies in the *Giver quadrant* appear to give more than they get, having a few happy customers but (usually) unhappy shareholders. Although their business models excel in customer value, the lack of adequate mechanisms for building business value prevents them from securing a fair share of the created value for the owners. The usual problem for Givers is failing to evaluate and charge for the true cost of delivery on their promises, resulting in costs exceeding the revenues, or simply low-quality delivery. Finally, the optimal and sustainable quadrant to be in is *Winners*, comprising the companies with high customer value—which results from addressing their customers' most important preferences—coupled with well-accepted and highly profitable delivery. Without deliberate efforts, no company can stay in the Winners quadrant forever, and a series of mistakes in terms of customer or business value can lead to slipping toward the Taker or Giver quadrants.

4 Business Model Evolution: Escaping the 'Giver Trap'

Hence, a firm's business model as a routinized pattern of activity of value creation and appropriation is not static, and as such must be viewed from the dynamic, transformational view of the business model evolution (Demil & Lecocq, 2010). In line with this reasoning, Osiyevskyy and Zargarzadeh (2015) conceptualized business model change as any alteration of the existing business model of a firm, either radical (major shift in one or more dimensions of a business model), or incremental (progressive refinement of individual components). In terms of novelty, the general business model change concept includes both business model innovations ("new to the world" changes introduced in the industry for the first time) and imitative business model changes ("new to the firm" changes that copy approaches of competitors or firms from other industries). Business model innovations can be introduced in industries by entrepreneurial newcomers [either startups (Christensen, 1997) or diversifying entrants from adjacent industries (Tripsas, 1997)], or by entrepreneurial established players (Schumpeter, 1943). If the introduced business model innovation proves its potential, the remaining incumbents often learn about this, and respond by imitating and copying it (Casadesus-Masanell & Zhu, 2013). A useful classification of business model innovations was proposed by Giesen, Berman, Bell, and Blitz (2007), distinguishing among *enterprise model innovations* (changing the role of a firm in the industry value chain), *industry model innovations* (redefining the industry boundaries), and *revenue model innovations* (transforming product/service offering and pricing).

With an evolving business model, a company's position within the Value Matrix (Fig. 1) also changes with time (Biloshapka et al., 2016). After the initial stage, once the first customers are acquired and the first sales made, most technology ventures establish a business model of the Giver type—delivering the customer value at the expense of business value. This is a reasonable transitionary position, with the emphasis on gaining a customer base and a corresponding market share at the expense of profit. Yet, the first major obstacle such companies encounter is the need to eventually deliver on the business value, or monetize their business model. Unfortunately, escaping the "Give trap" does not happen automatically or smoothly, as illustrated by numerous cases of great companies with millions of happy customers yet zero or negative financial results (consider, e.g., WhatsApp or Viber).

5 NTBFs: Typical Business Model Problems

In this section, we discuss the particular business model-related challenges of technology new ventures, illustrating and corroborating them with the mini-cases of real companies. In its essence, moving from the Giver to Winner state requires the major improvement of the efficiency of a business model, or its ability to create business value without compromising the already superior customer value. The business value consists of two tightly coupled components: (a) delivery: quality of fulfilling the promise of the value proposition to the primary customer; (b) monetization: ability to charge customers a fair price, resulting in ultimate profit from the business model. The monetization component reflects the value appropriation function of a business model traditionally discussed in the academic literature (Zott et al., 2011). Yet, we argue that to fully explain the business value, the value appropriation (monetization) mechanism must be supplemented with its antecedent, high-quality value delivery, as without delivery no value appropriation can be performed in a sustainable manner. Similarly, the monetization is tightly linked back to value delivery in a feedback loop, in that without the economic incentives the value delivery process cannot be sustained for a long time.

In what will follow, we will demonstrate the typical problems with improving the delivery/monetization processes (problems 1–4 below) and preserving simultaneously the sufficient level of customer value (problems 5–6 below).

The current paper is grounded in the empirical results of an ongoing longitudinal study (undertaken by the authors' team in the U.S., Canada, and Eastern Europe) aimed at exploring the structure, characteristics, evolution, and performance outcomes of organizational business models.

The research project comprises three major parts: (1) the quantitative study of diverse business models of a large number of established organizations (over 500 companies in the U.S. and Canada, in the sectors of real estate brokerage, higher education and banking); (2) the qualitative, longitudinal in-depth study of a small number of large corporations (in the U.S. and Eastern Europe—in industrial equipment, computer solutions, consumer products (food, alcoholic beverages), consumer electronics, pharmaceutical and business services industries); (3) the longitudinal in-depth study of a large number of startups (over 200, broad spectrum of industries) coming through a venture incubator in one of the major universities in Massachusetts. The employed data collection techniques are: survey (for part 1), interviews with top managers and owners (for parts 2, 3), and secondary data and archival analysis (for all parts). Although we arrived at the conclusions reported in this paper on the basis of analysis of empirical data from our sample, the focal problematic issues will be illustrated using the cases of prominent, well-known technology companies.

5.1 Problem 1: Low Value Recognition from the Customer Side

This problem implies the situation when a new technology-based firm has a value proposition that is objectively superior to that of the competitor, but the customers choose the competitor, usually because of the inability to signal the high quality of the startup's offer. This situation is frequently observed when the competitor enjoys a loyal customer base, or when the company's efforts to give customer information about its proposal are ineffective, being presented in the wrong way. For NTBFs, this is usually the problem in communications: the subjective customers' value (in their view) does not correspond to the objective value offered by the firm. This problem is particularly salient for the 'experience' products/services (such as healthcare), when their characteristics (quality dimensions and price) are hard to observe in advance; instead, they can be properly evaluated only after consumption. Even worse is the situation with the 'post-experience' goods/services (such as vitamin supplements), which cannot be properly evaluated by consumers even after consumption. For experience and post-experience goods, the producer's reputation becomes a disproportionally important aspect of the business model (Ma & Osiyevskyy, 2017), creating the inertia preventing the consumers from trying the alternative, objectively superior offerings from startups. In such cases, new ventures' failure to convey their true value (signal high quality) leaves the objectively superior companies behind their inferior peers with better communication strategies or more established reputations.

An illustrative case of a new technology-based firm struggling to convey the objectively superior value proposition to its potential customers is the 11-year struggle of Be Inc. Founded in 1990 by Jean-Louis Gassée, a former Apple executive, and supported by the capital of the legendary computer scientist and entrepreneur Seymour Cray, the company intended to develop a revolutionary new operating system to be used by majority of personal computer users, outcompeting dominant at that time Classic Mac OS and Microsoft Windows. In 1991, the first release of BeOS became available, and the system achieved the initial aspirations of being technically superior to alternatives. It could reasonably appeal to the mass market, being optimized for digital media through taking advantage of top features of that time's computer hardware facilities (symmetric multiprocessing, multithreading, preemptive multitasking, and a 64-bit journaling file system able to handle file sizes up to 1 TB—all not available for the users of dominant alternatives at that time). The operating system's graphic user interphase (GUI) was based on the principles of clarity and uncluttered design, superior to that of Classic Mac OS or Windows. Although initial run on proprietary hardware (BeBox personal computer), BeOS was later adapted to run on Apple Computer's Power Macs, and then on Intel x86 architecture, by this means becoming a direct competitor to the two dominant personal computer operating systems at that time. The evidence for the technical superiority of BeOS is that around 1994 Gil Amelio (at that time CEO of Apple) made three offers to purchase Be Inc. to use BeOS on Mac computers. Also, when in 1996 Apple was selecting a new operating system to replace the Classic Mac OS, BeOS was a forerunner along with NeXTSTEP, but because of the influence of the latter's owner (Steve Jobs), BeOS lost that particular competition.

In the late 1990s Be Inc. was able to create and sustain a niche of enthusiastic followers. Yet, the reputation and customer loyalty of Microsoft and Apple, coupled with the customers' perceived switching costs (actually quite low because of the ability to run Mac OS and Windows software on BeOS, but subjectively perceived as high) ultimately prevented BeOS from securing a significant share in the operating systems market. As a result, the company never achieved commercial viability, and was sold in 2011 to Palm, Inc. for $11 million, a fraction of the company's evaluation at the peak of its development.

To avoid Be Inc.'s mistake, new technology-based companies must make conveying the high objective customer value their strategic priority, at the heart of the firm's marketing efforts. In other words, the superiority of the firm's value proposition has to emerge clearly in the customers' minds. Moreover, considering limited marketing budgets (Giver business models do not generate sufficient cash flow on their own), the question of properly targeting the customer acquisition efforts becomes crucial: i.e., the company must invest in acquiring only the targeted, high profit potential customers.

To illustrate a success story of conveying the objectively high value proposition of an ‘experience’ service, let us discuss the case of TaKaDu (based in Israel)—a leading software provider of Integrated Event Management solutions for the water sector, empowering utilities to manage their networks efficiently. Based on big data analytics, TaKaDu’s cloud-based solution enables water utilities to analyze and manage the full life-cycle of network events, such as leaks, bursts, water pressure issues, water quality, and faulty assets. Using raw data from multiple sources, TaKaDu helps utilities detect problems (events) early, reduce water loss, shorten repair cycles, and improve customer service. The technology offers in-depth visibility and quick insights into every type of event, facilitating smarter decisions.

The company was founded in 2009 by Amir Peleg, an entrepreneur with a passion for data analytics. The team worked on the software but needed data to create and test its algorithms. With the help of friends and colleagues, Peleg connected with several water utilities. Some of them were dismissive of the software’s efficacy, but others were intrigued and open-minded, so Peleg managed to obtain historical data on water flow, pressure, and other data points.

While the team was working with data and gathering new information from cooperation with water companies, Peleg was demonstrating the progress of the firm via presentations of progress carried out every few months. The main task of the CEO was to ensure that TaKaDu’s potential clients saw the benefits of working with the company. The team spent a lot of time with water companies, together doing important cases for them and showing how they care about their customer’s success. Thus, TaKaDu was able to convince these utilities of the potential value of its approach—a critical step in the firm’s business model. Once operational, the solution was piloted by two utilities on real-time data.

Now TaKaDu’s patented solution is deployed in leading utilities worldwide, including Australia, South America, the Middle East, and Europe. Its innovative approach has earned notable commendations, for example the World Economic Forum Tech-Pioneer Award and a Harvard Business School case study.

5.2 *Problem 2: Delivery Failure*

This typical situation embraces a broad scope of contexts when a startup fails to fulfill promises given to its key customers and, if so, to its investors. This can be related to financial promises, implementation of tasks in promised time, sales promises, etc.

This issue can be illustrated by Tesla Motors, creating a business model where it produces electric cars and provides all the services associated with them. While many car manufacturers have already delegated maintenance services to other companies, Tesla Motors wants to play a major role in every stage of the product life cycle, such as acting as a constant fuel supplier. However, it is impossible to provide such services all over the world at once. To fully satisfy the consumer, it is necessary not only to build a network of charging stations but also make them at comfortable locations for all. Two hundred and fifty nine charging stations in the US translates into about five stations for one state, so many customers must travel to other cities to recharge the car. Thus, the present-day company's resources do not allow the company to fulfill the promise, which in turn leads to loss of profits.

When that happens, the management must first analyze the reasons for delivery failure. What promises did the company fail to deliver? What is the size of failure? What are the factors that affected it? What actions are needed to prevent failure in the future? How can the situation be changed as quickly as possible? Which resources are needed to achieve a positive result? Lastly, what can be learned from the mistakes, to avoid them in the future?

The recommendation for NTBFs is simple: Every promise that a company makes must be reconciled from the position of the firm's capabilities, the market situation, and the demands of customers and stakeholders. To fulfill the promises, the founding team must make sure that they have everything needed (resources, permissions, confirmation of usefulness, etc.) at market entry. Moreover, they should not be afraid to admit failure when it emerges, as this allows redirecting the venture's potential for a useful purpose.

Another crucial factor of successful value delivery is employee engagement and inspiration. Employee engagement results in a substantive increase in productivity at the level of an individual and a high-performing team, while employee inspiration creates a positive externality when "engagement goes viral" and high-performing members through their passion and successful actions inspire others to engage and increase their productivity (Mankins & Garton, 2017), which all results in dramatic improvement of the quality of actual value delivery.

Employee engagement and inspiration to achieve value delivery hinges upon the proper balance of employee autonomy and responsibility (Mankins & Garton, 2017). In technological companies, delivery failure usually happens because of the wrong decision-making hierarchy, when the employees responsible for delivering the customer value do not have the necessary authority to do so (e.g., the decision-making hierarchy is too centralized and slow). For example, a major manufacturing company in Eastern Europe promised its clients a major freedom with customizing the orders, yet was not giving its own regional field officers the necessary decision-making authority to fulfill this promise. To deal with this problem, the crucial thing is fixing the organizational design to empower the employees to deliver on customer value promises, by eliminating the shortage in authority and span of control. Obviously, the authority has to be matched with responsibility for delivering the results, in terms of ensuring the creation of business value.

5.3 Problem 3: Monetization Failure

This generic situation implies the context when a technology firm offers a great value proposition for customers but suffers losses or has no income (small income) because of the inability to monetize it. To illustrate the case, consider the case of

Viber, a popular voice over Internet protocol (VOIP) application that is used by 360 million users in 193 countries worldwide. One of the reasons behind Viber's popularity lies in its mandate to never charge for its software, never display any ads, and never charge for Viber-to-Viber calls or text messages.

Is Viber Profitable? The short answer to this question is "no." Although having been around for nearly 5 years and boasting 249 million monthly average users, Viber still has yet to make a dime. In 2013, the company was acquired by the Japanese Internet giant, Rakuten, for $900 million as part of their global Internet services takeover strategy (Rakuten holds notable stakes in other social media services such as Pinterest and the failed Kindle-esque app, Kobo). On the day the sale was announced, Rakuten's shares plummeted by 9.5%, the most in 4 years, as shareholders assumed this was just another folly in a series of blunders committed by a management whose lavish spending was depleting the company's financial resources.

This bearish sentiment was not without support, as official documents from Rakuten showed that Viber made a total of $1.5 million dollars in revenue and incurred net losses of $29.5 million in 2013 and $14.7 million in 2012. While Viber's strict adherence to keeping the app free of advertisements and free to download is laudable, it is quite obvious that its current monetization model is woefully inadequate and requires a revamp, if Rakuten is to justify its $3.61 per-user investment. For now, based on official promo materials, Viber's website, and third-party sources, we can infer that Viber makes its money through the following channels: Viber Out, Viber Stickers, Viber games, and potentially from a 2013 soft launch of international call "termination" services (the current status of which is unknown). As of today, Viber has yet to make a profit.

Consider this against Facebook's case. When the company filed for an IPO in February 2012, expectations were extremely high. The social network had amassed 845 million users in 2011 and its revenue was growing to nearly $4 billion. Priced at $38 a share, Facebook was predicted to raise $16 billion, making it the largest technology IPO in U.S. history. Yet Facebook's key monetization mechanism—its advertising business—also came under fire. Days before Facebook's public debut, General Motors, the third largest online advertiser in the U.S., stopped its paid advertising on the social network. Executives at GM claimed advertising on Facebook had little impact on their consumers' car purchase decisions and did not feel the $10 million they spent the year prior was worth the investment. As the IPO loomed, some investors expressed concern that Facebook's advertising growth wouldn't keep pace with the growth of mobile users.

On May 18 2012, Facebook's public trading did not go as well as planned. Right from the outset, technical glitches with the Nasdaq exchange delayed orders almost 30 min. Then after jumping 13%, Facebook's stock struggled to stay above the IPO price, closing at only $0.23 above its original value. The opening day performance was largely considered a disappointment. Facebook shares continued to drop over the next few months, tumbling to as low as $17.73 in September.

Yet, Facebook was able to persuade its investors in the new opportunities for the company to leverage its wealth of data, connections to mobile apps developers, and improved search capabilities. As a result, Facebook's stock had recovered and rose to $61 per share by the end of January 2014.

On a strategic level, the monetization failure is caused by the inability to appropriate the rents: the margins go to resource providers (Porter's supplier bargaining power threat) or buyers, who enjoy economically unjustified low prices. The root cause of such a state is the absence of *real* competitive advantage, i.e., the differentiation in value creation that would secure sufficient market power.

Yet, competitive advantage is not enough to successfully monetize a business model; in addition, the startup has to develop a viable profit formula (assets and fixed cost structure, and the necessary margins and velocity: Christensen, Bartman, & Van Bever, 2016). Finally, once a Winner business model is established, companies can still fall back into the Giver state because of the failure to understand and manage the growth drivers (Treacy & Sims, 2004).

Hence, NTBFs have to nurture their real competitive advantage through going back to the basics of a successful strategy: (i) proper selection of the target market (to gain a temporary monopoly), (ii) developing and sustaining valuable, rare, inimitable, and non-substitutable resources (Barney, 1991), and constantly innovating (Teece, 2007). This competitive advantage becomes the basis for creating the business value through profit—real or potential. In addition, the secured competitive advantage must be leveraged by developing and implementing a viable profit formula within the business model and instituting the mechanisms for managing future growth.

5.4 Problem 4: Failing to Scale Up the Successfully Validated Business Model

The symptom of this challenge is the following: the business model of the technological venture is successful, but when attempting to expand the business (new store, market or country) using the business model successfully validated on a small scale, it loses its effectiveness and/or efficiency. Not all business models are inherently scalable, and the main task of the firm in that situation is to understand how to transfer a validated business into the new contexts.

Quirky manifested this problem. Launched in 2009 by Ben Kaufman, the start-up pledged to help regular people turn their ideas into real products and sell them in stores nationwide. Initially, the company looked like it would be a big success. The founder grew his company to 300 employees and raised $185 million in venture capital. Quirky created hit products, such as a power cord that could pivot or a stem that lets customers have fresh aerosoled juice to spritz up the food avoiding cutting process, and a few members of its inventor community earned hundreds of thousands of dollars in royalties (see Table 1).

Yet, the successful business model did not scale. At the end of 2014, the New York City start-up had laid off more than 20% of its staff, burned through

Table 1 Quirky's successful products

Product	Units sold	Inventor earnings
Aros—smart air conditioner. It can be controlled from your smartphone and learns your habits, knowing when you typically leave and return to your home	1762	$360,903
Cordies—a paperweight for cables that keeps them in a consistent location and helps to cut down on desktop clutter	521,750	$360,367
Stem—lets you avoid cutting or juicing the fruit of your choice. Just stick the nozzle into the fruit and spray and you'll quickly have fresh aerosoled juice to spritz up whatever food you'd like	157,829	$45,195
Verseur—a four-in-one tool that includes a wine opener, foil cutter, pour spout, and stopper	54,888	$40,618
Earbuds all too often end up a tangled mess when you keep them in your pocket. **Wrapster** prevents this technological spaghetti and makes daily life just a little bit easier	537,064	$175,085

tens of millions of dollars, and discovered that its founding business model broke at growth. Many of Quirky's products had thin to non-existent margins. For example, the company spent nearly $400,000 on developing a Bluetooth speaker that only sold 28 units. Its Wink unit also faced distress, and a botched security update meant the company had to do a nationwide recall the spring of the same year of all of its smart home hubs.

The startup ran out of money and filed for bankruptcy in 2015. It had struggled to change its business model after several rounds of layoffs, and eventually sold its Wink smart-home business for $15 million. On July 31, 2015, Ben Kaufman stepped down as CEO following a layoff of 111 employees due to trouble getting funding.

An opposite case of success in scaling up a business model comes from two of today's giants, Uber (a ride-sharing service operating in 633 cities worldwide as of August 2017) and Airbnb (an online marketplace for short-term lodging covering 65,000 cities worldwide). Both companies started as typical new technology-based firms in 2008, and were able to successfully grow to multibillion enterprises through a combination of scalable ("asset-light") business models coupled with access to sufficient venture capital funding allowing them to leverage their scalability.

From this, the key recommendation for technology ventures is obvious: the founders must make sure that their business model is flexible, self-sufficient, and free of major constraints before expanding the business. Scaling up can be achieved by: (1) moving to products/services with low variable costs (or low share of Cost of Goods Sold in revenue), instead of leveraging the fixed costs; (2) standardization of operations, products, services; (3) franchising strategy; and (4) engaging in low-cost marketing.

5.5 *Problem 5: Low Relevance of the Customer Value Offered*

This challenge of technology ventures happens when the founding team is focused on services it already offers, ignoring or neglecting the changing requirements of customers or emergence of new technologies entering that may affect the market. This results in an inability to actually solve customer problems (satisfy their needs) in the best way possible for the price asked, leading to the loss of dynamic consistency between the business model and the market environment coupled with the loss of market share to new competitors who meet consumers demands better. At the core of this issue lies the loss of the attractiveness of the company's value to its key customers; i.e., the company fails to offer a solution to one or more of the customers' key pressing problems that would be effective when assessed against the price asked and against the competitors' offerings.

The rise and demise of Cuil (active July 2008 till September 2010), a search engine aiming to directly compete with Google, illustrates the perils of failing to solve customer problems in the best possible way. Founded by former Google employees and having raised $33 million from top venture capital firms in Silicon Valley, Cuil claimed to have an index larger than that of any other search engine, not to store users' search activity or IP addresses, and to display relatively long entries and thumbnails in the results. Alas, as these features came at a cost of slower response times, and frequently wrong or irrelevant search results (including at least one recorded case of inappropriately showing pornographic images in thumbnails). Yet, in the modern world of information abundance, results' relevance trumps index size. As a result, Cuil's distinct value proposition turned out to be irrelevant (or at least inferior to that of Google) for most customers, and on the morning of September 17, 2010 the aspiring search engine shut down the service and laid off all employees without compensation.

Hublot's success case, on the other hand, demonstrates that failure is not inevitable. In 2004, Jean-Claude Biver took the helm of Hublot, a watchmaker founded in the 1980s. At the time, Hublot had made a splash by offering a watch whose case combined gold and natural rubber. But by the early 2000s sales had begun to wane. To give the House a fresh boost, Jean-Claude Biver capitalized on the original idea to invent a fusion concept for watchmaking, proposing a new take on high-end chronographs that spotlights functionality and the performance of the case, along with the materials of which they are made. This was a bold gamble in an industry deeply attached to traditions and the methods of time-honored craftsmanship. The concept became the cornerstone behind Hublot's renaissance.

The key cause for the failure in this context is usually related to primarily information acquisition and processing problems (bounded rationality of managers: relevant customers' information is not reaching the strategic decision makers). Root causes are (a) problems in the accounting system (external, customers' views not getting enough attention), and (b) top management team's cognitive "blinders" (inability to properly assess and act upon the objective situation). To ensure the movement in the right direction, the firm must constantly analyze the market and remain close to actual customer demand. Even if the firm's current business model is successful, there will always be changes that cannot be resisted.

5.6 Problem 6: Inability to Focus on the Key Customers

In its essence, a business model is intended to serve the stakeholders of the firm—its consumers, investors, and partners up and down the value chain (e.g., the suppliers and distributors). Yet, the management must choose the key (primary) customer—the market stakeholder that the firm is primarily designed to serve—and focus all its efforts on optimizing the value provided to this stakeholder: "Organizations can be designed effectively to serve only one master" (Simons, 2005). After the primary customer has been defined, the next step is to configure resources into a coherent structure to serve that stakeholder and to ensure that the firm delivers superior value to it. While the requirements of all essential stakeholders must be satisfied on the minimally appropriate level (to ensure their support), the value created for the key customer must be maximized. When there is no focus in a company, it may be confused about its purpose and whom it is designed to serve. If everyone is a customer, then no one is. Hence, successful business models should be aimed at a specific customer.

The case of Facebook and MySpace in 2007 illustrates this point. By the end of 2007, it had become clear that MySpace—then the largest online social network—had to start responding to Facebook, or risk losing its leadership position. Whereas MySpace always considered end-users its key customers, and hence concentrated on attracting and retaining them, Facebook selected a different strategy, that of concentrating on partners that would attract the end-users. The company launched the Facebook Platform in May 2007, allowing developers to build programs that could be integrated within the Facebook site and, even more, to keep any revenue that their application generated. By January 2008, over 13,000 applications had been released and an estimated 100,000 developers were building Facebook applications. Applications and games built on that platform had attracted over 40% of Facebook users by 2011. For example, the iLike site, which had about 3.5 million users, added five million new users within 60 days of its Facebook launch and reached more than 11 million people by the end of 2007. Satisfaction of needs of Facebook Platform's key customers—developers—helped to do the same for other users. MySpace had to do something quickly, but the fateful decision was delayed, ultimately costing MySpace its leadership.

In summary, the management of technology ventures must properly identify the key customer at a particular stage of the company's development: this can be partners in the value chain, end users, buyers (who are paying for end users: consider health insurance companies dictating the medical decisions), or key suppliers. Moreover, as the case of Facebook demonstrates, the key customer of a business changes with time, and this change must be handled timely and properly. The identification of key users can be done by frankly answering the following questions:

(a) What benefit do we bring? (b) Who appreciates it most? What are they giving to us? (c) Is there somebody who will give us more opportunities? What are their demands? Can we reach it through our current customer focus? If not, how can we do this?

6 Discussion

In the current chapter, we intended to address the following questions: (1) What is a firm's business model, and how is it related and distinct from strategy, technology, and innovation? (2) What is the role of the business model in the process of development of new technology-based firms? (3) What are the most frequently occurring problems with new ventures' business models that prevent their development? Drawing from the strategy and entrepreneurship literature, we demonstrate that in the process of development of NTBFs, the crucial role belongs to establishing an effective and efficient business model to deploy the focal technology in a sustainable way. By this means, we demonstrated that the business model design and testing/validation become the essential parts of a startup process. From definitional issues, we proceeded to discussing the role of business models in the process of development of NTBFs. Then, we summarized the available empirical material to formulate the most frequently occurring problems with new ventures' business models that prevent their development, paying particular attention to ways of preventing and dealing with such problems. The developed conceptual framework of business model-related NTBF challenges was illustrated and corroborated with the mini-cases of technology ventures.

During their development from the concept to operational venture stage, most NTBFs need to overcome the "Giver Trap," when the objectively high business model effectiveness (customer value) gets translated into high efficiency (business value). This Giver→Winner move requires a major improvement of the efficiency of a business model, along two tightly coupled paths: (a) delivery—quality of fulfilling the promise of the value proposition to the primary customer; and (b) monetization—ability to charge customers a fair price, resulting in ultimate profit from the business model. In addition to specific recommendations discussed with each of the four problems related to this transition (problems 1–4 above), in this section we emphasize one general recommendation for venture management: within NTBFs, it is essential to institutionalize processes for continuous monitoring of the unexpected failures and—more importantly—unexpected successes revealed during the business model execution. This will allow detecting the problems early on, while capitalizing on unexpected emerging market opportunities (Biloshapka, 2014).

Once a technology venture finds a way to monetize the business model, establishes sustained revenue streams, motivates new and current customers to switch from competitors and substitutions, and takes control of expenses, the company moves into the Winner quadrant. Yet, at this stage the success cannot be taken for granted: staying a Winner requires strategic decisions and relentless actions. Without deliberate efforts to extend the Winner period, with time, the customer value erodes, while the business value lasts as long as the firm can retain loyal customers, good reputation, and brand equity—the typical Taker situation. Then, predictably, with time, the customers switch to better alternatives and the company finds itself in the Loser situation. The key challenge of companies with the Winner business models is in sustaining this position. Although successful and prominent in the past, any company will be dethroned one day, unless it ruthlessly pursuits proactive growth strategies and shields from the fatal impact of the competency trap ('core rigidities' caused by cognitive inertia of the managers of a successful company). These proactive strategies include explicit acknowledging and acting upon the notion that the real success implies not only above-the-average returns and a top market position, but also understanding the true causes of this success. Embracing this paradigm leads to continuous evaluation and re-evaluation of the objective customer value created by the company's business model, and constantly keeping track of the efficiency of translation of customer value into business value.

Regardless of the current stage of the technology venture's current business model, there are general recommendations concerning moving to a Winner's business position and then sustaining it in the future. The basis of these recommendations is a high-performance organizational culture (Biloshapka, 2014). In today's turbulent environment, the venture's management must create and relentlessly sustain an externally-focused culture at the intersection of market and innovative domains (Cameron & Quinn, 2005). The key competency in this culture becomes alertness to external opportunities and ability to properly act on them.

At the same time, the culture within a technology venture must explicitly require all employees to take unambiguous responsibility for the elements of the business model. In other words, the organizational culture must require each key employee (up to CEO) to clearly formulate their commitments aligned with the organization's desired business model (creating customer and/or business value) and—most importantly—translate these commitments into actionable and viable individual plans. This culture must also fuel the efficient strategic dialogue within the company, ensuring that the way to the winner's business model is not only accepted, but also fully understood by every employee of the company—in terms of their own small or big steps towards it. Such strategic dialogue hinges upon a set of leadership competencies of the high-performance culture: setting the right agenda and expectations regarding the operation of the business model, making and gaining valuable commitments from subordinates, providing timely corrective feedback (Biloshapka, 2014). Our empirical evidence from numerous NTBFs struggling to reach the winner's business model suggests that it is the lack of such competencies that has to be addressed first. It becomes vital to secure the development of those competencies if the management is serious about preventing strategy and business model communication problems.

The next recommendation deals with an issue so obvious that it tends to be ignored by executives—the smart budgeting system, ensuring that investments in cost centers (R&D, marketing, business development) are closely tied to the commitments of internal customers of those centers to developing the winner's business model and further sustaining it through relentlessly exploiting the revenue growth drivers.

Finally, the numerous examples of stakeholder backlash against thriving new technological companies (such as cab drivers fighting Uber, renters associations and hotel chains fighting Airbnb) suggest the crucial importance of incorporating the "Shapeholders" thinking into the business models of NBTF from the outset (Kennedy, 2017; Osiyevskyy & Biloshapka, 2017). The term "shapeholders" refers to those persons or organizations that have no stake in a company but have a powerful ability to shape its future: e.g., social activists, media, politicians, and regulators. Because they don't share in a company's losses or gains, shapeholders have significant freedom to challenge or block the firms' activities, or impose actions or practices without clear micro-economic benefit for the firm (Verbeke, Osiyevskyy, & Backman, 2017), unlike "traditional" stakeholders (customers, employees, value chain partners) whose interests are at least partially aligned with the interests of the firm. However, shapeholders should not be treated solely as malevolent players that can only hurt the business. Shapeholders' concerns are usually well-grounded and legitimate; also, they can create enormous opportunities for smart new ventures capable of effectively engaging with them through proper configuration of their business models. Indeed, "Granting preeminence to market-focused shareholders with short-term planning horizons effectively diminishes the power of important stakeholders (such as innovative employees and partners) and shapeholders (e.g., clean energy carrot activists), whose commitment is essential to the long-term survival of the company. In a nutshell, managing shapeholders is a part of the messy democratic process that works when power is apportioned fairly, and this process underpins the winning business models of true market leaders" (Osiyevskyy & Biloshapka, 2017).

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Part II
Managing NTBFs

Identifying and Categorizing Risks of New Product Development in a Small Technology-Driven Company

Ivan Rakonjac and Vesna Spasojević Brkić

Abstract New product development (NPD), as a locus of the innovative potential of organizations, plays an essential role in small technology-driven company survival. To address the research gap and fulfill the companies' needs, this survey aims to post and verify a new, simple and not time-consuming methodology for risk identification and categorization of industrial products development. To check the hypothesis that NPD project technical, cost and schedule sets of risks could be categorized as both threats and opportunities, an experiment was conducted in a small Serbian enterprise that has developed 52 innovative solid state based lighting products for outdoor lighting infrastructure. There were 69 identified risks (51 threats and 18 opportunities) that through 76 factors influence new products' technical characteristics, schedule and cost. Explorative factor analysis was applied to reduce and compress the data and 26 composite factors were obtained as valid predictors of the NPD project results. Regarding the technical characteristics risks, the threats can be grouped into four factors consisting of six risk types, while opportunities can be grouped into two factors consisting of four risk categories. The risks influencing the schedule disturbance that act as threats are grouped into eight factors consisting of ten risk types, while those that could be used in opportunities are grouped in four factors with eight risks identified. The risks influencing the costs that threaten the project are recognized as five factors described by seven risks, while those that act as opportunities are grouped into three factors described by five variables in total.

Keywords Product development · Risk identification · Risk categorization · Technical characteristics · Schedule · Costs

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1 Introduction

The business environment is changing at a high pace, becoming more complex than ever before (Mason, 2007; Klarin, Cvijanovic, & Brkic, 2000; Klarin, Milanovic, Misita, Spasojevic-Brkic, & Jovovic, 2010; Spasojević Brkić, Klarin, Stanisavljev, Brkić, & Sajfert, 2016). Being complex and turbulent, today's contemporary business environment requires companies to launch new products intensively to succeed. Consequently, new product development (NPD), as a locus of the innovative potential of organizations, plays an essential role in company survival. R&D activities significantly increase the likelihood of all types of innovations (Ninkovic, Sedmak, Kirin, Rakonjac, & Misita, 2012). The link between product innovations and firm performance has been the subject of a large number of scholarly works and a majority of studies have proved that innovations lead to higher profit rates, boost sales growth and increase the survival rates of the companies that launch new products intensively (Danneels, 2004; Spasojevic Brkic, Djurdjevic, Dondur, Klarin, & Tomic, 2013; Talay, Calantone, & Voorhees, 2014). Still, it is also known that new product failure rates are usually higher than 80% (Castellion & Markham, 2013). Accordingly, it is evident that NPD is an activity with high risk level (Cooper, 2003), while market competition and product technology advancement are very intensive (Chin, Tang, Yang, Wong, & Wang, 2009; Segismundo & Miguel, 2008).

Risk management in NPD projects is usually done in practice by using informal and unsystematic methods (Cooper, 2006; Rakonjac, Rakonjac, Kirin, Spasojevic Brkic, & Sedmak, 2011). This is not surprising, bearing in mind its stochastic nature (Gidel, Gautier, & Duchamp, 2005; Stanisavljev, Ćoćkalo, Klarin, Spasojević, & Đorđević, 2015). On the other side, risk management of NPD projects has been well recognized by certain researchers (Cooper, 2003; Kayis, Arndt, & Zhou, 2007), but it has not been sufficiently considered in the literature (Keizer, Vos, & Halman, 2005; Shaw et al., 2005). Accordingly, there is a growing need to develop a systematic and effective method to assess the NPD project risks that will be scientifically based and easily implemented in practice.

Special emphasis should be placed on small technology-driven companies since they have scarce resources but could play a key role in the innovation field and have high growth rates (Almus & Nerlinger, 1999; Ganotakis, 2012; Leithold, Haase, & Lautenschläger, 2016; Greene, Brush, & Brown, 2015). Broadly speaking, different tools, techniques and models could be applied to manage the risks of NPD projects (e.g. the behavioral model, failure mode and effects analysis, technique for order preference by similarity to ideal solution, analytical hierarchy process, analytical network process, Bayesian network etc.). Still, all of them have some underlying weaknesses when applied in a complex environment with the lack of resources, such as the NPD in small technology-driven companies (Chin et al., 2009). In addition to the various concepts and methodologies proposed, in the reference literature there are also different definitions of NPD project risks and different terminology. Empirical research is also lacking (Oehmen, Olechowski, Kenley, & Ben-Daya, 2014). One of the rare studies in the field of high technology companies conducted by

Thamhain (2013) should be highlighted since it has identified the risk management factors of 35 NPD projects in 17 high technology companies. NPD projects in small technology-driven companies are supposed to be risky activities and need special attention.

To address the research gap and fulfill the needs of small technology-driven companies, this survey aims to post and verify a new, relatively simple and not time-consuming methodology for risk identification and categorization of industrial products development, since it can facilitate organization's preparation for risk management and respective risk assessment (Shrivastava & Rathod, 2015).

2 Problem Background

2.1 Previous Research on Risks of New Product Development

When new products are developed in practice, there is always a tendency to achieve the defined objectives, although frequently this may not be the case. Very often, schedules are overrun and/or budgets exceeded, and sometimes even the product quality can be questionable in spite of the efforts invested. Hence, risk management is a very important segment of the whole process of NPD project management. This is a complex process that consists of a set of defined subprocesses, whose implementation entails the use of project risk management methodology.

The reference literature in the field of risk management of industrial product development projects provides different methodologies, suggesting various subprocesses of project risk management. Available previous research classification of risks of NPD is presented in Table 1.

Analyzing the results according to the research approach used, it can be seen that 28 out of 43 references included in Table 1 suggest the Project risk management model, 18 out of which refer to general use, not focusing on a specific area. Only three models refer to high-technology companies. There are nine case studies, eight of which have more complex business systems as the areas of application (Aerospace, Automobile, Chemical, Pharmaceuticals, Construction, etc.). Only one case study refers to the field of risk management in small and medium-sized enterprises. There are two surveys and six research actions, two of which refer to small and medium-sized enterprises. There are three articles which combine model proposal and research action, i.e. case study. It should be mentioned that the reference literature whose area of application is risk management in small and medium-sized enterprises most often does not explicitly deal with the processes of industrial product development but offers a framework for risk management in small and medium-sized enterprises that may be implemented during the process of industrial product development.

According to the criterion referring to the analysis and quantification of project risks, it can be seen that six articles feature the FMEA method, with one suggesting expansion and adaptation, specializing it for the analysis and quantification of

Table 1 Classification of the literature on risk management of industrial product development projects

No.	Research approach	Analysis and quantification of project risks	Area of application	Author(s)
1.	Model proposal	FMEA	Non-specific	Puente, Pino, Priore, and de la Fuente (2002)
2.	Case study	FMEA, R FMEA	Non-specific	Carbone and Tippett (2004)
3.	Case study	Probabilistic risk assessment	Various (Aero-space, Hospital, Environmental)	Paté Cornell (2002)
4.	Model proposal	FMEA	Non-specific	Ravi Sankar and Prabhu (2001)
5.	Case study	FMEA	Aerospace	Garrick (1989)
6.	Survey	–	Various (Aero-space, Chemical, Construction)	Shenhar et al. (2002)
7.	Model proposal	–	Non-specific	Miller and Lessard (2001)
8.	Survey	–	Information systems	Jiang and Klein (1999)
9.	Research action, Model proposal	Risk level calculation	Software	Costa, Barros, and Travassos (2007)
10.	Model proposal	–	Non-specific	Ben-David and Raz (2001)
11.	Model proposal	Real option method	Information technology	Kumar (2002)
12.	Case study	Probabilistic risk assessment	Automobile	Chamberlain and Modarres (2005)
13.	Model proposal	–	Non-specific	Huchzermeier and Loch (2001)
14.	Model proposal	Monte Carlo, Graphic methods	Non-specific	Bose and Blau (2000)
15.	Case study	Graphic methods	Pharmaceuticals	Blau et al. (2000)
16.	Case study	–	Construction	Phillips (2002)
17.	Research action	–	Non-specific	Mikkelsen (1990)
18.	Model proposal	Utility function	Non-specific	Franke, Schlesinger, and Stapleton (2006)
19.	Model proposal	Scenario method	Non-specific	Kaplan, Haimes, and Garrick (2001)
20.	Model proposal	–	Non-specific	Hillson (2000)
21.	Model proposal	FMEA	Non-specific	Trammell, Lorenzo, and Davis (2003)
22.	Model proposal, Case study	–	Non-specific	Yu, Hwang, and Huang (1999)

(continued)

Table 1 (continued)

No.	Research approach	Analysis and quantification of project risks	Area of application	Author(s)
23.	Research action	–	Small and medium-sized enterprises	Brancia (2011)
24.	Model proposal	–	Non-specific	Alhawari, Thabtah, Karadsheh, and Hadi (2008)
25.	Model proposal	–	Small and medium-sized enterprises	Henschel (2009)
26.	Model proposal	–	Small and medium-sized enterprises	Henschel (2009)
27.	Model proposal	–	Non-specific	Galway (2004)
28.	Model proposal	–	Small and medium-sized enterprises	Blanc Alquier and Lagasse Tignol (2006)
29.	Model proposal	Utility function	Non-specific	Browning, Deyst, Eppinger, and Whitney (2002)
30.	Model proposal	Utility function	Non-specific	Browning and Hillson (2003)
31.	Case study	Risk level calculation	Small and medium-sized enterprises	Leopoulos, Kirytopoulos, and Malandrakis (2006)
32.	Model proposal	–	Small and medium-sized enterprises	Arnsfeld, Berkau, and Frey (2007)
33.	Model proposal	–	Small and medium-sized enterprises	Berry, Sweeting, and Holt (2007)
34.	Research action	–	Small and medium-sized enterprises	Islam, Tedford, and Haemmerle (2008)
35.	Model proposal	Graphic methods	Non-specific	Gouriveau and Noyes (2004)
36.	Model proposal	Utility function	Non-specific	Kwak and LaPlace (2005)
37.	Model proposal	Three-dimensional model—(1) Degree of uncertainty (variables, set #1) (2) Project complexity (variables, set #2) (3). Impact (variables, set #3)	High-technology companies	Thamhain (2013)
38.	Research action	Interview	Non-specific	Ogawa and Piller (2006)

(continued)

Table 1 (continued)

No.	Research approach	Analysis and quantification of project risks	Area of application	Author(s)
39.	Research action	–	Non-specific	Kahn, Castellion, and Griffin (2005)
40.	Model proposal/ Case study	Discrete-event simulation algorithm	High-technology companies	Wang and Lin (2009)
41.	Research action	FMEA	Non-specific	Liu, Liu, and Liu (2013)
42.	Model proposal	Event study	Biotech and pharmaceutical industries	Fang, Lee, and Yang (2015)
43.	Case study	Design for Six Sigma & Theory of inventive problem-solving (TRIZ)	Product (very-high-bit-rate digital subscriber line)	Wang, Yeh, and Chu (2016)

Modified from Segismundo and Miguel (2008) and extended with Thamhain (2013), Kahn et al. (2005), Wang and Lin (2009), Liu et al. (2013), Fang et al. (2015) and Wang et al. (2016)

project risks. Other quantitative approaches to risk analysis are distributed in such a way that four articles (with a non-specific area of application) suggest the use of utility function, while two articles (more complex business systems) suggest the probabilistic risk assessment. Three articles suggest using graphic methods, three suggest risk level calculation, and two of them refer to risk management in small and medium-sized enterprises. The methods of scenario, real option and Monte Carlo simulation occur in one article each.

The majority of articles (22) is not restricted to project risk application and is of general nature. The sphere of complex business systems such as aerospace, automobile, pharmaceutical and chemical industry, health and ecology is mentioned as an area of application in six papers, the area of information technology in three, while eight articles in this field deal with the research expansion to small and medium-sized enterprises. Only three papers are related to high-technology companies.

In addition to different concepts and the proposed methodologies, there are also different definitions of project risks, as well as different terminology. Although the majority of authors define risk as a combination (and often as a product) of the likelihood of emergence of a risk event and the impact of such an event, i.e. a consequence resulting from the potential occurrence of such an event, terminologically speaking, this result is presented in accordance with the author's preferences. Furthermore, certain differences in definitions also refer to the perception of risk only as a harmful effect on project objectives and the risk creating a potential opportunity, although the modern definitions of project risks perceive risks equally as harmful effects (threats) and useful effects (opportunities) (Browning & Hillson, 2003; PMI, 2008; Ward, 2000).

Most frequently accepted methodologies for project risk management (IPMA, 2006; Kerzner, 2013; PMI, 2008) recognize the importance of the subprocess of risk analysis (assessment) as the key segment in the comprehensive process of project risk management, aimed at obtaining highly relevant data related to possible risks and their effects on project objectives. The basic approaches to the risk analysis subprocess are qualitative and quantitative. Qualitative analysis is based on generic entities of the constructed model and does not take into account its specific characteristics such as the value of failure rate, while the quantitative approach uses the global relations pertaining to the various aspects of the problem (Gouriveau & Noyes, 2004). Quantitative approaches make it possible to measure the risk and express it numerically. Generally speaking, risk level is expressed via a certain mathematical relation or the function of the defined risk factors.

Risk levels or results are frequently expressed via tables (matrices), graphs and/or some of the established scales. These scales vary depending on the approach and preferences of different authors. Although some authors endeavor to use a standardized scale in keeping with the proposed quantitative approach and/or model, this often becomes confusing, especially when the suggested scales transform qualitative assessments into quantitative. Also, if we bear in mind that there are numerous methods and techniques for risk quantification, there is a question of choosing which one to use.

When it comes to industrial product development, the answer to this question is most often provided by the Failure mode and effect analysis (FMEA). However, this method, besides its complexity, predominantly favors the qualitative approach to failure analysis. The modified approach RFMEA (Carbone & Tippett, 2004) brings the model closer to the concept of project risk management, but there still remains the issue of complexity, as well as the twofold conversion of quantitative assessment into qualitative, in order to determine the risk factors value by scale comparison.

Browning et al. (2002) offer the solution to this problem by introducing the utility function, which assigns numeric values to the risk attributes related to the peculiarities of the industrial product development project.

Additionally, there is the issue of the complexity of the project risk quantification model, as well as of the mathematical model, in order to describe the project risk attributes objectively enough, and make the model itself relatively simple to use in the conditions holding in small and medium-sized enterprises that accomplish their business endeavors (also) through the industrial product development projects.

Based on the overview of the reference literature related to the area of risk management in the industrial product development process provided in this section, the following can be concluded:

- The vast amount of available literature is inconsistent when it comes to definitions, terminology and the proposed concepts of project risk management.
- Quantitative approaches to risk management in industrial product development projects are various and there are numerous methods and techniques used to perform the process of quantification.

- The overview of the risk level and/or risk results depends on the manner in which risk scales are made.
- The proposed concepts for risk management in both small and medium-sized enterprises and high-technology companies do not offer a clear framework for risk quantification in the industrial product development projects.

2.2 Previous Research on Small Technology Driven Companies

On the other side, it is well known that technology-driven entrepreneurship is the driving force for both economy and society that serves as the engine of innovation, job creation, productivity and economic growth and brings significant benefits both to individuals and societies (Petti, 2016). Entrepreneurs involved in new technology-based ventures usually receive significant support from policy-makers in different countries due to the belief that new firms are at risk because they suffer from financial constraints (Vendrell-Herrero, González-Pernía, & Peña-Legazkue, 2014). It is not surprising that recent research results indicate that technology-driven companies that proactively develop and rapidly integrate and use new technologies in new product development achieve very good performance indicators (Hao & Song, 2016).

Accordingly, special emphasis should be placed on small technology-driven companies since the majority of all enterprises are small, employing the highest percentage of all workers in the private sector. In contrast with large companies, small companies had previously undertaken fewer innovation projects due to limited resources (Berends, Jelinek, Reymen, & Stultiëns, 2014). Unpleasant contemporary market conditions and public support force smaller firms to reinvent their business through new technologies and innovations that are easily linkable with their organic management advantages compared to larger firms. At the same time, this kind of companies faces a large number of constraints in differentiating their products and adapting their business model to changing environment. A major liability still is the fact that small firms lack the required internal financial resources and technical capabilities for NPD (Vanhaverbeke, Vermeersch, & De Zutter, 2012), although public support tries to change that fact.

The search for efficient NPD models and approaches applicable in technology-driven companies has become a new and emergent topic for both scholars and practitioners due to the fact that today's environment requires NPD strategies and frameworks that combine simplicity, velocity and flexibility in an appropriate manner to survive and achieve good results (Conforto & Amaral, 2016).

Tan, Fischer, Mitchell, and Phan (2009) claim the research on innovation in small companies mainly uses theory derived from research on large firms and favors using top-down approaches such as quantitative survey research, thus failing to take into consideration the specific characteristics of small enterprises. Other authors add that general reviews of risk management undertaken by small organizational systems even when they are not technology-driven are scarce, mostly theoretical and when connected to practical application usually developed for project-oriented organizations (Marcelino-Sádaba, Pérez-Ezcurdia, Lazcano, & Villanueva, 2014). Certain authors emphasize the newly founded small enterprises with high-tech product innovations that have large market potentials, although it is known that they represent a very small fraction of all small firms (Veugelers, 2008). Based on embedded multiple case studies of small companies in Sweden, Löfqvist (2010) has noticed that small newly established systems have many promising innovation ideas that are suitable for NPD. Those activities are accompanied by high risk values due to the fact that they cannot spread risk over different innovation projects as large companies can, because of their often narrower markets and few products in their production program (Nooteboom, 1994).

In light of the afore-said, it is evident that risks of NPD in a small technology-driven company are not a sufficiently discovered topic that hence needs further examination and research.

3 Identifying Risks of New Product Development in a Small Technology-Driven Company

If the NPD project in a small technology-driven company is observed as a dynamic system, it is evident that during project implementation there are changing circumstances that bring about the occurrence of a possible risk event. Therefore, uncertain events during the project lifecycle affect project results, driving them further away or closer to the defined objectives. The basic assumption is that in an ideal case project results should fulfill the following objectives: to develop the product with the requested technical properties, on time and within the proposed budget. Essentially, risk affects the possible deviation from the desired objectives. This deviation or an error for each of the afore-mentioned objectives may be the parameter which can be monitored and whose values point towards the risk to project objective accomplishment.

If three parameters are defined as project objectives: the project schedule, i.e. the project duration, project's budget and technical properties of the product the enterprise endeavors to develop, in order to assess the expected deviation for each of the afore-mentioned parameters it is necessary to set up a mathematical model that would include all of the risks related to each of these parameters individually.

As proposed by Oehmen et al. (2014), there are often serious cost and schedule overruns, as well as problems in achieving the targeted technical performance of the product and, hence, this survey aims to monitor the risks identified on NPD results—the technical properties, time and cost. The quantification of risk events and their impact on project results is crucial for creating the project risk management model. Hillson (2002) has shown that the traditional view of risk should be changed from purely negative adverse consequences to the possibility of "upside risk" or opportunity, i.e. uncertainties that could have a beneficial effect on achieving objectives. Accordingly, NPD risks are expected be categorized into listed categories.

To check the hypothesis that NPD project technical, cost and schedule risks could be categorized as both threats and opportunities, an experiment was conducted in a small Serbian enterprise that has developed 52 innovative solid state based lighting products for outdoor lighting infrastructure, of the same product group. Serbian economy is in transition process, and needs to stimulate further creation and growth of innovative enterprises based on knowledge. Only 3% of Serbia's total manufacturing export is in high-technology products; this being much lower than the EU 27 average of 16% (IPA II 2014–2020, 2015). The company achieves good business performance and employs well-educated and trained workforce (2 of 15 employees possess a PhD degree). It implements the ISO 9001 quality management system and, thus, those records were used as basis for data collection, which makes the implementation of a model for project risk management significantly easier and proves that risk and quality management helps to steer the innovation process (Wohlfeil & Terzidis, 2015).

The model includes both threats and opportunities equally and provides a possibility to quantify the combined impact of all risk events on project objectives. Risks identification was performed by the team consisting of persons that had been working on product development, a quality management representative and a representative responsible for sales of a certain project. The models for determining the quantified objectives of NPD projects have been presented in Rakonjac et al. (2011) and Slavković, Budimir, Rakonjac, Jarić, and Budimir (2014). Furthermore, based on conformity assessment records, the problems that had occurred until a particular moment were perceived and identified as project risks and then, using an affinity diagram (Pritchard, 2014), they were classified into categories according to their impact on project results. Thus, three sets have been formed:

- The risks affecting the technical properties of the product—S_T
- The risks affecting the project schedule—S_S
- The risks affecting exceeding the project's budget—S_B.

In each of the sets are found clearly distinguished the subset of threats—S'_l and the subset of opportunities—S''_l, whereby $\left(S'_l \bigcup S''_l\right) = S_l\Big) \wedge \Big(S'_l \bigcap S''_l\Big) = \emptyset\Big)$ and $l = \{T, S, B\}$.

Tables 2 and 3 contain the lists of the identified risks that consequently pose as threats and opportunities, while the last three columns also show categories, i.e. belonging to certain subsets with respect to the impact on project results.

There were 69 identified risks influencing new products' technical characteristics, NPD schedule and cost, more specifically, 51 threats and 18 opportunities, which affect one or more defined sets of risk (that influence products' technical characteristics, project schedule or budget).

Besides risk probability of each possible risk factor, the probability of error (non) detection and the consequence of each risk event should be modeled as well in order to

Table 2 The list of identified threats (the impact of threat is present—×)

No.	Threats	S'_T	S'_S	S'_B
r1	Wrong market assessment			×
r2	Unclear (incomplete) demands made by the investors		×	×
r3	Investor's dissatisfaction with the proposed solutions		×	
r4	Lack of feedback from the market		×	
r5	Limited investment budget			×
r6	Unfeasible design (technological) solution		×	
r7	Oversights in technical documentation for prototypes	×	×	
r8	Deviations from the defined design solution	×	×	
r9	Prototype fails to comply with the technical characteristics	×		
r10	Unavailability of materials		×	
r11	Instability in material prices			×
r12	Problems with suppliers regarding on time delivery		×	
r13	Problems with suppliers regarding delivery quality	×		
r14	Problems with sub-contractors regarding the quality of services	×		
r15	Problems with sub-contractors regarding the manufacturing deadlines		×	
r16	Problems with sub-contractors regarding the quality of services			×
r17	Instability of the energy resources market		×	×
r18	Machinery and equipment failures		×	×
r19	Lack of trained personnel	×		
r20	Human factor induced manufacturing errors	×		
r21	Work accidents, sick leave		×	
r22	Work discipline		×	
r23	Natural disasters		×	×
r24	Political circumstances		×	×
r25	Unjustifiability of further prototype development		×	×
r26	Financial market instability			×
r27	Inadequately selected manufacturing technology	×		
r28	Product fails to comply with the prescribed technical norms	×		
r29	Incomplete quality control	×		
r30	Legislation risks		×	×
r31	Product certification risks	×		
r32	Inadequately selected packaging	×		
r33	Inadequately designed tools	×		
r34	Inadequately selected or manufactured tools	×		
r35	Assembly problems	×		
r36	Lack of tools and/or machines		×	×
r37	Investor's dissatisfaction with the proposed solution		×	×
r38	Problems in production resources planning		×	
r39	Omissions in workshop documentation	×		
r40	Storage and transport problems			×
r41	Thefts and sabotage			×
r42	Problems with patenting a product			×

(continued)

Table 2 (continued)

No.	Threats	S'_T	S'_S	S'_B
r43	Problems with recycling			×
r44	Insufficient marketing support		×	
r45	Competition		×	
r46	Insufficiently (inadequately) formulated conditions of warranty period	×		
r47	Insufficient instructions on transport, installation and storage	×		
r48	Investor's withdrawal from the project			×
r49	Problems with pay-out for undertaken obligations on investor's part			×
r50	Communication problems		×	
r51	Installation and maintenance problems	×		

Table 3 The list of identified opportunities (the impact of opportunity is present—×)

No.	Opportunities	S''_T	S''_S	S''_B
c1	Flexible investor		×	×
c2	Possibility of the entire manufacturing process in own production		×	
c3	Having material in stock		×	
c4	New product is a modified version of the existing product		×	
c5	Use of familiar technologies	×	×	
c6	Modularity		×	
c7	Use of existing tools		×	×
c8	Worker's motivation	×	×	
c9	Enhanced quality control process	×	×	
c10	Possibility of saving by optimizing the technological procedure			×
c11	Scrap reduction			×
c12	High demand			×
c13	Invention of new recyclable materials	×		×
c14	Better work organization		×	
c15	Use of secondary raw materials			×
c16	Useful scrap and rework			×
c17	Skillful negotiating		×	×
c18	Possibility of implementing new norms and standards	×		

quantify the total risk value on certain project, as proposed in our previous research (Rakonjac, & Jednak, 2012). Still, those activities are beyond the scope of this chapter.

4 Categorizing Risks of New Product Development in a Small Technology-Driven Company

Bearing in mind that our goal is to compress variables according to constructs, the R-type of explorative factor analysis will be used. Since we are aiming at data reduction, we will use the method of Principal Component Analysis. The initial hypothesis is that all the variables that describe each of the constructs are independent, so the number of factors in the setting will match the number of variables. Variables were grouped depending on risk factors according to Tables 1 and 2. Each of the defined subsets of threats—S_l' and opportunities—S_l'', where $l = \{T, S, B\}$, is a separate construct, while each subset in the sample is a data series in the form of a binary string (with the value of 1 for risk presence and the value of 0 for non-presence).

In order to achieve factors independence, when groups of factors are not distinguished, the transformation, i.e. Varimax rotation should be implemented. Based on the sample size in this study (52) and according to Hair, Black, Babin, and Anderson (2010) that give rules of thumb for assessing the practical significance of standardised factor loadings, the threshold level of the factor loading was 0.75 and the lower levels of correlation between the original variables and risk factors were not taken into consideration. Since the criterion of experimental probability of emergence of the binary type risk event was used to form the constructs, the Varimax rotation was implemented.

The obtained results are presented according to the research model constructs in Tables 4, 5, 6, 7, 8, 9 and 10.

The data shown in Table 4 reveal that factor loadings on Factors 3 and 5 are not high enough.

The data shown in Table 5 reveal that factor loadings on Factor 6 are not high enough.

The data shown in Table 6 reveal that factor loadings on Factors 3 and 5 are not high enough.

Tables 10, 11, 12, 13, 14, 15 and 16 show the extracted factors according to research model constructs for factor loadings over 0.75.

It has been shown that there is no division of variables into several factors, as well as that there is a tendency of logical grouping of variables, although not more than three variables per factor. Therefore, there was no need to conduct a reliability analysis.

According to Hair et al. (2010), after the applied factor analysis, it is necessary to form new variables and set up new datasets with respect to the extracted factors. Based on Tables 10–15, factors were marked, and then an algorithm to form the new datasets was set up. Hence, Tables 16–21 contain an overview of the new variables.

Data in Table 16 show that there was a grouping of two pairs of variables into two separate factors, more precisely, those two variables that refer to the failure to comply with technical norms, as well as those two that refer to human factor. The variables that did not tend to overlap (group) with other variables, and were also proven to be statistically relevant during factor analysis, will be discussed further on in their original form.

Data in Table 17 indicate that two pairs of variables were grouped into two separate factors. Factor 3 grouped the variables related to administrative and organizational risks, while Factor 9 included the variables referring to the risks related to investor's demands. The variables that did not tend to overlap (group) with other

Table 4 Explorative factor analysis for variables from the subset of threats affecting the technical properties of the product

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
r7	−0.006544	−0.139016	0.139338	0.402172	0.623526	0.351025
r8	0.108637	0.164897	0.051314	**0.787155**	−0.066112	−0.218377
r9	**0.871919**	−0.109680	−0.162713	−0.062499	−0.027593	−0.044639
r13	−0.004368	**0.760858**	0.201040	−0.035596	0.043032	−0.019967
r14	−0.099478	−0.111582	0.162468	0.541942	0.009207	0.139052
r19	0.235808	0.137639	−0.076331	**0.766999**	−0.149356	0.036549
r20	0.009585	0.177550	0.154618	0.682726	0.028939	0.281678
r27	0.458126	0.395719	−0.472751	0.377583	0.127719	−0.118111
r28	**0.855777**	−0.007932	−0.064060	0.050076	−0.178450	0.068083
r29	0.007783	0.398048	0.579585	0.161170	0.060761	0.130788
r31	0.700634	0.037188	0.359049	0.174874	0.018935	−0.085542
r32	0.332747	0.066461	0.567658	0.363770	0.092322	−0.157035
r33	−0.112968	0.614756	0.066596	0.279908	−0.039512	0.347442
r34	−0.087378	0.058027	0.051682	−0.009363	−0.118246	**0.852431**
r35	−0.071058	0.095450	0.651224	0.030765	−0.056131	0.105869
r39	0.165787	0.176517	0.140629	0.256639	0.411974	0.615233
r46	0.478722	0.068230	0.298105	0.261301	−0.637189	0.026485
r47	0.372862	−0.279002	0.308610	0.458807	−0.136846	0.130691
r51	0.089198	−0.169237	0.002762	0.336015	−0.658996	0.173653
Explained variance	2.810692	1.553968	1.794826	3.005528	1.527157	1.625993
% Total variance	0.147931	0.081788	0.094465	0.158186	0.080377	0.085579

Threats affecting the technical properties of the product, factor loadings >0.75 given in bold

variables, and were also proven to be statistically relevant during factor analysis, will be discussed further on in their original form.

Data in Table 18 show that two pairs of variables were grouped into two separate factors. Factor 1 grouped the variables related to withdrawal from the project risks, while Factor 7 comprised the variables referring to the risks of opportunity costs. The variables that did not tend to overlap (group) with other variables, and were also proven to be statistically relevant during factor analysis, will be discussed further on in their original form.

Data in Table 19 indicate that three variables related to the technical processes improvement were grouped into one factor, while the second factor is the original variable related to use of familiar technologies.

Data in Table 20 show that three variables related to design adaptability were grouped into one factor, while two pairs of variables were grouped into two factors: Factor 2 comprises the variable referring to flexibility and the possibility of negotiating while Factor 3 groups together the variables referring to the possibility of the entire product manufacturing process via own production capacities and resources. Factor 4 is an original variable related to the enhanced quality control process.

Table 5 Explorative factor analysis for variables from the subset of threats affecting the project schedule overrun

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9
r2	0.235064	−0.208430	0.116301	0.093642	0.078780	0.140002	0.016552	0.021300	**0.850626**
r3	−0.113940	−0.158279	0.094290	0.017880	−0.126306	−0.103951	−0.062866	0.009665	**0.902868**
r4	0.074222	−0.005195	−0.186621	−0.153760	0.708368	0.113665	−0.334325	0.253270	0.112160
r6	0.448631	−0.281206	0.077072	0.332384	−0.065464	0.409645	0.031446	−0.192897	0.411196
r7	−0.174527	0.089131	−0.114744	0.534279	0.139456	0.585519	−0.075220	−0.116799	−0.075222
r8	0.244884	−0.154038	0.337724	0.425826	−0.086382	0.224114	0.366715	−0.147139	0.389289
r10	−0.025668	0.140074	0.137743	0.026181	−0.193250	0.710684	0.258128	0.253710	0.050180
r12	0.213167	0.188576	0.132538	−0.068310	−0.095446	−0.009959	**0.823875**	0.028838	0.021875
r15	0.098466	0.027159	−0.023475	**0.844385**	−0.021040	0.107612	−0.026323	0.088910	0.154253
r17	0.033085	0.051483	0.052356	−0.031610	−0.106127	0.017426	0.062686	**0.872829**	−0.114451
r18	−0.425701	0.163202	0.033098	0.014106	0.018121	0.292295	0.427407	0.175109	0.500792
r21	0.380446	0.211920	0.266635	−0.015831	0.154736	0.639589	−0.196870	−0.130991	0.095544
r22	−0.050490	0.258032	0.354319	0.592994	0.052354	−0.396256	−0.080895	−0.169301	−0.132125
r23	**0.763621**	0.086956	0.050647	0.019686	0.142777	0.078830	0.096285	0.071853	0.014957
r24	0.211591	0.100168	0.356392	0.020720	0.132819	0.040706	0.042194	0.654048	0.319466
r25	−0.044653	−0.719654	−0.017117	−0.201052	0.077752	−0.179223	−0.291985	−0.127863	0.147637
r30	−0.128284	−0.077764	**0.924480**	−0.022409	−0.050928	−0.072896	0.110899	0.123598	0.043598
r36	0.718292	0.166566	−0.161172	0.019124	−0.269803	−0.038837	0.163835	0.147523	0.042305
r37	−0.195620	**−0.797746**	0.073812	0.050310	−0.116119	−0.101302	0.025932	−0.038227	0.244016
r38	0.187991	0.108681	**0.817757**	−0.016263	−0.066772	0.266012	0.092712	0.013200	0.140061
r44	−0.096667	0.051630	0.016845	0.149522	**0.826146**	−0.136596	0.133446	−0.255057	−0.130903
r45	0.089836	−0.464832	0.049210	−0.087728	0.403351	0.140258	0.531238	0.315150	−0.128904
r50	−0.220793	−0.265320	0.646917	0.326698	−0.001073	0.064570	−0.004736	0.379631	0.150525
Explained variance	2.052898	1.882595	2.533866	1.863108	1.622926	1.943117	1.679885	1.845072	2.458210
% Total variance	0.089256	0.081852	0.110168	0.081005	0.070562	0.084483	0.073038	0.080221	0.106879

Threats affecting the project schedule overrun, factor loadings >0.75 given in bold

Table 6 Explorative factor analysis for variables from the subset of threats affecting the project's budget overrun

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7
r1	0.357384	0.008260	0.049183	−0.257178	−0.711485	−0.049461	0.036428
r2	0.309679	**0.802140**	0.012027	0.038026	0.018751	0.029519	0.076327
r5	−0.092081	0.077958	0.028380	0.041598	0.131957	**0.892899**	0.081303
r11	−0.263585	−0.017667	0.626604	0.188615	0.048625	0.427753	0.157735
r16	−0.162017	0.484187	0.193708	−0.320739	−0.230176	0.258491	0.180876
r17	−0.055148	−0.188960	0.263204	0.259908	0.529720	0.400544	0.154550
r18	−0.086347	0.218081	−0.038051	−0.103625	0.080571	0.040812	**0.785082**
r23	−0.047053	0.313643	0.740501	−0.154233	−0.044939	0.027388	−0.258019
r24	0.033292	0.340259	0.401468	−0.119565	0.549914	0.357787	0.063963
r25	**0.884888**	0.036530	−0.216625	0.140802	−0.027861	−0.030803	−0.183831
r26	−0.164254	0.133609	0.593927	0.332861	0.315247	0.131606	0.205940
r30	0.097535	0.151235	−0.044032	−0.104703	0.692790	−0.002775	0.238394
r36	−0.223270	0.277321	0.404006	0.647505	−0.062095	−0.141128	−0.222175
r37	0.742602	0.087929	−0.078831	−0.203736	0.105644	−0.196644	0.257225
r40	−0.062168	−0.117063	−0.041409	**0.922463**	0.083559	0.167146	0.080467
r41	0.053591	0.547619	−0.048628	0.396885	0.255131	−0.335422	0.303833
r42	0.001975	0.096955	0.014708	0.113156	0.141210	0.088512	**0.836570**
r43	0.155938	−0.402563	0.656350	−0.012266	−0.114687	−0.438429	0.005179
r48	**0.763964**	0.255106	0.132299	−0.214792	−0.367686	−0.001100	−0.176627
r49	0.089258	0.701205	0.213559	−0.032462	0.272797	0.092365	0.410877
Explained variance	2.385142	2.350247	2.283018	1.995094	2.080750	1.767136	2.029511
% Total variance	0.119257	0.117512	0.114151	0.099755	0.104038	0.088357	0.101476

Threats affecting the project's budget overrun, factor loadings >0.75 given in bold

Table 7 Explorative factor analysis for variables from the subset of opportunities affecting the technical properties of the product

Variable	Factor 1	Factor 2
c5	−0.260649	**−0.839896**
c8	−0.285308	0.655400
c9	**0.807379**	−0.145336
c13	**0.774478**	0.268642
c18	**0.896347**	−0.102732
Explained variance	2.204453	1.238820
% Total variance	0.440891	0.247764

Opportunities affecting the technical properties of the product, factor loadings >0.75 given in bold

Table 8 Explorative factor analysis for variables from the subset of opportunities affecting the project schedule

Variable	Factor 1	Factor 2	Factor 3	Factor 4
c1	0.054309	**0.882714**	−0.039209	−0.013886
c2	0.238086	−0.035542	**0.883875**	−0.039609
c3	0.058982	−0.089157	**0.829574**	0.046456
c4	**0.843942**	−0.252836	0.171542	0.070359
c5	0.726500	0.278980	−0.070506	−0.228790
c6	**0.783012**	−0.123165	0.399995	0.029321
c7	**0.828957**	−0.169614	0.047868	0.229528
c8	−0.287921	0.469051	0.180823	0.596798
c9	−0.218188	0.117126	0.158998	**−0.805138**
c14	0.020434	0.437219	0.562373	−0.226861
c17	−0.238672	**0.803295**	−0.030799	0.024131
Explained variance	2.791317	2.044261	2.042840	1.171222
% Total variance	0.253756	0.185842	0.185713	0.106475

Opportunities affecting the project schedule, factor loadings >0.75 given in bold

Table 9 Explorative factor analysis for variables from the subset of opportunities affecting the project's budget

Variable	Factor 1	Factor 2	Factor 3
c1	0.041774	**−0.797714**	0.073921
c7	−0.183002	0.296419	**0.751877**
c10	**0.753806**	−0.125879	−0.200219
c11	**0.877816**	0.032428	−0.104262
c12	0.346904	−0.472855	−0.065275
c13	−0.101524	0.250364	−0.692569
c15	0.434652	−0.311295	0.074715
c16	0.646396	0.064026	0.341616
c17	−0.068804	**−0.878554**	−0.061109
Explained variance	2.116153	1.900244	1.231671
% Total variance	0.235128	0.211138	0.136852

Opportunities affecting the project's budget, factor loadings >0.75 given in bold

Table 10 Extracted factors for the variables from the subset of threats affecting the technical properties of the product

Factor	Variable		Loading
Factor 1	r9	Prototype fails to comply with the technical properties	0.871919
	r28	Product fails to comply with the prescribed technical norms	0.855777
Factor 2	r13	Problems with suppliers regarding delivery quality	0.760858
Factor 3		–	
Factor 4	r8	Deviations from the defined design solution	0.787155
	r19	Lack of trained personnel	0.766999
Factor 5		–	
Factor 6	r34	Inadequately selected or manufactured tools	0.852431

Table 11 Extracted factors for the variables from the subset of threats affecting the project schedule overrun

Factor	Variable		Loading
Factor 1	r23	Natural disasters	0.763621
Factor 2	r37	Investor's dissatisfaction with the proposed solution	−0.797746
Factor 3	r30	Legislation risks	0.924480
	r38	Problems in production resources planning	0.817757
Factor 4	r15	Problems with sub-contractors regarding the manufacturing deadlines	0.844385
Factor 5	r44	Insufficient marketing support	0.826146
Factor 6		–	
Factor 7	r12	Problems with suppliers regarding on time delivery	0.823875
Factor 8	r17	Instability of the energy resources market	0.872829
Factor 9	r2	Unclear (incomplete) demands made by the investors	0.850626
	r3	Investor's dissatisfaction with the proposed solutions	0.902868

Table 12 Extracted factors for the variables from the subset of threats affecting the project's budget overrun

Factor	Variable		Loading
Factor 1	r25	Unjustifiability of further prototype development	0.884888
	r48	Investor's withdrawal from the project	0.763964
Factor 2	r2	Unclear (incomplete) demands made by the investors	0.802140
Factor 3		–	
Factor 4	r40	Storage and transport problems	0.922463
Factor 5		–	
Factor 6	r5	Limited investment budget	0.892899
Factor 7	r18	Machinery and equipment failures	0.785082
	r42	Problems with patenting a product	0.836570

Table 13 Extracted factors for the variables from the subset of opportunities affecting the technical properties of the product

Factor	Variable		Loading
Factor 1	c9	Enhanced quality control process	0.807379
	c13	Invention of new recyclable materials	0.774478
	c18	Possibility of implementing new norms and standards	0.896347
Factor 2	c5	Use of familiar technologies	−0.839896

Table 14 Extracted factors for the variables from the subset of opportunities affecting the project schedule

Factor	Variable		Loading
Factor 1	c4	New product is a modified version of the existing product	0.843942
	c6	Modularity	0.783012
	c7	Use of existing tools	0.828957
Factor 2	c1	Flexible investor	0.882714
	c17	Skillful negotiating	0.803295
Factor 3	c2	Possibility of the entire manufacturing process in own production	0.883875
	c3	Having material in stock	0.829574
Factor 4	c9	Enhanced quality control process	−0.805138

Table 15 Extracted factors for the variables from the subset of opportunities affecting the project's budget

Factor	Variable		Loading
Factor 1	c10	Possibility of saving by optimizing the technological procedure	0.753806
	c11	Scrap reduction	0.877816
Factor 2	c1	Flexible investor	−0.797714
	c17	Skillful negotiating	−0.878554
Factor 3	c7	Use of existing tools	0.751877

Data in Table 21 indicate that two pairs of variables were grouped into two separate factors. Factor 1 grouped together the variables referring to the technological processes optimization, while Factor 2 included the variables referring to flexibility and the possibility of negotiating costs. Factor 3 is an original variable related to the use of existing tools.

It can be noticed that the Factor "Possibility of negotiating" appears as a new variable in the subset of opportunities that affect both the project schedule and project's budget.

An overview of the number of these variables before and after factor analysis application is shown in Table 22.

After factor analysis application on the technical characteristics risks, it is evident that the threats can be grouped into four factors consisting of six risk types, while opportunities can be grouped into two factors consisting of four risk categories. The risks influencing the NPD schedule disturbance that act as threats are grouped into eight factors consisting of ten risk types, while those that could be used in

Table 16 New variables of the subset of threats affecting the technical properties of the product

Factor	Variable		New variable
Factor 1	r9	Prototype fails to comply with the technical properties	Failure to comply with technical norms
	r28	Product fails to comply with the prescribed technical norms	
Factor 2	r13	Problems with suppliers regarding delivery quality	Problems with suppliers regarding delivery quality
Factor 3		–	–
Factor 4	r8	Deviations from the defined design solution	Human factor
	r19	Lack of trained personnel	
Factor 5	–	–	–
Factor 6	r34	Inadequately selected or manufactured tools	Inadequately selected or manufactured tools

Table 17 New variables of the subset of threats affecting the project schedule overrun

Factor	Variable		New variable
Factor 1	r23	Natural disasters	Natural disasters
Factor 2	r37	Investor's dissatisfaction with the proposed solutions	Investor's dissatisfaction with the proposed solutions
Factor 3	r30	Legislation risks	Administrative and organizational risks
	r38	Problems in production resources planning	
Factor 4	r15	Problems with sub-contractors regarding the manufacturing deadlines	Problems with sub-contractors regarding the manufacturing deadlines
Factor 5	r44	Insufficient marketing support	Insufficient marketing support
Factor 6		–	–
Factor 7	r12	Problems with suppliers regarding on time delivery	Problems with suppliers regarding on time delivery
Factor 8	r17	Instability of the energy resources market	Instability of the energy resources market
Factor 9	r2	Unclear (incomplete) demands made by the investors	Risks related to investor's demands
	r3	Investor's dissatisfaction with the proposed solutions	

opportunities are grouped into four factors with eight risks identified. The risks influencing the NPD costs that threaten the project are recognized as five factors described by seven risks, while those that act as opportunities are grouped into three factors described by five variables in total.

Table 18 New variables of the subset of threats affecting the project's budget

Factor	Variable		New variable
Factor 1	r25	Unjustifiability of further prototype development	Withdrawal from the project
	r48	Investor's withdrawal from the project	
Factor 2	r2	Unclear (incomplete) demands made by the investors	Unclear (incomplete) demands made by the investors
Factor 3		–	–
Factor 4	r40	Storage and transport problems	Storage and transport problems
Factor 5		–	–
Factor 6	r5	Limited investment budget	Limited investment budget
Factor 7	r18	Machinery and equipment failures	Opportunity costs
	r42	Problems with patenting a product	

Table 19 New variables of the subset of opportunities affecting the technical properties of the product

Factor	Variable		New variable
Factor 1	c9	Enhanced quality control process	Technical processes improvement
	c13	Invention of new recyclable materials	
	c18	Possibility of implementing new norms and standards	
Factor 2	c5	Use of familiar technologies	Use of familiar technologies

Table 20 New variables of the subset of opportunities affecting the project schedule

Factor	Variable		New variable
Factor 1	c4	New product is a modified solution to the existing product	Design adaptability
	c6	Modularity	
	c7	Use of existing tools	
Factor 2	c1	Flexible investor	Possibility of negotiating
	c17	Skillful negotiating	
Factor 3	c2	Possibility of the entire manufacturing process in own production	Independence of own production
	c3	Having material in stock	
Factor 4	c9	Enhanced quality control process	Enhanced quality control process

Table 21 New variables of the subset of opportunities affecting the project's budget

Factor	Variable		New variable
Factor 1	c10	Possibility of saving by technological processes optimization	Technological processes optimization
	c11	Scrap reduction	
Factor 2	c1	Flexible investor	Possibility of negotiating
	c17	Skillful negotiating	
Factor 3	c7	Use of existing tools	Use of existing tools

Table 22 A comparative overview of the number of variables before and after factor analysis

Variable set	Threats/Opportunities	Before factor analysis	After factor analysis
S_T	Threats	19	4
	Opportunities	5	2
S_S	Threats	23	8
	Opportunities	11	4
S_B	Threats	20	5
	Opportunities	8	3

In addition to risks identification, the obtained results also provide grounds for their categorization, as follows. For instance, the new categorization of threats that influence new products' technical characteristics includes these risks categories: (1) those not fulfilling technical standards (for prototype or product), (2) the issues with suppliers regarding quality and on time delivery, (3) human factor influence on design solution and inadequately trained personnel and (4) inadequately selected or developed tools used in production processes. The opportunities that influence new products' technical characteristics include technical processes improvement (described by the factors in the field of quality control, new recyclable materials and new norms and standards appearance) and the technology with which the company is familiar. Similarly, the risks influencing NPD schedule disturbance that act as threats are grouped as natural disasters, administrative and organizational factors etc., while those that act as opportunities are variables grouped into factors such as design adaptability, own production of all product components and similar. Regarding NPD costs, the risks can be grouped into categories such as the limited investment budget, opportunity costs in fields of facilities and patents, transport and warehousing problems etc. as threats, and technological processes optimization, the possibility of negotiating with the investor etc. as opportunities.

As can be seen, a very high degree of complexity reduction was achieved herein.

5 Conclusion and Recommendations

To address the research gap and fulfill the small technology-driven companies' needs regarding NPD as a locus of the innovative potential of organizations, this survey aimed to post and verify new, relatively simple and not time-consuming methodology for risk identification and categorization of industrial products development.

To check the hypothesis that NPD project technical, cost and schedule risks could be categorized as both threats and opportunities, an experiment was conducted in a small Serbian enterprise that has developed 52 innovative solid state based lighting products for outdoor lighting infrastructure, of the same product group. This experimental research has provided an insight into the risks that are present in the process of developing new solid state based lighting products for outdoor lighting infrastructure development in a small technology-driven company based on data of their frequency of occurrence.

The survey identified 69 risks that through 76 factors influence new products' technical characteristics, NPD schedule and cost, namely, 51 threats and 18 opportunities, affecting one or several defined sets of risks (technical properties of the product, the project schedule and/or the project's budget). Explorative factor analysis was applied to reduce the data, to identify groups of inter-related variables, to obtain an insight into the way in which they were related to each other and to compress the data. Hence, 26 composite factors were obtained as valid predictors of NPD project results. Regarding the technical characteristics risks, the threats can be grouped into four factors consisting of six risk types, while opportunities can be grouped into two factors consisting of four risk categories. The risks influencing the schedule disturbance that act as threats are grouped into eight factors consisting of ten risk types, while those that could be used in opportunities are grouped into four factors with eight risks identified. The risks influencing the costs that threaten the project are recognized as five factors described by seven risks, while those that act as opportunities are grouped into three factors described by five variables in total. The obtained research results as well as the proposed methodology can be highly beneficial to experts, executives, planners, risk and project managers in the implementation of a systematic approach to quantitative analysis of project risks in small technology-driven companies which are involved in industrial product development as part of their business endeavors. Thanks to our results, their work will be significantly simplified, as they will have the task of mastering a significantly smaller number of factors.

Compared to previous research such as Thamhain (2013) that identified risk management factors of 35 NPD projects in 17 high technology companies, this survey has been performed on a larger sample in one company. Also, there is a match in the obtained factors.

The company examined herein and other companies in the similar field could benefit from this research, since, in future development projects, the identified and categorized risks that have been proved as valid can be expected, and this can help deal with uncertainty that is the greatest challenge for small companies, which is especially important for Serbian innovative companies. We expect that this and similar research will speed up small companies to incorporate more innovation elements in their strategy and invest more in new product development.

Besides sample enlargement (since it is expected that the company will introduce more new projects in the future), the recommendation for future research is the Monte Carlo simulation with sensitivity analysis on new variables as outcomes of the principal components analysis herein, including also probabilities of risk event (non)detection, the consequences of risk events as well as error weighting factors, which depend on the stages of the process in which risks occur, to check the statistical distribution on total risk value on the project. Also, it is recommended to use Likert scale that could enable a broader differentiation of the projects. Usage of reliability analysis could be beneficial, too, to confirm the quality of factor solutions and can be seen as a limitation of this study. The repetition of similar methodology on projects in other high technology fields and in other countries is expected to be covered in future studies, too.

We hope so that the identified risks will affect public policy when encouraging small technology driven companies to strengthen their innovative potential.

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The Application of the Effective Innovation Leadership Model in ICT Practice

Sabrina Schork

Abstract This chapter examines the application of the Effective Innovation Leadership (EIL)-Model in the Information and Communication Technology (ICT) practice. The EIL-Model was the outcome of a study grounded in the iteration of six different data sources. In this chapter, the focus lies on insights taken by applying the EIL-Model within three German DAX-companies from different industries. The study leads to a better understanding of the EIL-Model components and reveals that seven sub categories are dominantly affecting the effectiveness of innovation leaders. Those sub categories are openness, trust, delivery, association, perseverance, entrepreneurship, and focus.

Keywords Leadership · Innovation · Change

1 Scientific Perspective on Innovation Leadership

Innovation can be a new product, service, process or structure (Damanpour, 1991). Innovation can be a new combination of existing resources (Schumpeter, 1934). 'Innovation' is an iterative process initiated by the perception of a new market and/or new service opportunity for a technology based invention which leads to development, production, and marketing tasks striving for the commercial success of the invention. […] It is important to elucidate that an invention does not become an innovation until it has processed through production and marketing tasks and is diffused into the marketplace (Garcia & Calantone, 2001).

It can only be said retrospectively if a newly implemented product, service or business model leads to a sustainable change in an organization or society (Trantow, Hees, & Jeschke, 2011).

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Leadership incorporates the **guidance** of individuals, groups or organizations. The core task of leaders is to influence their own and others attitudes so that resources lead to results (Malik, 2014).

Leadership is different from management. […] Rather, leadership and management are two distinctive and complementary systems of action. Each has its own function and characteristic activities. Both are necessary for success in today's business environment. Management is about coping with complexity. Its practices and procedures are largely a response to the emergence of large, complex organizations in the twentieth century. Leadership, by contrast, is about coping with change. Part of the reason it has become so important in recent years is that the business world has become more competitive and more volatile. More change always demands more leadership (Kotter, 2000).

The term «innovation leadership» has its roots in the 1990s and was first mentioned in the twenty-first century. The definition of innovation leadership varies. One option is »innovation leaders are **managers driving innovation**« (Bossink, 2004) another definition is »innovation leaders are **shaping a working space increasing the learning and absorption capacity** in a highly volatile context« (Carmeli, Gelbard, & Gefen, 2010).

Kaudela-Baum, Holzer, and Kocher (2014) say that innovation leaders **honour deviations** and **focus on cultural, communication as well as relationship factors**. Innovation leadership has a **strategy** orientation, focusing on the **long-term development of innovations** and knowledge. Innovation leaders work on the development of incremental and radical business models. They **deal with paradoxes and complexity**. Innovation leaders **see employees as partners** and **provide freedom, self-responsibility** as well as **reflexion cycles.**

Innovation leaders are Roger's (1995) innovators, early adopters, opinion leaders, and change agents. They **can support the success of the economy** and the organizations, products, and employees (Murphy & Murphy, 2002).

Gliddon (2006) defines innovation leaders in his Ph.D. thesis as managers of people and/or process who **can be (a) innovators, (b) early adopters, (c) opinion leaders, and (d) change agents**. Individuals in these categories are **leading the diffusion of an innovation within an organization's social system.** Expert **competencies** are specified **as learning, leading teams, motivation, management,** and **delegation**.

Rosing, Frese, and Bausch (2011) propose an ambidexterity theory of leadership for innovation that specifies two complementary sets of leadership behaviour that foster exploration and exploitation in individuals and teams opening and closing leader behaviours, respectively.

O'Reilly and Tushman (2013) propose that innovation leaders **switch intuitively between open and closed leadership**. Open leadership includes chaotic structures, intrinsic motivation, risk-taking, playful, dynamic and creative behaviours, based on autonomy and freedom. Closed leadership focuses on target agreements, power, planned task delivery, extrinsic motivation, and ordered structures.

Innovation leaders directly **provide creative input, clear work goals** derived from an overall vision as well as **resources and tools** necessary to fulfill job tasks.

Additionally, innovation leaders indirectly influence their employees by **establishing a supportive climate, acting as a role model, providing rewards, and compositing a good creative team** (Hunter & Cushenbery, 2011).

In this chapter, innovation leadership stands for executives empowering people to innovate and being responsible for a successful innovation portfolio. Innovation leaders' role is to set-up creative teams and to provide them a space in which they can unfold their strengths fulfilling the shared purpose »to build and test incremental, radical and disruptive innovations without fear, judgment, or concerns«.

2 Background on the Development of the EIL-Model

During my Ph.D. thesis, I executed six studies, one group discussion with ten participants, fourteen narrative one-to-one interviews, three industry case studies, one quantitative survey with 96 participants, 1 qualitative survey with 25 participants, and an ongoing analysis of secondary data (approx. 50 papers). The different data sets were analysed with the Grounded Theory Methodology interpreted by Strauss and Corbin. The outcomes of the studies were published at conferences (Schork, 2014a, 2014b; Schork & Terzidis, 2014, 2015; Schork, Heblich, & Terzidis, 2016) and in my Ph.D. thesis book (Schork, 2017).

The key insights taken from a half-day group discussion with ten innovation leaders are that the digitalization is one of the core transformational factors for current organizations in a constantly changing ecosystem. Now, organizations across industries act in the state of the unknown. They constantly ask themselves the question "how can we secure and track innovation success?". In addition to that, executives hope of not losing control and are searching for failure and success stories from which they can learn. The situation reflects insecurity, hope, and change. **Highly debated topics related to effective innovation leadership are »trust and freedom«, »purpose and drive«, as well as »transparency and communication«.**

After the group discussion, I executed fourteen narrative interviews with innovation leaders. The interviews lasted ninety minutes. The audiotaped deep dive monologues revealed that **most innovation leaders in the ICT context struggle to build and track an innovation culture.** An innovation culture is composed of artefacts (i.e. buildings, structures, vision or myths), shared values, beliefs, and behaviours (Schein, 2010).

The execution of three ICT case studies revealed that current innovation leaders **struggle to give a clear translation of the organizational mission, vision, and purpose, so that their employees know how they can contribute by adopting**

their strengths. Communication, knowledge, focus, trust, and transparency were mentioned as key factors for leadership effectiveness. None of the observed executives were perceived as stable, clear, and exemplary personalities.

The quantitative survey revealed that **cooperation** as a practice of innovation leaders is **not significantly correlated with enterprise profits**. **Focus** and **entrepreneurship** instead are **significantly and positively correlated with profits, business relationships, the development of new products, services, and business models as well as the satisfaction and professionalism of an innovation team**. Entrepreneurship, cooperation, focus, reflexivity, and space are significantly and positively correlated with well-being and professionalism of an innovation team.

The quantitative survey also showed that decision making, personal development programs, and provision of methodologies are more important to employees than to leadership. Executives on the other hand, believe that they provide more freedom for self-decisioning than employees perceive.

A secondary data analysis gave insights about existing scientific perspectives on innovation leadership as well as societal accepted leading practices (i.e. Elon Musk, Steve Jobs, Hasso Plattner, and Dame Stephanie Shirley). The insights taken from this analysis were constantly held against the five primary data sets.

3 The EIL-Model

Based on the iteration of six data sources, the EIL-Model emerged. It consists of the three categories values, strengths, and practices. Those three categories have twenty sub-categories (see Fig. 1).

The EIL-Model shows the most frequently mentioned properties of an effective innovation leader in the ICT—surrounding. Overall it has twenty categories—seven values, six strengths, and seven practices.

The innovation context is highly dynamic, unpredictable, and risky.

To be effective in an innovation economy an executive needs to build trustful relationships with diverse and complementary individuals who are creative, intrinsically motivated, and willing to make a change.

Values are defined as „*an enduring belief that a specific mode of conduct or end state of existence is personally and socially preferable to alternative modes of conduct or end states of existence*“ (Rokeach, 1973). When specifying values, a person answers the question “What is important to me?”. Because values are guiding principles providing a direction in decision-making processes, they are symbolized with a compass in Fig. 1.

The second circle in Fig. 1 shows strengths. **Strengths** are defined as „the ability to provide consistent, near-perfect performance in a given activity” (Buckingham & Clifton, 2001). The basic assumption of strength theory is that individuals have a unique mixture of talents that filter their thoughts, feelings, and behavioural patterns. There is a lot of potential in talents to be able to provide particularly superior

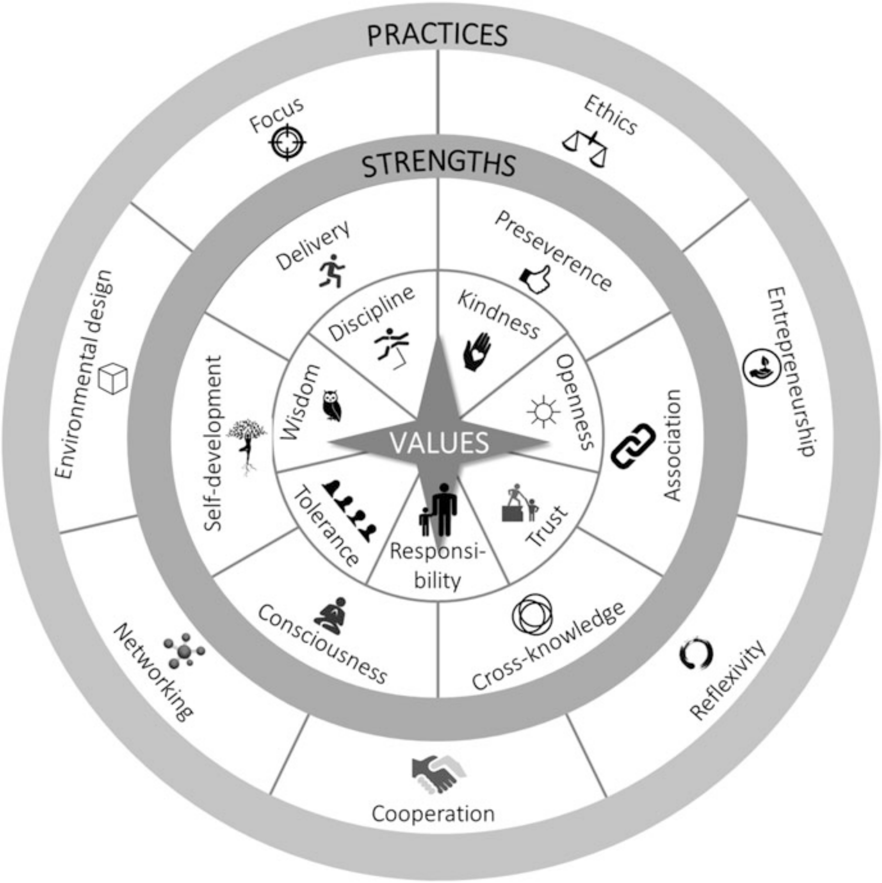

Fig. 1 The Effective Innovation Leadership-Model

performance. If a person is aware of her/his talents and utilizes them, she/he can develop strengths. When specifying strengths, a person answers the question "What do I like and is easy for me?".

Practices are defined as "specific professional behaviors that a person uses every day to be effective" (Malik, 2014). Malik refers to the learned behaviors (also: skills) that a person uses. Practices can be supported with instruments and methods.

4 Business Perspective on Innovation Leadership

Within the business context, there are several roles that could be defined as innovation leadership, i.e. Chief Innovation Officer (CIO), Head of Strategy & Innovation, Head of Business Development & Innovation, Chief Executive Officer, Chief

Technology Officer, Chief Information Officer, or Chief Digital Officer (CDO). The most common current specification of innovation leaders is «CIO» or «CDO».

Chief **I**nnovation **O**fficers are responsible to set-up a creative team that creates and implements successful innovations in the market. Usually, the development process is lean and agile and includes the four stages exploration, ideation, prototyping, testing, and scaling-up.

Chief **D**igital **O**fficers are responsible to drive initiatives that simplify the daily work routine through technology with the overall goal to save time. CDOs focus on fast and lean tests as well as delivery.

A Head of Business Development and Change, in contrast, is doing business with venture capital companies, must evaluate existing businesses and sets up plans how to maximize the value of a target.

5 Insights applying the EIL-Approach in ICT Practice

The EIL-Model evolved during the iteration of five primary studies held against one secondary data set. A circle of ten experts' quality checked the data iterations.

The EIL-Model consists of the three categories values, strengths, and practices. Adopting the EIL-Model within three DAX-organizations in the media, insurance, and pharma industry, showed the following additional insights.

Values

In the Grounded Research Study seven values originated relevant for effective innovation leadership. In the following, I aggregate new insights per sub category:

Discipline: It is important to create something new, despite obstacles

The »new« is not always welcome in enterprises. Especially when it changes power dynamics, which is foremost the case. If there is no top management buy-in or support, the engagement of innovation leaders to implement something »new« falls flat. Also, employees that boycott innovation can hinder leadership effectiveness. **Effective innovation leaders, therefore, need a constant self-discipline and management buy-in as well as a committed team.**

Openness: It is important to me to perceive my environment without judgment

The socialization of judgment goes back into cultures, families, schools and enterprise systems. Open mindsets believe in the lifelong ability to change thinking and behaviour patterns. People can train their ability to be non-judgmental. One option is to listen to the own thoughts while watching other people. As soon as judgmental thoughts come up, open thoughts are set next to it. Closed or fixed mindsets cannot lead to innovations. Ideation and testing demand the ability to let go of thinking patterns as well as of listening to different perspectives and combine them into something new. If a company wants to transform its mindset, there is no other way than letting-go off old and fixed mindsets. **Innovation leaders need to be open and set-up a team full of open-minded people willing to change constantly.**

Tolerance: It is important to me to recognize the uniqueness of people

In many cases, tolerance seems to relate to personal empathy or solidarity, as well as job performance. Tolerance has something to do with giving someone else the room to be oneself. Tolerance can relate for example to cultures, personalities or behaviours. **Innovation leaders not being tolerant won't be open for different perspectives which are pre-conditions for the evolvement of innovation.**

Responsibility: It is important to me to bring innovations into our world

Not everyone in a system takes the responsibility to bring innovation into the world, and not everyone is able in doing so. Those who are doing it, often follow a purpose. Those who are able in doing so, often have a creative mind combined with the strong will to execute, as well as the ability to execute in a structured manner. **Innovation leaders need to take ownership of innovation otherwise no one in an enterprise feels responsible for it and will care for its execution.**

Trust: It is important to me to trust in people unconditionally

Unconditional trust is an attitude. This form of trust isn't bound to any conditions. Unconditional trust is not naïve nor free. To live unconditional trust, a person needs a stable self and a positive attitude towards life and humankind. Opportunistic behaviours may reduce trust. Trust is one of the most important pre-conditions for information flow, collaboration, and co-creation. In hierarchical systems where fear and judgment is part of the DNA (deoxyribonucleic acid), it is very tough to bring people into a unconditional trust or »creator's mode«. **Innovation leaders need to live unconditional trust. Otherwise, no idea sharing or innovating will happen.**

Wisdom: It is important to me to make experiences through action

Wisdom is something that can only evolve if a person is self-reflected, intelligent and has wise mentors or friends giving additional perspectives. Not every person is aiming for wisdom. Due to pressure, there can be low reflection windows within an enterprise which is a pre-condition for wisdom. **Regarding innovation leadership, wisdom seems to be more of a hassle than a must. As well, wisdom seems to be hard to measure.**

Kindness: It is important to me to believe that people are trying to do their best

People with a kind mindset believe that every person is trying its best. Still, the best of person A can lead to better results than the best of person B. If person B would be trained and would have a higher learning absorptivity than person A, person B could overtake person A's performance after a while. **Regarding innovation leadership, kindness is important to build long-lasting and trustful relationships with business partners, peers, top managers, and employees. Kindness is something necessary to engage in networking activities. Kindness can be a pre-condition for felt acceptance which as a positive effect on employee development.**

Strengths

In the Grounded Research Study six strengths originated relevant for effective innovation leadership. In the following, I aggregate new insights per sub category:

Consciousness: It is easy for me to recognize and process my thoughts and actions

Being in the present moment is something that people can train with meditation. Regular meditation reduces stress levels. Organizational rules such as no mobile phones or laptops during meetings may increase peoples' consciousness. **Conscious innovation leaders better perceive upcoming changes, inconsistencies, and therefore opportunities.**

Self-development: It is easy for me to cultivate individual needs

The awareness of one's self can be more realistic if a person is regularly doing scientifically validated self-assessment tests, journaling or having coaching sessions, as well as peer mentoring. **Self-aware innovation leaders that are constantly in learning modus matching individual needs and actions will be more satisfied and in addition to that successful in the long run.**

Multi-talented: It is easy for me to penetrate many disciplines and directions

People having many interests and the will to learn tend to have multiple talents. **Multitalented innovation leaders have extensive competencies which are a good precondition to recombine resources or associate different insights to generate innovations.**

Perseverance: It is easy for me to convince others

Persevere people tend to bring their thoughts to the point and catch people's attention with few words. Perseverance is often grounded in friendliness, empathy, and a clear mind. **Perseverance is a core strength to make innovations happen.**

Delivery: It is easy for me to make changes

A person with self-drive and a strong will to execute tends to deliver intrinsically. The person acts as a role model for other enterprise members. Its energy is contagious for others. **Delivery is a core strength necessary for innovation leadership to implement innovations in the market.**

Association: It is easy for me to link independent concepts in a new way

A leader, strong in association is very seldom. Research, brainstorming, and co-creation trains the association capacities. Association is also defined as fluid intelligence. **Association is a core strength relevant for the innovation creation procedure.**

Practices

A quantitative survey with 96 innovation leaders showed, that entrepreneurship and focus both significantly correlate strongly and positively with enterprise profits, the successful introduction of innovations in the market, longterm stakeholder relationships, innovation team well-being, and innovation team professionalism (Schork, 2017).

When specifying practices, a person answers the question "What am I doing to fulfill my daily job tasks?". In the Grounded Research Study seven practices originated relevant for effective innovation leadership. In the following, I aggregate new insights per sub category:

Cooperation: In my daily practice, I develop solutions with others

Cooperation in the innovation context is needed so that information flow can lead to great ideas. People who like each other tend to cooperate immediately. In highly professional companies people who do not like each other also cooperate, sometimes with negative effects on the working climate. »Trittbrettfahrer« are usually killing innovation culture. **Innovation leaders need active cooperation so that their team acts professional and is satisfied. Innovation leaders need to be aware of, manage, and minimize »Trittbrettfahrer«.**

Entrepreneurship: In my daily practice, I change the world through my actions

Entrepreneurship empowers employees in taking ownership to create circumstances leading to new and better conditions. At the leadership level, current systems struggle to hire real entrepreneurs because they tend not to go into formed structures. Entrepreneurs only come and stay if they do have the freedom, support, and space to grow their ideas and strengths. **Innovation leaders do not necessarily have to be entrepreneurs themselves. Still, they need to act entrepreneurial and being able to support entrepreneurs bringing their business ideas into life.**

Focus: In my daily practice I do little good, rather than much bad

The focus is needed, especially when it comes to the clarification and communication of the company purpose and goals. Employees need to know and understand how they can contribute to shaping a competitive enterprise and what ideas might be more successful than others. **Effective innovation leaders focus their energy on intrinsically motivated talents, marketable ideas, as well as strengths.**

Networking: In my daily practice, I exchange ideas with qualified people

During the innovation process, the integration of qualified people with different perspectives takes place in the ideation and conception as well as testing phase. Networking is something that must be cultivated continuously so that the right and qualified experts can be integrated whenever needed. **Networking is a core practice that innovation leaders must cultivate to ensure a constant information flow.** Although networking has not necessarily a positive effect on enterprise profits, it can lead to a better understanding of the market and increase output quality. **Innovation leaders especially need to be able to build stable and good top management relationships.** Otherwise their engagements do not have any effects.

The practices environmental design (In my daily practice, I sow and let something arise.) and reflexivity (In my daily practice, I clarify my thoughts through dialogues.) currently receive high attention and adoption from innovation leaders. Ethics (In my daily practice, I set an example with my actions.) is a practice that is highly affected by individual convictions.

6 Study Contributions

The adoption of the EIL-Model within three DAX companies of different industries showed that openness and unconditional trust are highly relevant values for the effectiveness of innovation leaders in ICT-practice. Both values have an impact on the willingness and drive of employees to innovate.

Effective innovation leaders are especially strong in association, delivery, and perseverance. They know how to do innovation, how to bring thoughts into action, and how to convince others from developed solutions.

Especially with entrepreneurial and focused behaviours, innovation leaders increase team and in addition to that enterprise innovation success.

Ineffective innovation leaders tend to be egoistic, fixed to their convictions, and inflexible. They live conditional trust, are judgmental and are unable to deliver innovations in a focused manner.

As well, the adoption of the EIL-Model in ICT-practice helped me to deepen the understanding about the specified sub-categories which are concretizations of innovation leaders' values, strengths, and practices having a positive effect on innovation success.

7 Limitations

The study is based on three German industry case studies in DAX-companies examined between January 2016 and June 2017. I worked with one Chief Executive Officer, one Chief Information Officer, and one Chief Digital Officer.

8 Outlook

As a next step, I will execute a quantitative survey, focusing on the seven constructs trust, openness, entrepreneurship, focus, association, perseverance, and delivery to assess the innovation leadership effectiveness in corporates and mid-sized companies in the south of Germany compared to the south of England.

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A Unified Model of the Technology Push Process and Its Application in a Workshop Setting

Orestis Terzidis and Leonid Vogel

Abstract The process of commercializing new technologies, i.e. of creating technology push innovations, is poorly understood and modeled in very different and heterogeneous ways in the academic literature. Furthermore, no framework exists up to now to allow for practical facilitation like Design Thinking supporting user-centric innovations. To tackle these shortcomings, this chapter aims to improve the understanding of the technology push process and take initial steps towards a practical methodological framework. The understanding is enhanced by creating a consolidated and unified model of the process which builds on a systematic literature review. Additionally, methods are identified, evaluated and combined into a workshop format for the most critical phase of technology application selection. A case example in a university setting shows that the workshop is well-suited to advance technologies. Both the process model and the workshop concept are relevant for the academic and practical contexts: The process model aids in better understanding the technology push process and unifies different views. The workshop is an essential first step in designing a systematic framework for practical technology push developments with concrete methods and tools. The methodology is new to the field of innovation management and forms a well-designed starting point for similar endeavors.

Keywords Entrepreneurship · Management of technological innovation · Intellectual property management · Technology transfer

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1 Introduction

Innovation and entrepreneurship are considered important for economic development (Hall, 2003). Most innovations are derived from emerging customer needs, which is referred to as 'market pull'. However, a certain percentage of innovations are based on technologies that originate from research. This is called 'technology push' as technologies have to find a market and must be applied to respond to a market need in a way that creates progress (for a comparison of the two approaches, see e.g. Gerpott, 2005).

The management of technology push innovations is more difficult than market pull innovation because the process requires a lot more time and the results are more uncertain as it is often unclear which market is suitable for a technology (Lynn & Heintz, 1992). As an example, the mp3 format was developed 100 years after the base technology, auditory masking, was discovered (Kirchberger & Pohl, 2016). Moreover, the innovation management literature has focused more on the market pull process because it appears more often and is usually considered to be easier. This has left the technology push process underdeveloped, less described and understood.

Conversely, the potential gain is considerable: Technology push innovation are often more fundamental and sometimes lead to breakthroughs (Gerpott, 2005). Reemploying the mp3 example, the format has changed the ways people listen to music as it has enabled portable music players with a large number of songs stored (Kirchberger & Pohl, 2016). Thus, understanding the technology push process is a practically and scientifically relevant issue.

A plethora of technology push process models has been developed for a multitude of purposes: The models are used to communicate with stakeholders (Lane, 2000, 283), understand the big picture of the technology push development (Lane, 2000, 284), planning like setting milestones (Klocke & Gemünden, 2010, 80) and benchmarking between young ventures (Klocke & Gemünden, 2010, 80).

Most models introduce new ideas and new models emerge almost every year. Looking at this multitude and the apparent lack of convergence, there is a need for a systematic review of process papers and the unification of different perspectives to derive a comprehensive view on the technology push process.

Moreover, there is no broadly accepted approach for technology push development, which practitioners could apply in actual projects. To date, despite its importance for making the technology push process more efficient, no broadly applied framework with methods and practice for technology push exists (such as design thinking for user-centered innovation).

2 Research Questions and Methodology

Given this situation, we looked at the following research questions:

- What stage models have been described in the literature for the technology push process?

- How can the existing models be consolidated into a unified model?
- What methods and tools can be used in the various stages of the technology push process?
- How can these methods and tools be applied in practice?

To adequately analyze the state of the art with regard to process models a systematic literature review was employed. In the following, both the search process and the method of analysis are explained.

The search was not limited to journal articles, because master theses, dissertations, and books have produced very important models as well, which became apparent after a short preliminary search.

At first, search terms in meta search engines (Business Source Premier, EconLit, Google Scholar, TEMA, Web of Science and wiso) were used to find scientific research that conceived process models of technology push in a wider sense (e.g. including university spinoffs). Then, the references and citing paper list in Google Scholar were consulted to find more relevant articles. The process of analyzing citations was repeated until no relevant new article was found.

In order to find relevant articles, the search terms used needed to combine the "what" and the "how" aspects. The "what" aspect included terms that describe the object of analysis (the organization, the technology). The "how" aspect encompasses terms that describe what happens with the object and how it is analyzed. Those were terms of sequence like "phase" and terms of action like "method". The two aspects were combined to a search phrase that had to be exactly matched, e.g. "technology development phase". The complete permutation of combinations of the terms depicted in Table 1 was connected with a logical "OR".

When scanning the citation list the information of the articles was reviewed in the following sequence:

Table 1 Search term combinations

WHAT	HOW
• Technology development • Technology push • Research startup • Spin-off • Technology transfer • Research innovation • Innovation from research	• Sequence – Phase(s) – Stage(s) – Process(es) – Implementation – System • Action – Development – Approach – Method – Tool – Practice – Design

1. Title
2. Abstract
3. Full article scan
4. Full articles read

A title is considered relevant if it includes both a process (stages, process, phases, etc.) and technology aspects (technology push, high-tech, university, spinoff, technology transfer). If the title was focused on innovation in general or product development, it was considered too broad. We also excluded articles on the process of raising capital or team formation since we considered them as too specific.

We created a citation graph of all relevant articles in order to identify central articles that define fundamental principles around which other models are built. With the graph, we could also identify clusters of articles. This allows for a better understanding of the multitude of process models and their purpose.

Moreover, the different elements of the process models, as well as the activities mentioned, were compiled among all identified articles and grouped together when possible. Finally, a unified model of the technology push process was created that encompasses the principles and related activities.

To answer the research question about the methods and their use in practice, the most important stage of the process was selected to focus the analysis of this study.

The selected phase is analyzed in greater detail in a second literature review. This includes both an in-depth look at the process articles of the first literature review as well as their references and an analysis of newly found articles by a new systematic search. This review not only serves to better understand the selected phase but also to identify appropriate methods and tools.

Lastly, a workshop format was designed that deals with the concrete implementation of the chosen stage of the process. A workshop was particularly well-suited because of three reasons: Firstly, elaborate methods can be shortened and tested in a smaller time frame. Secondly, it is standardized which makes it easy to repeat, evaluate and improve it continuously. Thirdly, it is a very productive format as it produces most results per time unit.

The workshop design outlines detailed steps of the phase and it follows design science principles. On top of that, success factors for technology push in general and for specific steps are employed to assess the final planning and to reflect on the results. Both design principles and success factors also support the choice of methods.

3 Unified Process Model of Technology Push

3.1 Quantitative Results and Citation Graph

The described approach resulted in 1057[1] search results over all search engines. The list was reduced by scanning the title (to 67), the abstract (to 28) and the content

[1]Several search engines could have produced the same results so this number includes duplicates. On top of that, Google Scholar alone resulted in 2900 hits, but only the first 500 were examined (and

(to 12). The subsequent citation analysis produced another 79 publications, so 91 in total, of which 65 describe process models.

The 42 publications from journals are predominantly from three journals in the field of technology and innovation management: Research-Technology Management, Journal of Product Innovation Management and Technovation. The other 23 publications are from conference papers, books, working papers and theses.

55 of the 65 publications derive new process models, the remaining 10 discuss process models on a meta level.

The citation analysis visualizes the reference structure of the domain. Thus, ideologically fundamental models can be identified by looking at articles that were cited the most. It might also be possible to derive why there are a plethora of models. Figure 1 shows the citation graph which was created by the igraph package in R using manual positional adjustments to improve visibility. It includes the 91 publications that either create their own process model or discuss domain models.

In general, the citation network is very sparse: The number of outgoing links ranges from 0 to 10. However, the median of outgoing links is only 1 and the mean 1.62. Merely six articles cite more than four articles that are also part of this network. Five articles are not at all connected to the main component, which comprises the remaining 86 publications. They were only found via the initial search.

Several reasons for the sparsity of the network can be found: Firstly, different authors use different terms, e.g. technology transfer versus technology push.

Secondly, only 15 process models (Arts, 2012; Bandarian, 2007; Bishop, 2004; Brilhuis-Meijer, Pigosso, & McAloone, 2016; Caetano, da Silva Araujo, Amaral, & Guerrini, 2011; Chiesa, Coughlan, & Voss, 1996; Högman & Johannesson, 2010; Kim et al., 2009; Maarse & Bogers, 2012; Pfleeger, 1999; Rasmussen, 2005; Souder, 1989; Souder, Nashar, & Padmanabhan, 1990; Watson, Goddard, & Fulcher, 2010; Whitney, 2007) are based on the literature and incorporate aspects or elements from other models.

Thirdly, there is a general lack of rigor with regard to how the literature review is executed: Arts (2012) and Brilhuis-Meijer et al. (2016)) are the only two publications that undertake a systematic literature review with a well-documented methodology. Eight articles (Eldred & McGrath, 1997a, 1997b; Farrukh et al., 2004; Glynn, 1990; Jolly, 1997; Lane, 2000; Mankins, 1995; Paul, 1987) do not conduct a literature review at all.

Finally, process models are created for different purposes and from different perspectives. For example, papers that highlighted the importance of management control might not cite an article that focuses on spin-off creation.

included in the number of results) because the last 100 of them were all completely irrelevant and the value of scanning all results was minimal.

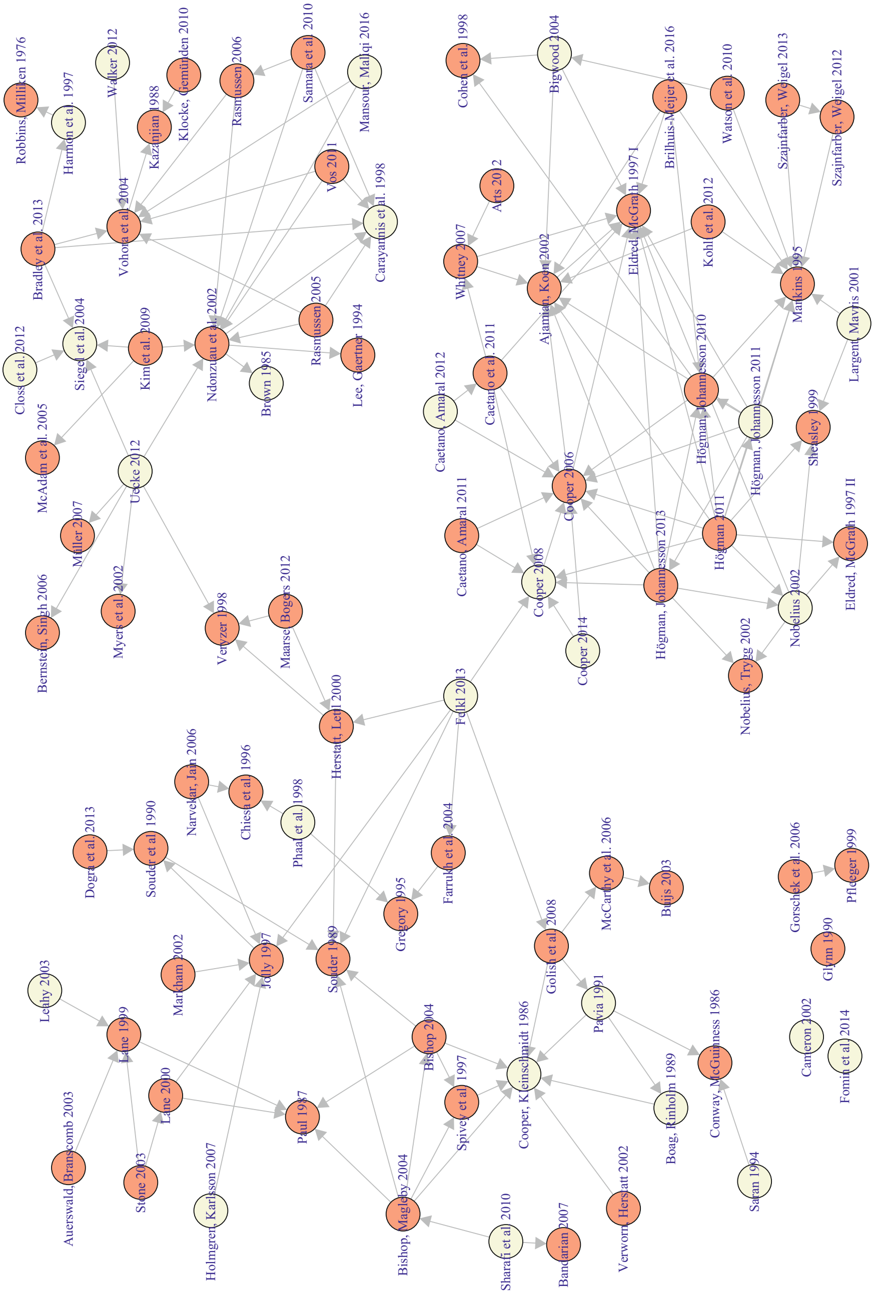

Fig. 1 Citation network graph. This graph shows the citation relationships between publications that create process models (red) and that deal with the process in general (white)

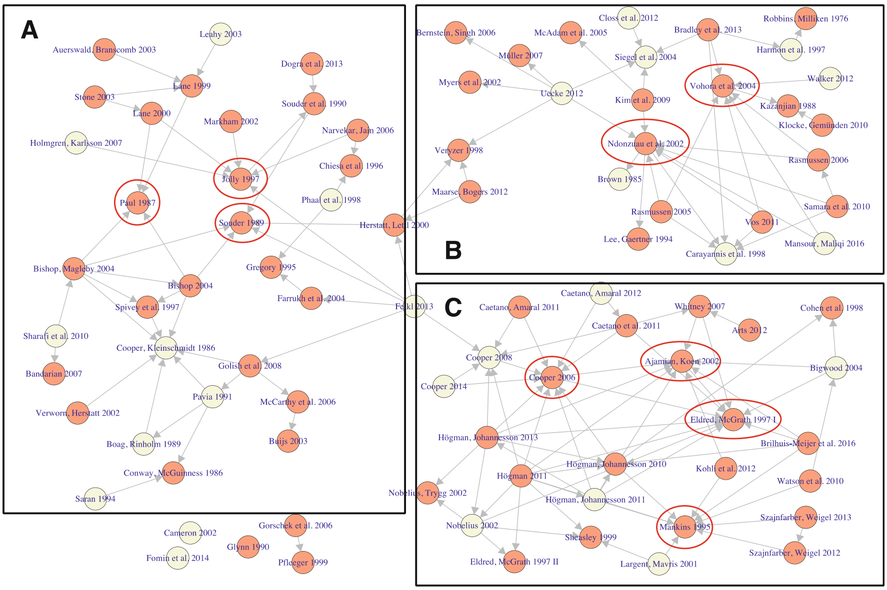

Fig. 2 The clusters in the citation graph. This graph shows the three clusters that are more strongly connected within themselves and their central publications circled in red

The citation graph shows three major clusters which are somewhat connected among themselves, but barely between each other. In fact, they are only connected through two dissertations (Felkl, 2013; Uecke, 2012), which have cited a lot of articles.

To understand principles and basic models, the most cited articles in each cluster are marked in red in Fig. 2.

The central articles in cluster A are Jolly (1997), Souder (1989), and Paul (1987). All three models are designed to understand and improve the technology push process. Jolly's model, in particular, incorporates the necessary stakeholder involvement in each stage and both Jolly and Souder highlight the iterative nature of the stages and the importance of technology-market-fit. Conversely, Paul's model is linear, but it also suffers from other problems: there is neither a methodology nor a literature review and stages like "do homework" are very vague. As a consequence, the paper is only cited by two authors (and four publications), which renders the paper less relevant.

Publications with a focus on university spin-offs are clearly concentrated in cluster B with 10 out of 13. Also, the two central articles by Ndonzuau, Pirnay, and Surlemont (2002) and Vohora, Wright, and Lockett (2004) deal with this topic. Although those two papers differ with regard to their phase relationship (linear and iterative respectively), they both focus on identifying critical issues and junctures to

Table 2 Elements of the central process models

Model source	Cluster	Phase structure	Context	Phases/activities
Jolly (1997)	A	Iterative	General	Imagining the dual (techno-market) insight, mobilizing interest and endorsement, incubating to define commercializability, mobilizing resources for demonstration, demonstrating contextually in products and processes, mobilizing market constituents, promoting adoption, mobilizing complementary assets for delivery, sustaining commercialization
Paul (1987)	A	Linear	General	Identify technology attributes, creatively identify possible customers/applications, do homework, validate with market research, test, launch
Souder (1989)	A	Iterative	Established firms	Characterization, embodiment, peripheral applications and substitute uses, internal fitting and broadcasting exercises, technology and market scanning, trial & re-trial processes, selection of target application(s), expanded Application Work
Ndonzuau et al. (2002)	B	Linear	University	Generate business ideas from research, finalize new venture projects, launch spin-off firms, strengthen economic value creation
Vohora et al. (2004)	B	Iterative	University	Research phase, opportunity framing phase, pre-organization, re-orientation, sustainable returns
Ajamian and Koen (2002)	C	Dynamic	General	(not defined ex ante)
Cooper (2006)	C	Linear	Established firms	Project scoping, technical assessment, detailed investigation, business case, development, testing, launch
Eldred and McGrath (1997a)	C	Dynamic	General	Product strategy, technology development, technology transfer, product development
Mankins (1995)	C	Linear	Space	Basic principles observed and reported, technology concept and/or application formulated, analytical and experimental critical function and/or characteristic proof-of-concept, component and/or breadboard validation in laboratory environment, component and/or breadboard validation in relevant environment, system/subsystem model or prototype demonstration in a relevant environment (ground or space), system prototype demonstration in a space environment, actual system completed and "flight qualified" through test and demonstration (ground or space), actual system "flight proven" through successful mission operations

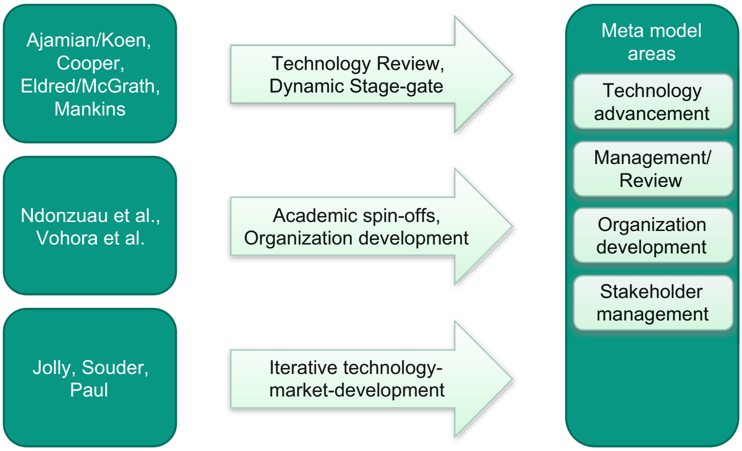

Fig. 3 Central principles and synthesis

overcome for university spinoffs. This includes the importance to create a team and establish an organization.

The focus of all four central articles in cluster C is to define the technology development process and to better manage and assess it. Cooper (2006) transfers his stage gate methodology from product to technology development, which is further refined by Ajamian and Koen (2002) and Eldred and McGrath (1997a) in their dynamic stage gate models. Mankins (1995) introduces the widely used Technology Readiness Levels that describe the maturity of a technology, which is also used outside the aerospace industry. Table 2 gives an overview of the phases mentioned in the papers.

Figure 3 summarizes the central articles in each cluster and the respective areas: technology advancement, management review, organizational development, and stakeholder management.

3.2 *The Unified Model*

The different models refer to a plethora of activities throughout the whole technology push process. In total, 379 activities are mentioned (counting duplicates) across models. After having removed duplicates, 24 very sector-specific activities like "preclinic" (Müller, 2007) and "university holds title to invention" (Bradley, Hayter, & Link, 2013) are excluded. The 320 remaining activities can be grouped together based on similarity, which results in 19 distinct groups of activities.

Based on the content analysis of the state of the art, one of our research questions was related to the description of a unified process model for the technology push

Table 3 Assignment of activities to process areas

Area	Activities
Technology advancement	Technology awareness, basic research, project scoping, characterization, application identification, application selection, technology development, prototype development, trial, product development, launch, growth
Management review	Strategic fit analysis, decide approval, post-launch review
Organizational development	Launch spin-off firm
Stakeholder management	Mobilize interest and endorsement, acquire financial resources, contact to potential buyers

process. The next parts show how the activities can be related to the principles mentioned above and how they can be systematized.

The 19 activities can be assigned to one of the four areas shown in Table 3.

The area of management review can be further enriched with the Technology Readiness Levels by Mankins (1995). Although they are not an activity per se, the concept is very important for this area. This is in line with Wiesinger (2016) and Brilhuis-Meijer et al. (2016)) who have also incorporated Technology Readiness Levels into their models.

To better understand the process, the technology advancement activities are used to derive main phases of the process. The four main phases are:

1. Preparation: Basic Research, Applied Research, Technology awareness, Project scoping
2. Technology-Application-Selection (TAS, name derived from Larsen, 2001): Characterization, Application identification, Application selection
3. Experimental development: Technology improvement, Prototype development, Trial
4. Product introduction: Product development, Launch, Growth

These main phases are derived by considering the foci of the different activities. The three first activities clearly focus on detection, planning and finding, whereas the next three activities subsumed under technology application selection explore and focus ideas. The next three activities deal with explorative development and testing. Lastly, the remaining activities are concerned with the development of a market-ready product, with close market relationships and market penetration.

The remaining activities from other areas can also be assigned to those main stages: In the management area, the strategic analysis is typically done during the phase where an application is chosen both to generate new ideas from strategy and to assess the strategic fit. The approval is decided upon tests with customers and the post-launch review is obvious. Stakeholder management activities can also be easily assigned: Interest and endorsement need to be generated when the application is selected. Before advanced prototyping can start, the project needs investments. Lastly, potential buyers have to be contacted before the launch to communicate the value and finalize the product. In the area of organizational development, spin-off firms are typically launched during the product introduction stage.

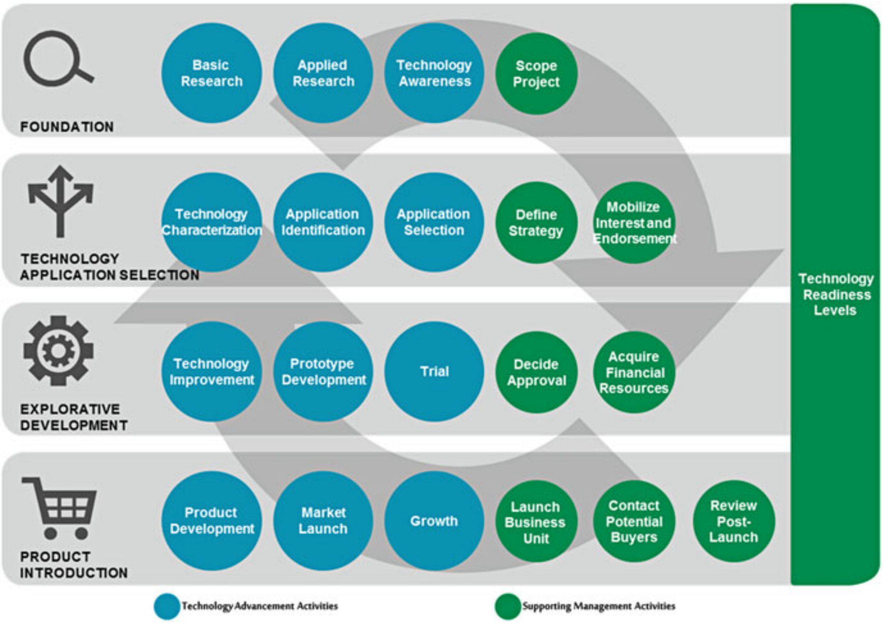

Fig. 4 The unified model of the technology push process

Figure 4 depicts the unified process model. The depiction is chosen to show progress and sequence, but we deliberately avoided linear arrows between the phases and instead put circular arrows in the background to indicate the iterative nature of the model.

3.3 Identification of the Critical Stages

As described in Sect. 2, the critical stages are defined to focus the effort to find and evaluate supporting methods and tools. A critical stage should be (i) of key importance for the success of a technology push process, (ii) potentially underserved in practical settings and (iii) easy to support with standardized methods that can be applied to a diversity of cases. The activities of the second main phase "Technology Application Selection" (TAS) (Characterization, Application identification, Application selection) fulfill all criteria very well: Firstly, their success is critical, since a poor match between technology functions and customer need is a reason for many delays in technology commercialization (Jolly, 1997, 9). Secondly, there are established systems for science and research for the foundation stage, industrial Research (the 'R' of R&D) for explorative development and industrial development and marketing units for the product introduction stage. The TAS stage linking the scientific and industrial world is typically challenging and often underserved.

Thirdly, TAS is generalizable across different fields of science and technologies as can be seen in the vast amount of literature that does not focus on a specific technology area, but in one way or another mentions this stage. Moreover, this stage is improperly treated in the literature (Felkl, 2013, 28) and methods are crucial to coping with the high ambiguity and uncertainty in the "fuzzy front end" of technology innovation (Felkl, 2013, 27–28). Lastly, TAS is unique to technology push as market pull innovation start with user needs in a fixed application area.

4 Operationalization of the Technology Application Selection Process

As pointed out in the previous section, TAS deserves a further analysis with regard to its operationalization. Success factors and design science principles are outlined that guide that implementation. Methods and tools are researched and an evaluated set is applied to a workshop design.

4.1 Success Factors

The literature offers a large amount of publications that analyze what factors in organizational processes contribute to the success of technology push innovations. The identified success factors and guidelines are used to derive criteria for method selection and to assess the quality of the workshop design.

Table 4 summarizes the seven guidelines contributed by Ozer (2005, 20–23). They define what is important when selecting ideas for the new products.

The last guideline is also supported by other authors who state that high-level management support (Herstatt & Lettl, 2000) and idea champions (Hüsig & Kohn,

Table 4 Ozer's guidelines

Guideline	Description
Comprehensive and holistic	Different viewpoints and approaches are needed to reduce risk.
Flexible	Rapid market changes have to be taken into account by choosing multiple viable ideas for different scenarios.
Dynamic and continuous	Repeated testing produces new information to incorporate.
User-friendly	The participants in the process have an equal understanding of the methods used and any employed criteria are explained.
Objective	The process is fair and balanced and no political agenda constitutes a major driver behind the process.
Learning-focused	The participants and the organization learn from the process and improve.
Implementation-oriented	Executives are involved and there is a commitment to implement the resulting solutions.

2003, 12) are important. Cross-functional teams might also help to increase the commitment across the whole organization instead of one narrow function (Herstatt & Lettl, 2000).

Moreover, suitable methods and tools significantly support the process (Hüsig & Kohn, 2003, 12), especially if they foster direct and informal communication (Herstatt & Lettl, 2000). A good balance has to be found between time for free thought on the one hand and milestones and project planning on the other hand (Herstatt & Lettl, 2000). At the start of the process, proper technology characterization is crucial because working knowledge of the technology is important to discover applications (O'Connor & Veryzer, 2001, 240).

The literature mentions several success factors with a particular focus on the last two stages of the TAS process. An entrepreneurial climate/culture lays the foundation for a successful application identification (Arts, 2012, 26; Hüsig & Kohn, 2003, 11). The people finding the application also play a major role: they need to be entrepreneurial minded (Arts, 2012, 26) and ideally have prior business experience (Vos, 2011, 35). In order to identify appropriate markets, one has to be sensitive to market needs (Wohlfeil & Terzidis, 2015, 9) and people from outside the organization might enrich the process (Arts, 2012, 26). Furthermore, it is useful if participants are aware of the core competencies of the organization so that the application ideas fit the organization (Arts, 2012, 26).

Whether the inclusion of customers is a success factor or even potentially misleading is an open debate: Hüsig and Kohn (2003, 8–9) argue that customer involvement leads to better product concepts and better screening of alternatives. Lead users might also help to define the product and guide technology development in the right direction (Herstatt & Lettl, 2000). On the other hand, customer inclusion may be problematic because it is not clear who the customer is and potential customers do not necessarily understand the technology, nor can they imagine the potential development paths (Herstatt & Lettl, 2000). Focusing on a customer segment might also prevent seeing completely new opportunities, which Christensen (2013) coined "Innovator's Dilemma". The customer might be more useful later during product development (Jolly, 1997, 40).

Let us turn to the selection process. A detailed evaluation is a very time-consuming process, which is why it makes sense to initially screen the ideas and determine which opportunity to investigate further (Arts, 2012, 34). Furthermore, the detailed evaluation should not be done by a single person, but by a diverse team of people from different backgrounds (Arts, 2012, 34).

4.2 Design Science Principles

Apart from success factors, design science principles also play a significant role in determining a good workshop design. In their article, Hevner, March, Park, and Ram (2004) define guidelines to be used when following the design science paradigm. Although their article is positioned in the domain of information systems, the guidelines can be applied to other contexts as well. In this work, the guidelines form the basis for the development of a workshop design concept in Sect. 4.4.

The following guidelines are specified (Hevner et al., 2004):

1. Design as an Artifact
2. Problem Relevance
3. Design Evaluation
4. Research Contributions
5. Research Rigor
6. Design as a Search Process
7. Communication of Research

Hevner et al. (2004) explain the guidelines in the following way: To fulfill the first guideline "design as an artifact", an artifact, e.g. a construct, a model, a method, or an instantiation, has to be created as a result of the research effort. Guideline 2 indicates that the (technology-based) solution needs to tackle a relevant business problem. The utility, quality, and efficacy needs to be demonstrated by using evaluation methods (guideline 3). The area of design artifacts, design foundations, and/or design methodologies must be enriched by the research project (guideline 4). To meet the requirements of guideline 5, the construction and evaluation need to be rigorously executed. During the search process available means need to be utilized to reach the desired aim (guideline 6). Lastly, the results are communicated to both technology-oriented and management-oriented audiences to meet guideline 7.

4.3 Methods and Tools

As pointed out in Sect. 4.1, methods and tools are crucial for a successful technology push development. They are less abstract and therefore they enable practitioners to advance their technologies. This section will outline different methods and tools found in the literature from a phase-specific view. Throughout the section, the word "participant" is used to describe those performing the method or using the tool.

With respect to technology characterization methods, the following tools were mentioned in the literature:

- Root cause method
- Voice of technology
- Technology Fact Sheet
- Technology Canvas

The root cause method tries to unfold knowledge and experience of the participants by asking several deeper-diving questions, e.g. "What laws govern its [the technology] performance?" (Nelson, 2005, 45–48).

Lyne's (2003) "Voice of technology" combines elements of a SWOT analysis with technological relevant aspects like intellectual property status and product/material. It is oriented towards established technologies as it also contains information about the method of manufacture.

The Technology Fact Sheet is a tool that allows to comprehensively describe a technology as it consists of six technological, four economical, four ecological and five social criteria (Wiesinger, 2016, 88).

The Technology Canvas is inspired by the elements of a patent and describes the most important information to characterize a new technological invention (Wiesinger, 2016, 87). Its elements are:

- Name: What is the technology called?
- Problem: What problem is solved by the technology?
- Technology Description: What is the main idea and how does it solve the problem?
- Technical benefits: What are the technical benefits of the technology?
- State of the art: What are current solutions for the problem? What are alternatives?
- Drawing: How can the functionality of the technology be depicted?
- Technical novelty: What makes the technology unique? How is it different from the state of the art?

Ideation methods often depend on ideation stimuli. There is a large number of creativity methods to generate new ideas. In the following, a selection is presented that was found in the technology and product development literature:

- Product Features Worksheet: identify unique capabilities, derive fitting customer needs, specify appropriate product features (Markham, 2002, 35)
- Trend analysis: current trends are derived from the technology features and used in conjunction with lead users (Henkel & Jung, 2009)
- Disney method: three roles (dreamer, realist, critic) view the problem from different perspectives (*InnoFox*, 2016)
- Emotive word analysis: unrelated elements are used as stimuli for new ideas (*InnoFox*, 2016)
- Method of analogies: inspiration by existing solutions for different problems (*InnoFox*, 2016)
- Brainwriting Pool: brainstorming in writing with a central pool of paper in the middle where idea sheets are returned to and then taken by other participants (*InnoFox*, 2016)
- Knowledge Café: different topics are discussed in each group of participants and groups rotate from topic to topic (*InnoFox*, 2016)
- Web search for competing products: web search helps to define one's competitive position and refine the idea (Lundqvist, 2014, 51)
- Focused brainstorming with Product Identification Matrix: technology characteristics are firstly matched against potential industries and then against potential products (Nelson, 2005, 57–69)

- Brainstorming can also be used, e.g. in conjunction with given industries (based on Nelson, 2005, 57–69)

Several techniques are based on or benefit from ideation stimuli, e.g. emotive word analysis, method of analogies, Knowledge Café. Examples for effective stimuli are 2D or 3D objects (Emma, 2008). Other possibilities are employed by Wohlfeil and Terzidis (2016) in a former workshop:

- Spontaneous associations
- Low cost application
- Natural phenomena
- Everyday life
- Decentralized use
- Extreme environmental conditions
- Combination with other technologies and megatrends

The last stimulus by Wohlfeil and Terzidis (2016) warrants some additional discussion. It is especially important to define whether the technology should be paired with other emerging technologies or whether it makes sense to combine it with existing technologies on the market.

Emerging technologies, e.g. to be found in the Gartner Hype Cycle (2016), can often grow parallel to the technology at hand. They also rarely have an established partner/supplier base so that market barriers are lower. Sometimes multiple technologies, as well as markets, need to develop in parallel (Balachandra, Goldschmitt, & Friar, 2004).

In contrast to emerging technologies, established technologies present a smaller risk of failure. The markets and needs are already established and thus, they are better understood.

As a first step of the evaluation, the most important information can be summarized in an Application Proposal (Wiesinger, 2016, 68). It contains the relevant elements for making a decision about the viability of the application idea:

- Title
- Problem/Application area
- Solution/Drawing
- Advantages/Disadvantages

As traditional market research methods are unreliable at best for technology push (Hellman, 2007, 85), a simple utility analysis provides a good educated guess, which Wiesinger (2016, 69) operationalized in an Idea Scorecard.

A more elaborate and systematic method to evaluate a technology application is the Technology-Utilization-Model, which assesses whether a technology fits a certain task (Hartelt, Wohlfeil, & Terzidis, 2015). An important visualization is the value profile (profile of customer need fulfillment), where several technologies can be compared regarding their fulfillment level of certain customer needs. This is useful to evaluate whether and where the new technology provides a significant advantage.

Table 5 Method selection criteria

Selection criterion	Derived from	Further explanation
Understand technology	Characterization is crucial (O'Connor & Veryzer, 2001, 240)	
Easy to understand	User-friendly (Ozer, 2005, 20–23)	User-friendliness is divided into two criteria because both the passive and the active understanding of a method is important.
Easy to repeat	User-friendly (Ozer, 2005, 20–23)	
Comprehensive perspective	Comprehensive and holistic (Ozer, 2005, 20–23)	
Multiple markets	Flexible (Ozer, 2005, 20–23)	If ideas are situated in multiple markets, the technology is a lot more flexible.
Atmosphere	Entrepreneurial climate and atmosphere (Hüsig & Kohn, 2003, 11)	
Comprehensive criteria	Different perspectives are required (Arts, 2012, 34; Nelson, 2005, 32)	A well-balanced set of criteria has to be chosen.
Needs awareness	Sensitivity to market needs (Wohlfeil & Terzidis, 2015, 9)	
Implementation	Implementation-oriented (Ozer, 2005, 20–23), idea champions (Hüsig & Kohn, 2003, 12)	

A very similar method is the Technology Choice Tool, which simply uses a radar plot as its visualization instead of a profile line (Felkl, 2013, 233).

In later stages, when the customer is already known to some degree, focus groups might make sense to better understand their needs (Roberson & Weijo, 1988, 29). As mentioned before, the process is iterative and results gained in earlier stages may be refined in later stages with complementary methods.

Table 5 shows the criteria for method selection and shows how they were derived from the different success factors and guidelines of Sect. 4.1.

Moreover, there are four criteria for the workshop as a whole that cannot be applied to specific methods:

- Use of suitable tools and methods (Hüsig & Kohn, 2003, 12)
- Balance between free thought and planning (Herstatt & Lettl, 2000)
- Two-step evaluation process (Arts, 2012, 34)
- Direct and Informal communication (Herstatt & Lettl, 2000)

There are other criteria that cannot be influenced by methods. These include criteria of participants selection, e.g. cross-functional teams (Herstatt & Lettl, 2000), and organizational factors like high-level management support (Herstatt & Lettl, 2000). Moreover, it depends on the method execution whether it is learning-focused and/or objective instead of biased (Ozer, 2005, 20–23). Finally, a method cannot be dynamic and continuous (Ozer, 2005, 20–23) in itself, but it has to be repeated over a certain time span (e.g. after a month).

4.4 Design of Workshop Format

A workshop is an interesting format for the TAS process since it is possible to cover most activities in a 2- or 3-day time window. In the following, the objective and results of the workshop format are outlined as well as the method selection. The last part discusses whether the workshop design follows the guidelines and whether it is likely to provide the success factors.

The objective of the workshop is to enable practitioners to generate ideas about possible applications of a given technology, to methodically evaluate the alternatives and to select a small subset for detailed investigation. The results are documents that characterize the technology, an evaluated list of potential customer-application combinations and a selected subset of applications.

A specific method for every phase has to be chosen. To perform this selection, a utility analysis was conducted. For each stage, a subset of criteria from Sect. 4.3 was chosen as well as weights. Then, a score was given on a scale from 5-point Likert scale.

The criteria are not appropriate for each stage since they have a specific focus that is not relevant all the time. Only the criteria "easy to understand" and "easy to repeat" are applicable throughout all stages.

Only four of the defined criteria make sense for the characterization phase:

- Understand technology
- Easy to understand
- Easy to repeat
- Comprehensive perspective

Based on the scoring, the Technology Canvas is best-suited method especially because it is easy to understand and to repeat.

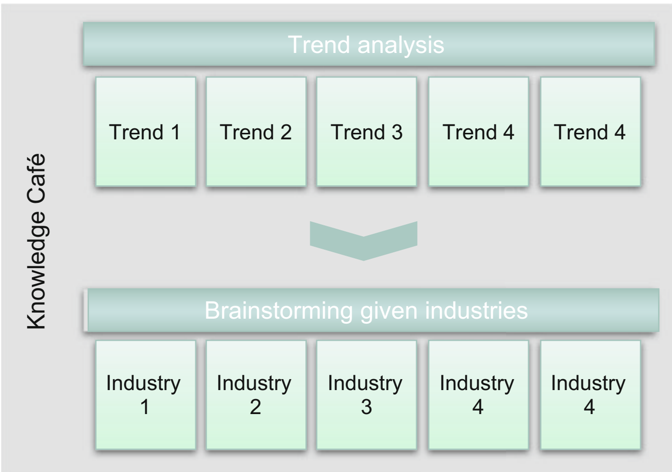

Fig. 5 Method composition in the ideation phase

To evaluate ideation methods all nine criteria are applied except "understand technology" and "comprehensive criteria" since they are specific to the characterization and evaluation phase respectively.

The evaluation result in highest scores for the following methods:

- Product Identification Matrix
- Brainstorming given industries
- Knowledge Café
- Trend analysis

They are all either very easy to use, very comprehensive and/or well-suited for the specific task. As the first two methods are fairly similar, it does not make much sense to do both in one workshop. As "Brainstorming given industries" is rated higher, it is selected.

The resulting two-step process is depicted in Fig. 5: In this process "Trend analysis" and "Brainstorming given industries" are the two perspectives. In each of those two process steps, a Knowledge Café of a certain number of stations is employed. The number of stations depends on the available time for the workshop.

The utility analysis reveals that the Technology-Utilization-Model and the Idea Scorecard are the most suitable tools. As the evaluation should be done in a two-step process, the idea scorecard is used first to perform a broad screen. Afterward, the Technology-Utilization-Model helps to thoroughly investigate the remaining alternatives.

Firstly, the workshop operationalizes the TAS process since it comprises all three major steps. Secondly, it also adheres to a strong degree to the principles and guidelines outlined in Sects. 4.1 and 4.2 as discussed in the following.

The different methods were selected partly based on the guidelines by Ozer, which is why the following section focuses on the workshop as a whole.

Comprehensive and holistic
The whole TAS process is depicted, although not every method can be shown in this format. During ideation, different creativity stimuli are employed to provide a more comprehensive view.

Flexible
The evaluation process is effectively a funnel of methods that become more and more specific. They yield a decreasing number of ideas each evaluation step. The last step features an evaluated list where multiple ideas are viable in different scenarios. This implies that the initial choice of application idea can easily be reverted by a similarly viable idea in case of market changes or if the idea does not prove to be a success.

Dynamic and continuous
A short workshop cannot deal with market dynamics and continuous improvement. However, the general moderation and introduction to the methods can highlight their importance. Thus, the guidelines are followed as much as possible, but the fulfillment remains on a theoretical level.

User-friendly

In every step of the process, methods were chosen based on their user-friendliness, which indicates that this guideline is strongly followed.

Objective

Since the methods used are standardized and political agendas should not play a role, the workshop is very objective.

Learning-focused

Whether the workshop is focused on learning depends to a large degree on the concrete execution as pointed out in Sect. 4.3.

Implementation-oriented

The criteria used in the evaluation step of the TAS process are oriented towards an implementation on a relevant market, which is why the resulting ideas should satisfy this guideline.

As discussed in Sect. 4.3, four out of the irrelevant criteria were not used for method selection because they can only be applied to the workshop as a whole. These are discussed in the following:

Use of suitable tools and methods (Hüsig & Kohn, 2003, 12)

The workshop uses well-defined methods and tools in every phase of the TAS process. They were selected based on success factors and guidelines for the specific phase, which should lead to suitable methods.

Balance between free thought and planning (Herstatt & Lettl, 2000)

The ideation phase leaves plenty of room for free associations and thoughts. On the other hand, the evaluation and selection process allows to quickly converge to a small set of possible applications. This allows for a good balance between free thought and planning.

Two-step evaluation process (Arts, 2012, 34)

This success factor is realized since the evaluation consists of two methods: a broad screen with the Idea scorecard and an in-depth evaluation with the Technology-Utilization-Model.

Direct and Informal communication (Herstatt & Lettl, 2000)

Although it is not directly touched upon, direct and informal communication can be realized by sufficient breaks between the different methods. It should also be encouraged to talk freely and openly during brainstorming sessions.

Guideline 1: Design as an artifact

The first principle is fulfilled since the workshop concept consists n instantiation of a method selection and all methods are well defined.

Guideline 2: Problem relevance

TAS is very relevant for technology push, which in turn is relevant in general to create (radical) innovations. Its operationalization, in particular, is very important.

Guideline 3: Design evaluation
In order to deal with the third guideline, the last section described the derived criteria and how well they are considered in the workshop design.

Guideline 4: Research contribution
TAS is an under researched area, particularly with respect to concrete operationalization. This workshop concept and its evaluation is, therefore, an important research contribution.

Guideline 5: Research rigor
The workshop concept was constructed with methods and evaluation criteria that were systematically derived from literature, which represents significant rigor with respect to a workshop design.

Guideline 6: Design as a search process
The design was a search process since its theoretical base is grounded in an intensive search in the literature. Moreover, former experience and existing practical tools were incorporated. The design will be continuously reviewed and adjusted after each execution.

Guideline 7: Communication of research
This guideline was realized by a presentation of the workshop design at a conference.

5 Conclusion

In the following the four research questions that formed the basis of this study are discussed. This summarizes this study and its various sections.

55 publications were reviewed that created their own technology push process model. In the sparsely connected citation network, three major clusters were apparent. By analyzing the underlying principles and model structures, four areas were derived: technology advancement, management review, organizational development, and stakeholder management. The 19 activity clusters were assigned to one of those areas and synthesized in the unified process model that shows both the linear progress and the iterative nature of technology push.

The Technology Application Selection process was chosen as the focus. Methods were identified for the three steps technology characterization (four methods), application identification (ten methods), and application selection (four methods) and evaluated based on guidelines and criteria from the literature.

A workshop format was designed that provides a method choice based on a utility analysis. The format was tested in a case example. A detailed description can be found in the master thesis of Leonid Vogel.

Implications are discussed for three major stakeholders: researchers, managers/technology transfer offices, and inventors/founders.

This study establishes an understanding of different process models and their link structure. Moreover, the unified model provides a good overview that enables researchers to further adapt their process models to specific purposes and contexts. The unified model also improves their understanding of the different underlying principles that guide the development of the existing plethora of process models. Furthermore, the method selection approach can be reused in other process steps to provide a complete picture of methods in technology push development.

The unified model contributes to the relevance of the dynamic nature of technology push, which is important to understand as a manager of technology processes. This study also provides an overview of methods for the different phases of the TAS process. Moreover, the workshop format can be directly applied by universities and laboratories to improve their technology push development.

The unified model shows the direction a technology takes during its early development and what activities help it to advance. The synthesized guidelines and success factors guide the technology development and improve its results. The workshop design also helps investors to perform TAS if required.

Of course, this work is not without limitations. The literature review focused solely on technology push and transfer publications although the market pull and new product development literature might have contained valuable insights. However, there were simply too many of them so a focus was required. Moreover, possible relevant articles were missed due to the smaller number of complex exact matches in meta search engines. A search with unquoted terms on a journal-per-journal basis might have yielded other results.

On top of that, the workshop is not thoroughly evaluated empirically, which is necessary to prove its effectiveness in everyday use.

In order to properly validate the workshop, quantitative data across a multitude of cases is required. Experimental settings could help to test the effectiveness of certain methods and method parameters.

Furthermore, a longitudinal study would complement the short workshop well as a larger part of the process would be analyzed. This might uncover other methods to be suitable. This longitudinal study could also encompass other main stages (other than TAS) and possibly develop workshop formats for those stages as well.

A more statistical approach could provide additional insights that analyzes how much time is spent in each activity and what sequence of activities is most probable.

Finally, methods for technology push could be united and enriched with methods from market pull frameworks like Design Thinking. This will enable not only a usage of widely-accepted and refined tools, but it might also enrich the understanding of innovation processes as a whole.

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Part III
Factors Influencing NTBFs

Women-Led Startups and Their Contribution to Job Creation

Katherina Kuschel, Juan-Pablo Labra, and Gonzalo Díaz

Abstract Purpose: Given the scant literature of female founders in technology ventures, and scarce evidence of Latin American startups, we have examined gender similarities and differences between male and female-led teams regarding their business stage, growth expectations, strategic vision skill, and team composition.

Design/methodology/approach: A unique online survey was sent to male and female founders via email and social networks, out of which a total of 199 responses were analyzed using tools for descriptive analysis and mean comparisons. We deliberately sought for a greater proportion female founders from Latin American countries. The respondents were surveyed on their individual and startups characteristics.

Findings: We have found (1) no significant gender difference in business stage, (2) slightly fewer growth expectations among women, compared to men, although not significant, (3) slightly less strong skill of strategic vision among women, compared to men, (4) female-led teams are smaller than male-led teams, both diverse teams in terms of employees' gender, and (5) male- (73%) and female- (55%) led teams create further jobs than the minimum team size.

Originality/value: This study discusses the findings on gender differences (growth expectations, strategic vision, team-building) in relation to the discussion on whether startups create employment or not. According to our results, both male and female-led startups create jobs.

Keywords Startups · New high-technology ventures · Gender differences · Team size · Team composition · Latin America

JEL Codes L26 entrepreneurship · M13 new firms and start-ups · L1 firm strategy

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1 Introduction

"Business creation contributes to economic development" is a statement that has been often mentioned in the entrepreneurship literature. The general assumption is that small businesses create value and jobs (Acs & Audretsch, 1988; Schumpeter, 1934). Moreover, it was found that opportunity entrepreneurship has a positive significant effect on economic development, whereas necessity-driven entrepreneurship has no effect (Acs & Varga, 2005). Aligned to this statement, many countries have implemented policies for fostering an entrepreneurial culture for encouraging business creation and economic development. Accordingly, to the increasing female participation in entrepreneurship (Brush, 1992; Minitti, Arenius, & Langowitz, 2005), there is growing research interest in the dynamics and economic impact of female entrepreneurship (Zinger, Lebrasseur, Robichaud, & Riverin, 2007). Latin American countries have higher rates of entrepreneurial activity among women. Terjesen and Amorós (2010), using GEM data, demonstrate the role that formal and informal institutions have in improving the quality and quantity of female entrepreneurs.

In spite of their many contributions, SMEs are characterized by high failure rates and poor performance levels (Jocumsen, 2004). Startups share similar characteristics. Shane (2009) argued that the typical startup is not innovative, creates few jobs, and generates little wealth. According to Isenberg (2016), a large majority of startups fail, and only some of them survive and create jobs in this increasingly competitive international environment. On average, a startup in the UK reaches only $180,000 in revenues after its sixth year, barely enough to pay salaries (Coutu, 2014). Moreover, two thirds of the jobs created by startups in Denmark are low-skilled service jobs (Kuhn, Malchow-Møller, & Sørensen, 2016).

And for the last couple of years, there has been a discussion whether "startup creation contributes to economic development". Are startups creating value? Are startups creating jobs? Do women-led technology ventures perform differently than men-led startups?

This study explores the characteristics of male- and female-led new high technology ventures, shedding light to the question: are women-led startups creating jobs?

First, our work reviews the relevant literature related to a particular measure of performance that is important for economies development: job creation.

Our study contributes to the evidence on job creation of new high-technology business. This study discusses the findings on gender differences (growth expectations, strategic vision, team-building) in relation to our results: both male (73%) and female-led (55%) startups create jobs.

2 Literature Review

This literature review summarizes previous research that informs this study, on the topics of gender differences on startup performance and growth expectations, and job creation.

2.1 Women-Led Startups and Women's Growth Expectations

Women participation in the technology industry remains low. While only 5% of high technology entrepreneurs who received private funding in 2008 in the U.S. were women (Robb & Coleman, 2009), recently, the Startup Genome Report (2015) identified that the global average of startups with female founder was 18% in 2015, and 10% in 2012. This low female participation also exists in emerging countries. For example, 15% of technology ventures benefited by Start-Up Chile acceleration program were led by women (Kuschel and Labra, forthcoming). This number is becoming the "new norm".

Women are just as likely as men to desire growth, although women seem to have less prior business ownership experience and less freedom from domestic responsibilities, and are less likely to measure success by the size of their firms (Cliff, 1998). Research on the dynamics and economic impact of female entrepreneurship is important because there is a marked difference between men and women in high-growth businesses (Gatewood, Brush, Carter, Greene, & Hart, 2009) and more research should be done in developing countries (De Vita, Mari, & Poggesi, 2014; Kuschel & Lepeley, 2016a).

Despite growing participation of women in the public arena, still studies report that women have less access to financial resources (De Bruin, Brush, & Welter, 2007; Gatewood et al., 2009; Marlow & Patton, 2005), less quality and diversification in their product and services (Bulanova, Isaksen, & Kolvereid, 2016; Costin, 2012), and a less qualified team (Costin, 2012), which determine their business performance and potential for growth.

Gender differences on access to financial capital has been well studied since the creation of the Diana Project (Gatewood et al., 2009). According to Eddleston, Ladge, Mitteness, and Balachandra (2016), capital providers reward the business characteristics of male and female entrepreneurs differently to the disadvantage of women. Women normally obtain significantly less financial capital to develop their new businesses (Alsos, Isaksen, & Ljunggren, 2006), which is critical in early stages, particularly for technology ventures (Alsos & Ljunggren, 2017; Kuschel, Lepeley, Espinosa, & Gutiérrez, 2017).

A possible explanation to this "underperformance hypothesis" is the social expectation. Women are expected to play a primary role as mothers and caregivers. Consequently, women in business receive little support from the family (Bogren, von Friedrichs, Rennemo, & Widding, 2013; Venugopal, 2016) and are still doing most of the household chores (Office for National Statistics, 2016). This fact may impact on women's ability and time horizon for strategic planning (Mitchelmore & Rowley, 2013).

Women have less time available to devote to the business (Marlow & Patton, 2005) and to participate in exhibitions and events (Greene, Hart, Gatewood, Brush, & Carter, 2003) and networks (Kalafatoglu & Mendoza, 2017; Surangi, 2015; Wing-Fai, 2016).

2.2 *Job Creation: Team Size as a Measure of Growth*

There are a number of ways in which we can measure the growth of a company (e.g., sales, workforce, market share, book value, cash flow, etc.), and no "best way" to do so. The most common SME's measures for growth are sales and number of employees. However, startups do not necessarily have sales (they have enough "traction" to get investment), and they might not even have employees (either the founding team absorbs the entire workload, or they hire "freelancers"), particularly in their earlier stages. Performance comparison among startups is a tough task. Often, they require different amounts of investment to develop a product which highly depends on their level of progress (stage) and industry.

In our exploratory study, we focus on the founding team, because it has been shown that the team size and composition is critical for a startup success (Baum & Silverman, 2004; Kaiser & Müller, 2015; Li, 2008).

A cross sectional study among startup teams participating in Start-Up Chile acceleration program, showed that those teams led by men are bigger than teams led by women (Kuschel and Labra, forthcoming). Most of them were startups in their earlier stages, that haven't still scaled their sales, nor studied in a longer period of time of 3 or 5 years to explore the survival bias. Kuhn et al. (2016) studied the job creation and job destruction of startups and established firms in different industries and job types in Denmark. They developed a "surplus job creation" measure. Based on the idea that startups and small firms are not identical, although startups are typically small, and small firms are often young, their results illustrated that new firms can account for the entire net job creation in the economy, regardless their size and industry. Similarly, in order to compare job creation by women- versus men-led startups, we measured jobs that have been created beyond the minimum team size of a startup.

3 Theoretical Framework

3.1 Homosociality: An Explanation to Team Composition and Size

Human capital is a critical factor for young successful companies (van der Sluis, van Praag, & Vijverberg, 2008), and not only the level of human capital, but also the diversity among the team members may affect performance positively (Hambrick, Cho, & Chen, 1996). These studies suggest that there are beneficial outcomes from skills heterogeneity or diversity for young business success.

A heterogeneous composition of the top management team (TMT) may increase creativity, which in turn increases the odds of making innovative and strategic decisions (Bantel & Jackson, 1989; Barkema & Shvyrkov, 2007; Beckman, Burton, & O'Reilly, 2007; Talke, Salomo, & Rost, 2010; Wiersema & Bantel, 1992). It has been found that heterogeneous teams behave in a more innovative way, entering to new markets, compared to homogeneous TMT (Boeker, 1997a, 1997b).

New venture team heterogeneity is associated with both cognitive conflict and affective conflict (Kaiser & Müller, 2015). Education and prior wages heterogeneity of the team is positively associated to cognitive conflict, as it avoids group think and leads to a variety of perspectives. Moreover, age heterogeneity is associated with affective conflict which is negative and leads to problems in communication and decision making. Age is a relationship-oriented characteristic and hence may lead to affective conflict, while prior wages and education constitute task-related characteristics which are more closely linked to cognitive conflict.

Existing empirical evidence does not, however, clearly suggest that there are beneficial effects of skill heterogeneity for the success of young firms. It rather by and large shows that there is a weak positive but often a statistically insignificant link between skill heterogeneity and performance (see the reviews and meta-analyses by Bell, Villado, Lukasik, Belau, & Briggs, 2011; Bowers, Pharmer, & Salas, 2000; Horwitz & Horwitz, 2007; Webber & Donahue, 2001; Williams & O'Reilly, 1998). But according to a study conducted in the U.S. by First Round Capital (2015), startups with at least one women in the TMT have had 63% more success than those startups with only men in their TMT.

But contrary to team heterogeneity, the homophily—"the tendency of agents to associate disproportionately with those having similar traits" (Golub & Jackson, 2012: 1287)—may also play a role during the earlier stage of a company. For example, new venture's initial network ties are precisely formed by the entrepreneurs' assessments of the resource's value, but this process is amplified by age and gender similarity. Copreneurial teams in technology ventures normally met each other during their undergraduate education, therefore they have the homogeneous set of skills and knowledge (Kuschel & Lepeley, 2016b). This type of TMT can result in a less qualified team with lack of organization and planning (Davidsson, Achtenhagen, & Naldi, 2010) which affect growth potential.

These arguments on the benefits of a heterogeneous team conflict with the homosociality framework. This paradox raises the question whether women will tend to look for similar traits rather than pick the best talents for their startups partners and employees.

4 Methodology

4.1 Design and Procedure

We have built a survey both in English and Spanish using the platform Qualtrics. That survey was distributed on-line among many accelerators and networks of entrepreneurs via mailing in Chile (Start-Up Chile, UDD Ventures, Wayra, ASECH, ONG Emprendedoras de Chile, Girls in Tech Chile, Women who Code Chile), social networks (Facebook, Twitter and LinkedIn), and some international networks (Mujeres del Pacífico, business schools, and accelerators abroad, such as Endeavor Uruguay, IESA Business School in Venezuela, and the Universidad de San Andrés in Argentina), during 2015.

Both versions of the survey included a consent form at its beginning. Average time for completing the survey was 26 min. The participation was voluntary and it has an incentive of participating in a contest of one US$100 Amazon Gift card, if the survey were fully completed.

4.2 Measures

The survey included questions regarding the participants' characteristics (e.g., skills, computer language knowledge, country of origin, gender, age, motivation to start up a business) and the startup characteristics (e.g., team size, team composition, type of product, industry, business stage, growth expectations).

4.2.1 Growth Expectations

Expectations to grow the business was measured by the question "Does your business scale?" Five possible answers were:

- No. You add operating costs (sales force, marketing, administrators, R&D) at the same rate you grow revenue.
- Yes. You add sales (new markets, new lines of product, new businesses), that requires relatively smaller and smaller additions to operating costs.
- Does not apply.
- No. It's too soon.
- No. I prefer to have control over the business. If it's too big, it's difficult to manage it.

The small business literature suggests that women business owners prefer to grow slowly or remain small (Morris, Miyasaki, Watters, & Coombes, 2006). We expected similar proportions of the results among men and women but we also expected a higher proportion of women answering the stereotype: “No. It’s too soon”, and “No. I prefer to have control over the business. If it’s too big, it’s difficult to manage it”.

4.2.2 Strategic Vision

Strategic vision was measured with a single item: “I can scan the marketplace and assess potential needs and gaps”. Participants should assess their skill level as “need improvement, average, or strong”.

4.2.3 Business Stage

The measure of the business stage is the same used by the Global Entrepreneurship Monitor, GEM. The stage before the start of a new firm is called nascent entrepreneurship (0–3 months) and the stage directly after the start of a new firm is called owning-managing a new firm (4 months to 3.5 years). The distinction between nascent and new firms is made by GEM in order to determine the relationship of each to national economic growth. Taken both stages together this phase is defined as “total early-stage entrepreneurial activity” (TEA). Owner-managers of established firms have been working in their business by more than 3.5 years, which is the last category of business stage.

4.2.4 Team Composition

We have measure team composition according to both number of co-founders and employees, by gender.

4.3 Inclusion Criteria

There was a total of 1177 surveys completed. We have left out from the sample; (1) 587 participants that did not declare their gender, (2) 216 participants that were only employees and, therefore are not running an active venture, (3) 151 participants that run a non-technology business or that do not require a software engineer or programmer for its operation, and (4) 24 outliers.[1] After that filter, 199 effective surveys were ready for analysis.

[1]We have considered as “outliers” participants who didn’t declare the number of co-founders or declare 0 co-founders, and/or more than 150 employees.

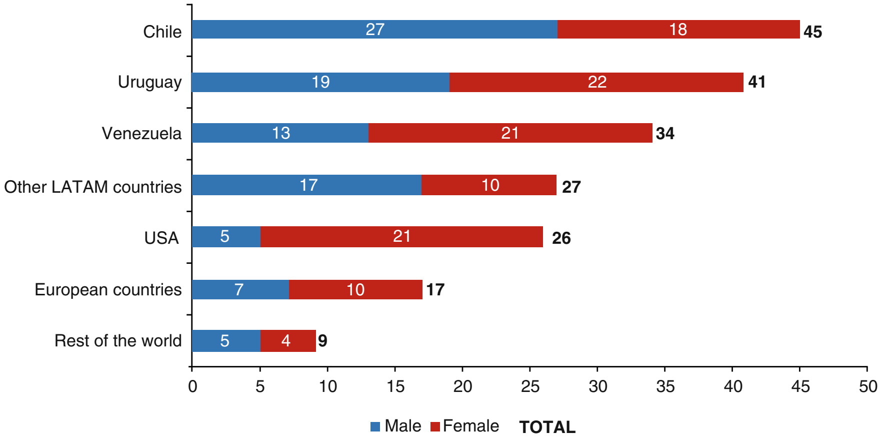

Fig. 1 Gender distribution by country

4.4 Sample Description

4.4.1 Country and Gender

Most individuals that participated in the survey were originally from the following countries: Chile, Uruguay, Venezuela, and United States. Figure 1 shows the country distribution of the sample, according to gender. Latin American countries represent the 73.8% of the sample.

According to Fig. 2, 53% of the sample were female (n = 106) and 47% male (n = 93).

These descriptors are the reflection of our active intention to collect data from female participants, i.e., women-led startups from Latin America.

4.4.2 Industry

According to Fig. 3, the main industry of this sample was IT and Software, for both male and female founders.

4.4.3 Product

The three main product categories (see Fig. 4) for this sample were: (1) software and web applications, (2) service and tangible, and (3) software for mobile devices.

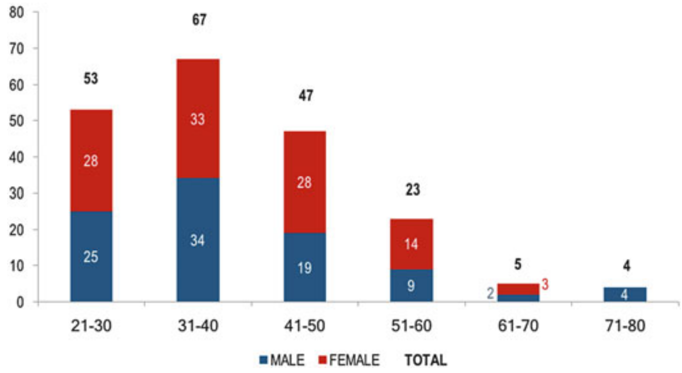

Fig. 2 Gender distribution by age

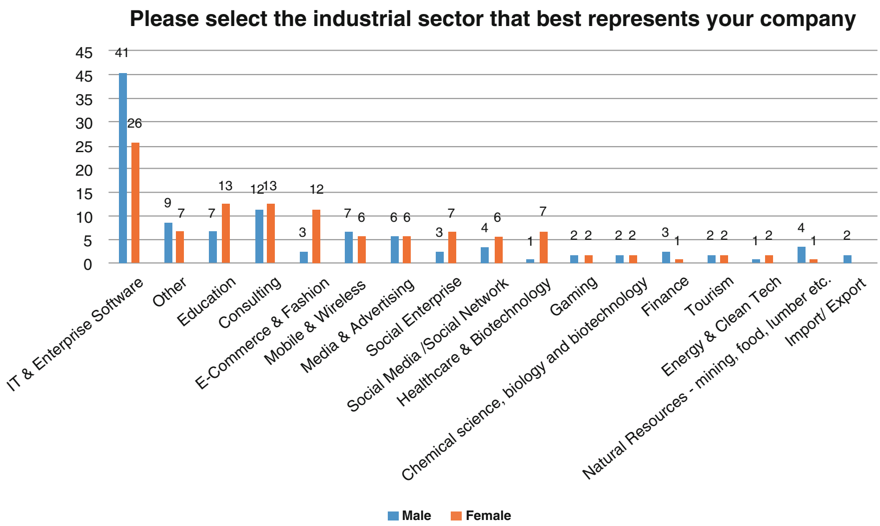

Fig. 3 Industry distribution by gender

4.5 Analysis

Data was downloaded from Qualtrics and analyzed using Microsoft Excel. First, we have conducted a descriptive analysis, and then, we have performed mean comparisons.

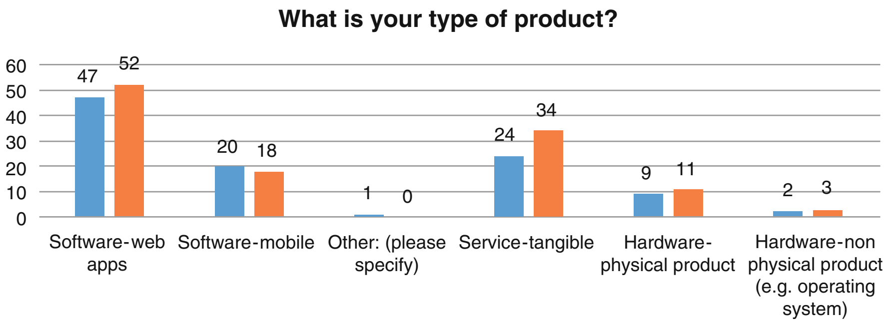

Fig. 4 Type of product

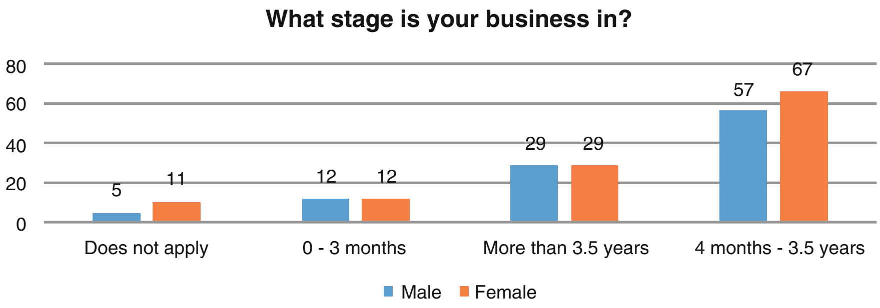

Fig. 5 Business stage by gender

This study structured the results in five major topics.

1. Business Stage
2. Growth expectations
3. Strategic vision
4. Team formation

5 Results and Discussion

5.1 *Business Stage*

Most of the sample report that their business is in the second stage (4 months to 3.5 years), but still not an established stage (more than 3.5 years) (see Fig. 5).

The gender distribution shows similar proportions of ventures for male (55%) and female founders (56%) in the business stage from 4 months to 3.5 years (Fig. 6).

According to this result, most of men (55 + 12 = 67%) and women (56 + 10 = 66%) are working on an early stage of their business.

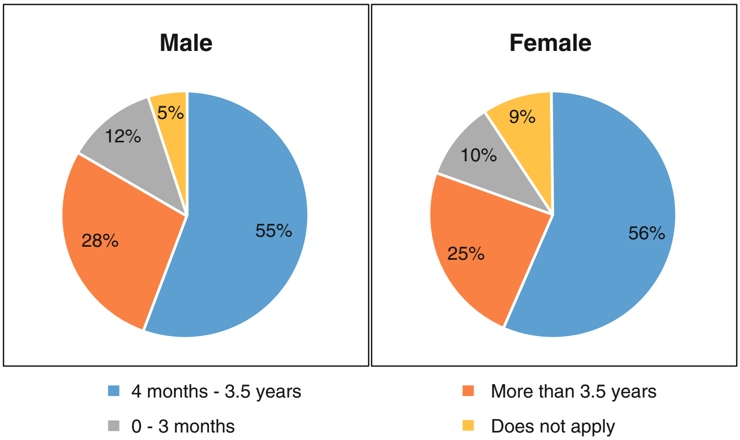

Fig. 6 Proportion of business stage by gender

5.2 *Growth Expectations*

Although female founders have high levels of commitment, they have slightly lower (52%) expectations to scale their business than male founders (58%) (Fig. 7).

Altogether, the proportion of women that don't have growth expectations (6 + 8 + 27 = 41%) is higher than men (13 + 6 + 15 = 34%). We perform a mean comparison analysis to assess whether this difference was significant (Table 1), resulting in non-significant difference between means ($p > 0.05$).

5.3 *Strategic Vision*

Strategic vision is a skill that has been measured with the question whether the participant can scan the marketplace and assess potential needs and gaps. Participants self-assessed their level of development (need improvement, average, or strong) of that skill (Fig. 8).

More than the half (54%) of male founders report that their level of this skill is strong, compared with a 42% of women (Fig. 9).

5.4 *Team Composition*

There are differences on how men and women build their teams, both at the management level (co-founders), and their employees (or freelancers). In our study, 199 startup founders answered the survey, indicating their team size and the

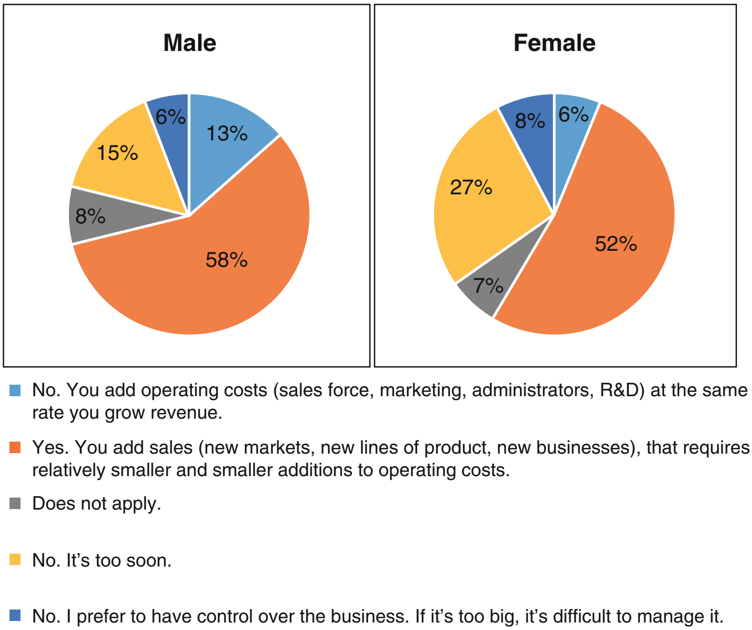

Fig. 7 Distribution of scaling expectations by gender

Table 1 Mean comparison analysis

	Male	Female
Mean	2.4231	2.5918
Variance	1.1785	0.9966
Observations	104.0000	49.0000
Hypothesized mean difference	0.0000	
df	151.0000	
t Stat	−0.9200	
P(T ≤ t) one-tail	0.1795	
t Critical one-tail	1.6550	
P(T ≤ t) two-tail	0.3590	
t Critical two-tail	1.9758	

number of co-founders that participated in the team. A preliminary analysis of team composition yielded the following results:

Our sample had an average of 8.5 team members, having on average 2.3 founders and 6.2 employees. A view per gender of the founder revealed that males had larger team sizes, in terms of number of co-founders and number of employees, versus female founders.

To analyze job creation as a variable, we excluded from the analysis those teams whose total number of members was equal to the number of co-founders (that is, a

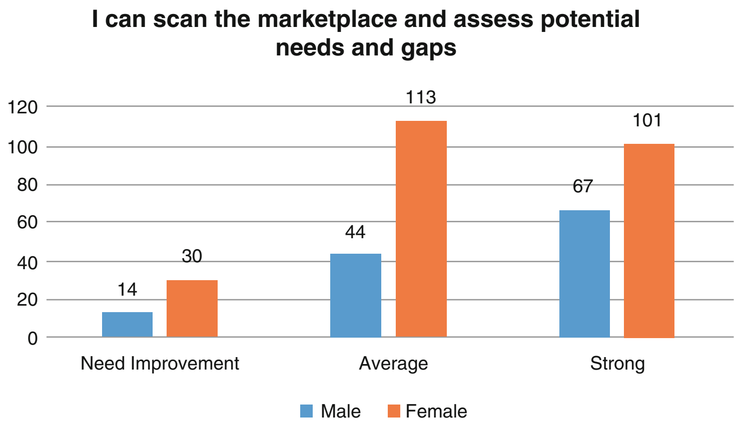

Fig. 8 Strategic vision by gender

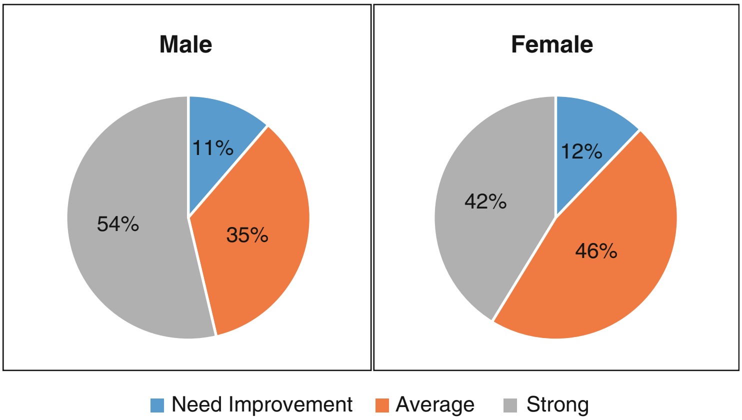

Fig. 9 Proportion of strategic vision by gender

team of five members comprised of five cofounders does not generate jobs). We also excluded those cases where the total number of members in the team was three or less than three, considering that independently of the fact that a team of three may be comprised of one founder and two employees, or two founders and one employee, we established three members as the minimum size required to make a startup work (for example considering the typical positions of CEO—Chief Executive Officer, COO—Chief Operating Officer and CMO—Chief Marketing Officer).

This filter left us with a total of 126 startups that created jobs. That is 63% of the teams in our sample created jobs, ranging from 1 to 50 employees in each company. The table below that the creation of jobs is associated more predominantly to male-founded startups.

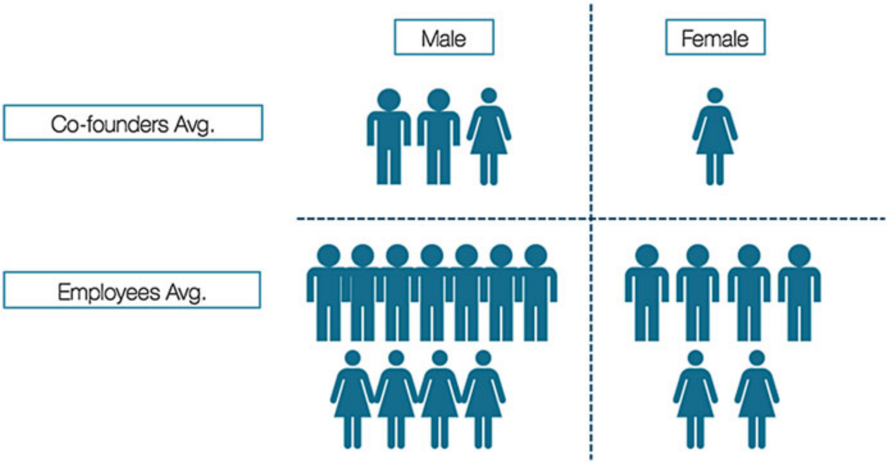

Fig. 10 Average team size and diversity, according to co-founder gender

Table 2 Team composition, according to founder gender

Gender of the founder	Number of teams	Average number of co-founders	Average number of employees	Average number of team members
Male	93	2.6	8.7	11.3
Female	106	2.0	4.1	6.1
Total	199	2.3	6.2	8.5

6 Discussion and Conclusion

6.1 Contribution

Our study contributes to the evidence on job creation of new high-technology business. Both male (73%) and female-led (55%) startups create jobs. According to our results, female founders have similar (or slightly lower levels of, but not significant) grow expectations, strategic vision, and were in similar business stage than their male counterparts. The analysis shows that the big difference between male- and female-led teams is how they build their teams, both regarding to size and gender diversity. This finding is consistent with the evidence found in SMEs and startups (Kuschel and Labra, forthcoming) literature (see Fig. 10).

As it can be inferred from Tables 2 and 3, male and female co-founders tend to "homosociality" (i.e., same-sex relationships), being this effect stronger in the management team. More research is needed to explore if the decision of women to get a female business partner is made using the criteria of "trust"—as has been explicitly expressed by female founders of technology ventures in Latin America (Kuschel and Labra, forthcoming; Kuschel & Lepeley, 2016b)—or, on the other hand, is that men do not want to have female partners or female leaders in the

Table 3 Job creation, according to founder gender

Gender of the founder	Number of teams	% of teams that created jobs	Average number of co-founders	Average number of employees	Average number of team members
Male	68	73	2.6	11.8	14.3
Female	58	55	2.3	6.9	9.2
Total	126	63	2.5	9.5	12.0

technology sector, which is a highly male-dominated industry. A common underlying assumption of the studies on top management teams is that new venture teams are stable over time, i.e., the studies (including this exploratory study) emphasize the initial team characteristics and do not account for changes in the team as the venture grows. However, there is evidence that supports the fact that women-led TMTs do not change significantly over time (Kuschel & Lepeley, 2016b). Future research can explore the TMT restructuring and the opinion of male partners and employees on female founders' leadership styles.

6.2 *Implications for Entrepreneurship Research and Policy*

The entrepreneurial ecosystem in Chile is relatively young and still underdeveloped. This ecosystem doesn't provide sufficient resources for women entrepreneurs, in comparison to more developed ecosystems.

Our findings suggest that a continuing development and investment into the ecosystem will strengthen women-led teams in high technology by providing networks, support, mentors and role models. This current lack of support might be adding obstacles and leading entrepreneurs, particularly women, into the so called "business failure or underperformance".

We suggest that there is a need for affirmative actions for women in Latin American entrepreneurial ecosystems. To build strong, sustainable companies and fill the growing talent gap, we need more qualified women in leadership roles within our tech community. The Chilean agency of development (CORFO) is supporting pre-acceleration programs (e.g., The S Factory from Start-Up Chile, ADA Academy from Girls in Tech Chile) intended for women in technology ventures. We believe that this is a way other Latin American countries can follow, as well.

Although special acceleration programs and workshops for relevant skills development are key elements for women founders, other ingredients are needed too. For the ecosystem to be sustainable and growth-oriented, it has to address the need for strong mentorship and effective role models (Kuschel and Labra, forthcoming), as well as cultivating in our society more flexible and inclusive HR practices and raising awareness of the advantages of a diverse workforce. This suggestion is particularly relevant for countries where women have had a traditional role outside the public spheres. All these elements will assist women in tech in maximizing their careers and in general industry development.

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What Drives the Intellectual Property Output of High-Tech Firms? Regional- and Firm-Level Factors

Christian Masiak, Christian Fisch, and Jörn H. Block

Abstract This study analyzes the effects of regional- and firm-level factors on the intellectual property (IP) output of high-tech firms. So far, little is known on how regional factors influence the IP output of high-tech firms. We combine data on 8317 German high-tech firms with regional data and perform various regression analyses. We measure the IP output by the number of granted patents and trademarks. In particular, the receipt of venture capital and firm size have a significant effect on the IP output. With regard to regional factors, the student rate in a region is positively linked to IP output, whereas the existence of a technical university in a region has no significant effect on the IP output. Implications for policy makers and practitioners are discussed.

Keywords Intellectual property output · Innovation · Knowledge spillovers · Patents · Region · SME · Trademarks · Venture capital

1 Introduction

Previous studies have investigated the determinants of intellectual property (IP) output at the firm level (e.g., Galende & De la Fuente, 2003; Huergo & Jaumandreu, 2004; Madrid-Guijarro, Garcia, & Van Auken, 2009) and regional level (e.g., Cohen & Levinthal, 1990; Dyer & Singh, 1998). However, only a small number of studies have combined firm- and regional-level data in a study (e.g., Naz, Niebuhr, & Peters, 2015; Smit, Abreu, & De Groot, 2015). Naz et al.

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(2015) emphasize the demand for the combination of firm-level data with corresponding regional data. In this study, we focus on high-tech firms because of their link to innovation (e.g., Bhattacharya & Bloch, 2004; Block & Spiegel, 2013; Kim & Marschke, 2004). We investigate the research question: Which firm- and regional-level factors drive the IP output of high-tech firms?

To address this research question, we use a unique dataset of high-tech firms provided by Spotfolio and expand it with regional data from INKAR as well as data on universities. Various regression analyses estimate the IP output of high-tech firms. We use patents and trademarks as proxies for IP output, allowing a more precise comparison of these measurements with regard to high-tech firms (Sandner & Block, 2011).

The results show that regional- and firm-level factors have an impact on the firm's IP output. While the existence of a technical university in a region (as opposed to no technical university in the region) has no significant effect, the student rate has a significant positive effect on the high-tech firms' IP output. With regard to firm-level factors, firm size and the receipt of venture capital are found to be positively linked to the firm's IP output. Additionally, both proxies for IP output (number of granted patents and number of granted trademarks) show similar results, indicating that trademarks can be used to measure the innovation output of high-tech firms similar to patents. Interestingly, it also appears that firms use patents and trademarks as complements rather than substitutes.

The remainder of the study is structured as follows: Sect. 2 derives hypotheses, while Sect. 3 describes the dataset and the variables used in the empirical analysis. Section 4 concerns the empirical analyses. The results are discussed in Sect. 5 and the study closes by acknowledging limitations as well as proposing starting points for future research.

2 Hypotheses

2.1 Firm-Level Hypotheses

2.1.1 Venture Capital

Venture capitalists have a variety of selection criteria to evaluate investments in start-ups (Franke, Gruber, Harhoff, & Henkel, 2008). This evaluation is often thorough and aims to ensure the success of the venture capital investment. As a result, firms with particularly strong capabilities pass the evaluation process more often (Florida & Kenney, 1988). This selection process leads to investments in technology-driven and highly innovative firms because they are characterized by a high-growth potential (Gompers & Lerner, 2004). Beside the selection process, venture capital firms are active in supporting activities such as the recruitment of managers, sharing experience gained from previous successful business expansions or the provision of further non-financial assistance (Block, Fisch, & van Praag, 2017;

De Vries, Pennings, Block, & Fisch, 2017; Florida & Kenney, 1988; Franke et al., 2008). Hence, venture capital-financed firms should have a higher IP output than firms without venture capital support.

Second, entrepreneurs face several funding challenges at the beginning of a firm's life cycle. Venture capitalists can help firms in overcoming these challenges (Alexy, Block, & Term Wal, 2012). For example, venture capitalists often possess established networks of large corporations, financial institutions, universities, and other organizations. Therefore, venture capital firms reduce several risks which high-tech firms face (e.g., reducing uncertainty by establishing relationships with suppliers or financial institutions). Due to networks and cooperation which are established by venture capital firms, we assume that venture capital-financed firms have a higher IP output than firms which are not venture capital-financed. Hence, we hypothesize:

Hypothesis 1 *Receiving venture capital is positively linked to the IP output of high-tech firms.*

2.1.2 Firm Size

High-tech SMEs might be particularly disadvantaged with regard to identifying collaborations and transferring knowledge due to a lack of resources (e.g., De Jong & Freel, 2010; Freeman, Carroll, & Hannan, 1983; Singh, Tucker, & House, 1986). Also, SMEs often lack the necessary capabilities required to manage and process external knowledge (Cohen & Levinthal, 1990). According to Cohen and Levinthal (1990), the absorptive capacity of an organization plays a crucial role in the learning and innovation process. Absorptive capacity includes the ability to identify, comprehend, and apply external knowledge. Thus, firms that possess a larger absorptive capacity are able to learn from universities, institutions or other organizations and can effectively use external knowledge for the development of innovations (Dyer & Singh, 1998). SMEs often have less experience than large firms as well as less financial resources and resources for extensive R&D investments (Block, Fisch, Hahn, & Sandner, 2015; Nooteboom, 1994). Furthermore, the qualification of employees is essential for developing innovations.

In addition, rapid environmental changes characterize the high-tech industry so that a continuous development of the skills and abilities of a firm's employees are necessary. SMEs are thus disadvantaged with regard to the development of employees' expertise. Although formalization (e.g., codified instructions or formalized procedures) within a firm might lead to inflexibility, prior research notably highlights positive effects (Jansen, Van den Bosch, & Voberda, 2005; Lin & Germain, 2003). Formalization enables a codification of best practices as well as a guideline for the knowledge process in order to efficiently implement external knowledge in the innovation process (Jansen et al., 2005; Lin & Germain, 2003). Formalization, however, appears to occur more likely in well-established and larger firms due to time constraints and lack of resources in smaller firms. As a result, larger firms have a higher absorptive capacity, higher formalization and consequently a higher IP output. We thus argue:

Hypothesis 2 *Firm size is positively linked to the IP output of high-tech firms.*

2.2 Regional-Level Hypotheses

2.2.1 Presence of a Technical University

Knowledge spillovers, intense cooperation in R&D activities, and research efforts can lead to regional networks which favor the development of innovation systems (Block & Spiegel, 2013; Cooke, 2001). Universities are often considered as a "knowledge factory" and various possibilities exist for firms (e.g., publications, scientific paper, and collaboration) to acquire knowledge from universities (Agrawal & Henderson, 2002; Fisch, Block, & Sandner, 2016; Fisch, Hassel, Sandner, & Block, 2015; Fritsch & Schwirten, 1999). Moreover, the high-tech sector itself is notably innovation-driven and has been shown to favor a closer connection between universities and high-tech firms (Fritsch & Aamoucke, 2013; Hellerstedt, Wennberg, & Frederiksen, 2014).

Proximity is an important factor that shapes the way in which firms profit from spillovers by universities. Previous research has indicated that spillovers are often limited to a certain geographic distance (Anselin, Varga, & Acs, 1997; Fritsch & Schwirten, 1999; Jaffe, Trajtenberg, & Henderson, 1993). A possible explanation for spatially bound knowledge spillovers is the nature of university knowledge. In general, there is a distinction between explicit (codified) and implicit (tacit) knowledge. Explicit knowledge is codified and can be transmitted verbally or in writing (Howells, 2002; Polanyi, 1962, 1966). Publications or papers are examples of explicit knowledge that are transferrable to industries. In contrast, tacit knowledge cannot be transmitted in a direct way, since it depends on experience, procedures and learned behavior (Howells, 2002; Polanyi, 1962, 1966). Examples of tacit knowledge include students, professors or scientists of the university, who experience or embody tacit knowledge. Face-to-face interaction and continuous personal contact becomes more important with regard to the transfer of tacit knowledge, which implies that spatial proximity favors knowledge spillovers (e.g., Audretsch & Lehmann, 2005; Bade & Nerlinger, 2000).

Due to the content-related proximity, beneficial knowledge spillover effects should especially arise among technical universities and high-tech firms. As a result, not only the regional innovation system but also the IP output is improved due to knowledge spillovers between technical universities and high-tech firms. Therefore, we assume:

Hypothesis 3a *The number of technical universities in a region is positively linked to the IP output of high-tech firms.*

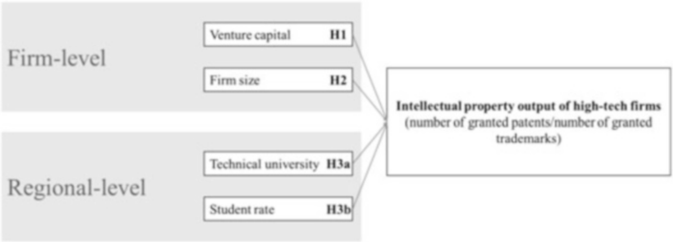

Fig. 1 Conceptual model

2.2.2 Student Rate

In addition, universities can contribute to regional innovativeness by educating skilled employees. The high-tech industry particularly needs educated employees in order to stay competitive. Highly educated workers have the ability to easily adapt and implement new technologies. They are mainly responsible for the know-how trading in a firm, since highly educated employees possess the required knowledge (Blundell, Dearden, Meghir, & Sianesi, 1999; Carter, 1989; Vinding, 2006). Combined with the general improvements in human resource management practices (e.g., job rotation, delegation of responsibility), the absorptive capacity of a firm increases and its IP output will likely grow as a consequence (Bartel & Lichtenberg, 1987; Vinding, 2006).

The student rate in a region represents a source of potential highly qualified employees for the various firms. Previous research indicates that firms often recruit technical staff from local universities and this source for the recruitment of new employees is more important than customers, suppliers, competitors or other organizations (Dahlstrand, 1999). Prior research used the student rate as a proxy for university knowledge spillovers and tested the relationship between student rate and regional innovation output (Block & Spiegel, 2013). Thus, we argue:

Hypothesis 3b *The number of students in a region is positively linked to the IP output of high-tech firms.* We have summarized our hypotheses in Fig. 1.

3 Data

3.1 Dataset

Our dataset combines data at the firm level with data from the regional level. At the regional level, data from 360 German districts in the year 2010 is included (NUTS 3-level). The NUTS classification used is a hierarchical system designed to delineate the territory of the European Union, for example for socio-economic analyses

(Eurostat, 2015). The NUTS 3-level includes small regions and is equivalent to the German district level ("Kreisebene") including both districts ("Kreise") and autonomous cities ("kreisfreie Städte"). The Federal Office for Building and Regional Planning in Germany provides data on the various districts. This data is complemented by data from the Gründungsatlas (Fritsch & Brixy, 2004), which includes detailed data on German start-ups. Additionally, we use the Spotfolio database to add information about German high-tech firms. Spotfolio primarily focuses on smaller, innovative high-tech firms and provides company information either from web crawling or from companies registered on the website (self-reported).

Various definitions of high-tech sectors exist. A simplified classification is provided by Legler and Frietsch (2007): Firms that exceed a 7% share of R&D expenditure in turnover belong to the high-tech sector, whereas a share of between 2.5% and 7% corresponds with medium-tech sectors. The remaining firms are classified as belonging to low-tech industries (Legler & Frietsch, 2007). Spotfolio uses this approach and a study of the Lower Saxony Institute for Economic Research (NIW), the Fraunhofer Institute for Systems and Innovation Research (ISI), and the Centre for European Economic Research (ZEW) to classify high-tech companies in Germany. In Spotfolio, the industries in which a firm operates are categorized by the WZ-2008 classification, the German categorization of industrial sectors by the Federal Statistical Office. The following industries are considered: manufacturing (C10–33), information and communication (J58–63), professional, scientific and technical activities (M69–75). Most importantly, however, information about the patent applications and trademarks of the firms is also included in Spotfolio. We matched the company data to districts using the postal code. In addition, we matched this data with data on all private and public German universities or universities of applied science, which was obtained from the Higher Education Compass (Hochschulkompass, 2015).

3.2 Variables

3.2.1 Dependent Variables

We use two different dependent variables. First, a dummy for granted patents is used as a proxy to measure the IP output of companies. Patents are an adequate and reliable proxy for innovations (Acs, Anselin, & Varga, 2002; Acs & Audretsch, 1989; Block & Spiegel, 2013). Second, a dummy for trademarks is used as a further proxy to measure a firm's IP output (Gotsch & Hipp, 2012; Mendonça, Pereira, & Godinho, 2004). We include both innovation indicators (patents and trademarks) to measure different facets of IP output (De Vries et al., 2017; Kleinknecht, Van Montfort, & Brouwer, 2002). Patents protect technological assets (e.g., inventions), whereas trademarks protect marketing assets (e.g., brands) (Block et al., 2015).

3.2.2 Independent Variables

The variable *venture capital* (H1) measures whether a company has received venture capital (1 = company has received venture capital; 0 = company has not received any venture capital). The second independent variable (H2) is *firm size (small firms)*. There are four types of companies according to total assets, sales revenue, and number of employees. Two of the three classifications have to apply to the relevant firm for two consecutive years. Spotfolio differentiates between micro-enterprises, small enterprises, medium-sized companies, and large companies.[1]

With regard to H3a, the variable *technical university* measures the existence of a technical university in the respective district (1 = at least one technical university exists; 0 = a technical university does not exist). The variable captures knowledge spillovers between technical universities and firms. We focus on technical universities because high-tech firms benefit more from technical universities focused on engineering as well as science subjects. Moreover, technical universities receive higher funds than non-technical universities in order to compete for technology transfer (Audretsch & Lehmann, 2005). The *student rate* represents another important independent variable that is used to assess H3b. It measures the number of students at a university divided by the number of inhabitants in respective district where the university is located. The student rate reflects human resources that might be employed in the district and can foster knowledge spillovers to firms as well as increase the IP output of a firm. In comparison to the university variable, it includes students from universities and universities of applied science (Block & Spiegel, 2013; Fritsch & Schwirten, 1999).

We include several control variables that have been shown to influence IP output at the firm or regional level. Even though the majority of studies have focused on the relationship between regional factors and the regional innovation output, some regional factors appear to have a direct effect on the firm's innovation output (Srholec, 2010). First, the variable *start-up rate* measures the number of start-ups divided by the number of inhabitants and is consequently a proxy for entrepreneurship (Block, Thurik, & Zhou, 2013). Although it has been used as a proxy for regional innovation output in previous research (Block & Spiegel, 2013), it can be argued that the start-up rate influences the IP output of a firm as well. According to Almeida and Kogut (1997), small firms are able to exploit new technologies in local small firm networks better than large firms. Therefore, a high number of small firms in a German district should positively influence the IP output of a firm. Furthermore, *GDP per employed person* and *household income* both reflect the economic environment in the relevant district, whereas the *unemployment rate* and *R&D employee rate* characterize the labor market in the specific region (e.g., Block & Spiegel, 2013; Florida, Mellander, & Stolarick, 2008; Naz et al., 2015). In addition, *R&D subsidies* measures the loans granted by the German Development Bank divided by the

[1]We included small firms and grouped medium-sized and large firms together as the reference group.

number of inhabitants. Subsidies, such as R&D subsidies, lead to an increase in firms' innovation activities (Almus & Czarnitzki, 2003).

Prior research shows the positive impact of various industries on the IP output of individual firms (e.g., Klenow, 1996; Santarelli & Piergiovanni, 1996). An additional firm-specific variable refers to the *fixed assets* of a company, which is used as a proxy for its capital. Table 1 describes the variables used in more detail.

Table 1 Variable description

Variable	Description
Firm characteristics	
Venture Capital	Dichotomous variable (1 = firm has received venture capital; 0 = firm has not received venture capital)
Small firms	Dichotomous variable (1 = firm is a small firm; 0 = firm is not a small firm)
Medium-sized/ large firms	Dichotomous variable (1 = firm is a medium-sized/large firm; 0 = firm is not a medium-sized/large firm)
Log (fixed assets)	Logarithmized fixed assets of a firm
Log (Patents)	Logarithmized granted patents of a firm
Log (Trademarks)	Logarithmized granted trademarks of a firm
Patents (0/1)	Dichotomous variable (1 = firm holds at least one granted patent; 0 = firm does not hold any granted patent)
Trademarks (0/1)	Dichotomous variable (1 = firm holds at least one granted trademark; 0 = firm does not hold any granted trademark)
Patents (count)	Number of granted patents based on applicant firm
Trademarks (count)	Number of granted trademarks based on applicant firm
Main area	Dummy variable for the relevant industry based on the WZ-2008 industry classification (manufacturing; information and communication; professional, scientific and technical; other)
Regional characteristics	
Technical university	Dichotomous variable (1 = at least one technical university exists in the specific German district; 0 = a technical university does not exist in the specific German district)
Student rate	Measures the number of students which are enrolled at a university divided by inhabitants (in 1000)
Start-up rate	Number of start-ups divided by inhabitants (in 10,000)
GDP/employed person	Gross domestic product per employed person in 1000 € (in the specific district)
Household income	Household income per inhabitant in € (in the specific district)
R&D employee rate	Number of R&D employees divided by total employees (in 1000)
R&D subsidy	Granted long-term loans by the KfW Bankengruppe to encourage innovation (in 1000 €) divided by inhabitants (in the specific district)
Unemployment rate	Number of unemployed people in the region divided by employed people (in the specific district)

Data Source: Eurostat (2010), Federal Office for Building and Regional Planning (2015), Fritsch and Brixy (2004), Gotsch and Hipp (2012), Hochschulkompass (2015), Mendonça et al. (2004), Naz et al. (2015), Spotfolio (2016)

3.3 *Descriptive Statistics*

To enable a better understanding of the data and variables used descriptive statistics are displayed in Table 2. In total, our final dataset contains 8317 German high-tech firms, which are mostly small firms (approx. 92%). On average, each firm possesses 1.35 patents and only 0.45 trademarks. With regard to the dependent variables, the average number of technical universities is 0.25 per district and 0.01 firms, on average, received venture capital. The dataset mainly consists of small firms.

Figure 2 (Appendix) shows the geographic distribution of firms in the dataset. In total, 360 districts are included in the regression analyses. The majority of firms (in this dataset) are located in Western and Southern Germany, whereas some districts in Eastern Germany are not included in the further analyses. Moreover, Fig. 2 depicts the distribution of technical universities. Some technical universities are located in districts with a high number of high-tech firms.

Table 2 Descriptive statistics

Variable	Mean	SD	Min.	Max.
Firm characteristics				
VC	0.01	–	0	1
Small firms	0.92	–	0	1
Medium-sized/large firms	0.08	–	0	1
Log (fixed assets)	10.49	2.57	0	18.66
Log (Patents)	0.15	0.58	0	6.93
Log (Trademarks)	0.14	0.45	0	4.72
Patents (count)	1.35	19.64	0	1021
Trademarks (count)	0.45	3.13	0	111
Patents (0/1)	0.09	–	0	1
Trademarks (0/1)	0.12	–	0	1
Main area				
Manufacturing	0.60	–	0	1
Information	0.33	–	0	1
Professional	0.07	–	0	1
Others	0.00	–	0	1
Regional characteristics				
Technical university	0.25	0.43	0	1
Student rate	0.03	0.05	0	0.35
Start-up rate	0.26	0.06	0.09	0.47
GDP/employed person	0.03	0.02	0.01	0.10
Household income	1.70	0.28	1.23	3.11
R&D employee rate	0.13	0.13	0.00	0.94
R&D subsidy	0.18	0.21	0	1.37
Unemployment rate	0.07	0.03	0.02	0.17

Notes: N = 8317 firms

4 Multivariate Analyses

4.1 Method

First, a logistic regression was conducted with the dependent variable *patents (0/1)* (y = 1 firm has a granted patent; y = 0 firm does not have a granted patent) as well as the variable *trademarks (0/1)* (y = 1 firm has a granted trademark; y = 0 firm does not have a granted trademark). Second, we perform negative binomial regressions. The dependent variables is the number of granted patents (*patents*) and the number of granted trademarks (*trademarks*). In general, both Poisson regressions and negative binomial regressions are appropriate for data with a count-character, such as the number of patents or trademarks (Cameron & Trivedi, 1998; Chatterjee & Simonoff, 2013). The negative binomial regression, however, is more appropriate than a Poisson regression for a data set with a possible overdispersion (Cameron & Trivedi, 1998), which is usually the case for patent data (e.g., Fisch et al., 2015, 2016).

4.2 Results

We use patents and trademarks as the dependent variables. Both variables are dummy variables that measure whether a company has at least one patent or trademark (coded as 1) or not (coded as 0). The results of our analyses are displayed in Table 3.

H1 states that the receipt of venture capital is positively linked to the IP output of high-tech firms. To assess this hypothesis, Model 1 shows the results of a logistic regression with patents (0/1) as the dependent variable and indicates that the variable *venture capital* ($p < 0.01$) is statistically significant. Thus, H1 is strongly supported by the data. With regard to H2, the empirical results indicate that being a *small firm* ($p < 0.01$) decreases the likelihood of having a granted patent or trademark. In other words, the IP output increases with the size of the firm. H3a addresses the knowledge spillover effects of technical universities. It is hypothesized that firms should have a higher IP output if a technical university is located in the same region as the firm. Our results (Model 1) do not show a significant effect and hence do not support H3a. H3b refers to the impact of the student rate in a region on the IP output of high-tech firms. *Student rate* ($p < 0.05$) shows a significant effect on the IP output. H3b is consequently supported by our results. Beside the hypotheses tested, some control variables show significant effects as well. It is noteworthy that the independent variables *patents* and *trademarks* show significant results. The variable *log (trademarks)* ($p < 0.01$) has a significant positive effect on the probability of having a granted patent. Moreover, the variables *GDP per employed person* ($p < 0.05$) and *household income* ($p < 0.05$) show statistically significant results.

The second model shows the logistic regression results for *trademarks (0/1)* as the dependent variable, which is used as an additional measurement for IP output in the regression analyses. Overall, the results are very similar to Model 1. Model

Table 3 Logistic regression (Model 1 and 2) and negative binomial regression models (Model 3 and 4)

Variable	Model 1	Model 2	Model 3	Model 4
Dependent variable	Patents (0/1)	Trademarks (0/1)	Patents (count)	Trademarks (count)
Firm characteristics				
VC	1.459 (0.325)***	1.326 (0.252)***	1.543 (0.353)***	0.891 (0.200)***
Small firms	−1.357 (0.105)***	−0.859 (0.124)***	−2.795 (0.266)***	−1.706 (0.243)***
Log (fixed assets)	−0.033 (0.016)**	0.013 (0.016)	−0.061 (0.029)**	−0.019 (0.021)
Log (Patents)		1.289 (0.080)***		1.085 (0.076)***
Log (Trademarks)	1.719 (0.110)***		2.057 (0.167)***	
Regional characteristics				
Technical university	0.092 (0.131)	0.107 (0.125)	0.013 (0.226)	0.155 (0.173)
Student rate	2.237 (0.915)**	1.515 (0.802)*	2.701 (1.591)*	0.563 (0.987)
Start-up rate	−1.140 (0.766)	−0.686 (0.740)	−1.746 (1.215)	0.273 (1.042)
GDP/employed person	−8.993 (4.028)**	−4.417 (4.011)	−14.29 (7.495)**	−1.558 (5.341)
Household income	0.305 (0.131)**	0.310 (0.170)*	0.218 (0.289)	−0.277 (0.253)
R&D employee rate	0.257 (0.288)	−0.146 (0.324)	1.730 (0.694)**	−0.128 (0.452)
R&D subsidy	0.134 (0.213)	0.263 (0.284)	0.581 (0.473)	0.040 (0.452)
Unemployment rate	−2.509 (1.796)	2.552 (1.682)	−2.345 (3.924)	−1.461 (3.275)
Main area (dummies)	Yes	Yes	Yes	Yes
Pseudo log-likelihood	−1754.44	−2503.62	−4008.74	−4442.30
Wald Chi-squared	722.07***	463.24***	505.04***	465.14***

Notes: N = 8317 firms. Coefficients, standard errors (clustered at regional level) in parentheses
Significance levels: *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$

2 (Table 3) shows that the variable *venture capital* ($p < 0.01$) is significantly positive. The variable *student rate* ($p < 0.10$) has a positive impact on the likelihood of having a trademark as well. Moreover, *technical university* is not statistically significant while being a *small firm* has a significantly negative effect on having a granted trademark. The results of the logistic regression analysis using *trademarks (0/1)* as the dependent variable, substantiate the previous results. In addition, two control variables show a significant effect. The variables *household income* ($p < 0.10$) and *patents* ($p < 0.01$) increase the firm's probability of holding a trademark.

Furthermore, negative binomial regressions are performed to check the robustness of the main models. The number of granted patents and trademarks are used as dependent variables. The results of the negative binomial regression are presented in Table 3 (Model 3 and 4) and underline the robustness of the logistic regression analyses. H1, H2, and H3b are supported by the robustness checks (Model 3), whereas H3a is not supported by the results. The non-finding of H3a is consistent across all models (Model 1–4). While *student rate* positively influences the number of patents and trademarks, Model 4 does not show a significant result.

5 Conclusion

5.1 Discussion

In line with H1 we find a positive effect of venture capital on the IP output of high-tech firms. This finding is in line with previous results: for example, Kortum and Lerner (2000) underline the positive effect of venture capital activity within an industry on the patenting rate of a firm. However, it can be argued that venture capital does not necessarily induce IP output. The selection process of venture capital-financed firms itself might be responsible for the fact that these firms have more granted patents or trademarks than others (Engel & Keilbach, 2007; Florida & Kenney, 1988). We address this in the last section of this paper, as it poses a limitation to the generalizability of our results.

The empirical results indicate that being a *small firm* decreases the likelihood of having a granted patent or trademark. In other words, the IP output increases with the size of the firm. The results confirm the theoretical argumentation that SMEs face problems, such as the liability of newness, having a lower degree of absorptive capacity, and consequently having a lower IP output compared to larger firms. This is in line with previous results (e.g., Arundel & Kabla, 1998; Henderson & Cockburn, 1996; Kleinknecht, 1989; Naz et al., 2015).

Although prior research indicates that technical universities are a key element in regional innovation systems (e.g., Cooke, Uranga, & Etxebarria, 1997; Fisch et al., 2016), our results do not show an effect on firm's IP output. A possible explanation lies in the use of the dependent variables (*patents* and *trademarks*). According to Acs et al. (2002), this is because patents might underrepresent research spillovers and other proxies might be more appropriate for the measurement of university knowledge spillovers. The dataset used might be another reason for the insignificant results: first, the number of firms in the various technical university districts is relatively low (Fig. 2), which might lead to an underrepresentation of spillover effects. Second, the focus on the German district level is very specific and limits the research spillover effects of technical universities. Third, the variable *technical university* considers only technical universities and does not take into account universities with strong faculties in, for example, natural sciences, medicine, computer linguistics, or biotechnology. Also, it is likely that there are spillover effects to other German districts near the actual district of the technical university. This might explain why we do not see an effect for the actual district. Anselin et al. (1997), for example, find empirical evidence that university spillovers on innovation extend over approximately 80 km.

Interestingly, the *student rate* shows a significant effect on the IP output. In contrast to the variable *technical university*, the variable *student rate* refers to *all* German universities and universities of applied science. This might explain the difference between the results. Previous studies indicate a positive relationship between the student rate and the regional innovation output (Block & Spiegel, 2013). It appears that the regional variable *student rate* has a direct impact on the firm's IP output. Naz et al. (2015) use the variable *graduates per employee* instead of *student rate*, but the results do not show any significant effect on the firm's innovation output. They argue that students might migrate to other regions after graduation. This contradicts the results presented in this study. Our significant finding shows that the regional *student rate* has a direct impact on the firm's IP output. Thus, firms seem to be able to hire highly skilled workers from universities and translate their human capital into an increase in IP output.

Interestingly, firms often favor both patents and trademarks instead of using only one of the protection rights. This is consistent with previous research, which points out that trademarks and patents are often used in conjunction (e.g., Thomä & Bizer, 2013). Previous research has also indicated that firms' motives to trademark and patent overlap but also differ in several aspects. In particular, SMEs file trademarks due to protection, marketing, and exchange motives (Block et al., 2015; De Vries et al., 2017). According to Block et al. (2015), the latter includes an increased negotiation power with regard to external shareholders, such as investors. Marketing motives refer to the increase of brand equity or the corporate image while protection refers to the prevention of imitations and free riding (Block et al., 2015). Both protection and exchange motives play an important role when filing patents (Blind, Edler, Frietsch, & Schmoch, 2006). Additionally, blocking and strategic motives play an important role when filing patents. While protection, exchange and blockade motives are relatively independent of firm size, reputation motives tend to be more important for small firms than large ones (Blind et al., 2006).

5.2 Implications

The results of the present research have implications for theory and practice. Our results are useful for managers of high-tech firms. Locations with a high student density appear to improve the IP output. If smaller firms have a lack of resources, it may help to be located in regions with a high student density, as this allows firms to hire highly educated employees more easily. The recruitment of highly-skilled workers may be especially important for firms with financial constraints, since the geographical proximity may help smaller firms to employ students more readily. Another implication for managers refers to venture capital as our results indicate that the ambition to receive venture capital could increase the IP output of high-tech firms. Although it remains unclear whether the ex-ante selection process of venture capital firms or the ex-post monitoring process and network effects of venture capitals are responsible for the increase of IP output, firms obviously benefit from venture capital. In addition, managers can use trademark and patent applications in order to review innovation activities of their industry and compare their own company with other firms (benchmarking studies).

Also, policy makers may benefit from our results. Both trademark and patent registrations reflect the innovation activity of high-tech firms. Policy makers can use these indicators in order to examine the success of innovation subsidies or policy instruments. Nevertheless, as indicated by Flikkema, De Man, and Castaldi (2014), policies have to control the possible misuse of subsidies. Firms might apply for trademarks, which are relatively cheap in comparison to patent applications, in order to signal innovations instead of actually developing innovations. Additionally, the IP output tends to depend more on firm-specific factors than on region-specific factors. Political initiatives should focus slightly more on firm-specific measurements in order to improve the IP output of firms. Nevertheless, the indirect effects of regional factors should not be completely omitted (Naz et al., 2015).

5.3 Limitations and Future Research

This study is not without limitations. First, the measurement of the dependent and independent variables poses a limitation. Although trademark variables and especially patent variables are established as a proxy for innovation output in the literature (e.g., Acs & Audretsch, 1989; Block & Spiegel, 2013; Gotsch & Hipp, 2012; Mendonça et al., 2004), the proxy may under-represent university research spillovers or further spillover effects (Acs et al., 2002). Therefore, further analyses, such as a multi-level regression, should test these effects. Furthermore, our independent variable *technical university* does not consider non-technical universities or universities of applied sciences that have prestigious faculties with a focus on natural sciences, biotechnology or similar areas. Future research may match the faculty footprint with the industries of the firms to analyze knowledge spillovers in a region.

Second, there is a potential causality problem with regard to venture capital. While we assume that the receipt of venture capital leads to a higher IP output of firms due to the network and knowledge spillover effects of venture capital firms, it can also be argued that firms are selected by venture capital firms because they are notably innovative (Engel & Keilbach, 2007; Florida & Kenney, 1988). Therefore, the reason for the IP output of venture-capital financed high-tech firms cannot be properly explained. Either high-tech firms have a higher IP output because they receive venture capital or firms are selected by venture capital firms due to their patents and trademarks. Therefore, the selection process of venture capital firms might be the main reason for the high IP output rather than the support, for instance the knowledge spillover effects or the established networks of the venture capital firms.

Future research could complement and expand the current research project. By using the existing Spotfolio data, multi-level regression models could form an additional robustness check in order to explore the effects of different variables at the firm and regional level on the IP output of high-tech firms. The firm level and the regional level are two hierarchical levels in the sample which may not be completely independent from each other (Aguinis, Gottfredson, & Culpepper, 2013).

Finally, while this study highlights knowledge spillovers between universities, venture capital firms, and high-tech firms, future research could focus on differences between industries. The differences between low- and high-tech sectors have only received a cursory examination with regard to IP output. The focus has been on either high-tech or low-tech companies rather than including both industries (e.g., Sáenz, Aramburu, & Rivera, 2009). A more comprehensive analysis could for example look into the effects of human capital and knowledge spillovers. Universities of applied science focus on teaching rather than research, whereas technical universities have their core competencies in engineering and science. The consequences have not been analyzed in detail with regard to the type of innovations. The same applies to venture capital and its spillover effects on product or process innovations. Venture capital might be more effective in specific industries or might depend on the type of innovations.

Appendix

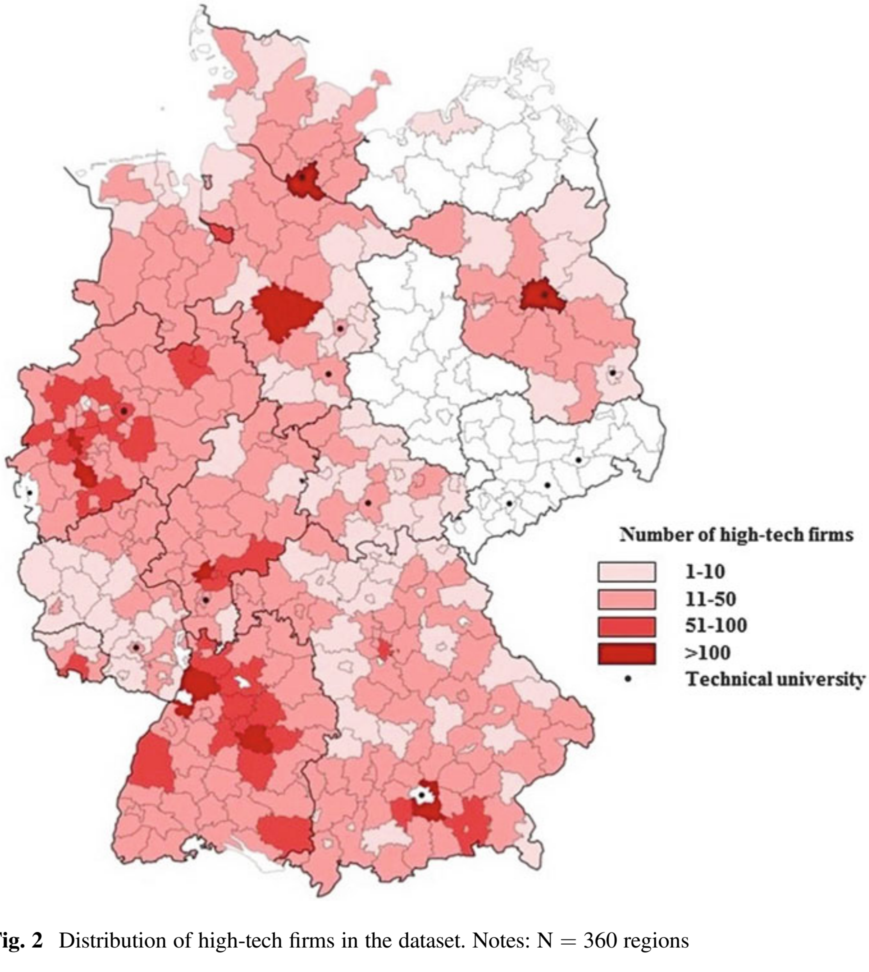

Fig. 2 Distribution of high-tech firms in the dataset. Notes: N = 360 regions

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New Technology-Based Firms and Grants: Too Much of a Good Thing?

Nicolas Pary and Olivier Witmeur

Abstract While they boost the economy and innovation, New Technology-Based Firms (NTBF) frequently experience difficulties to finance themselves. In Europe, policy makers react by providing them with grants. However, three elements cast doubt on these grants. First, it has been argued that most NTBF financing constraints would be due to the immaturity of projects rather than the lack of investors. Second, Pecking Order Theory suggests that grants, being free and non-dilutive, may be solicited without actual financing constraints. Third, the ability of grants to help their beneficiaries pursue commercial and financial development has been questioned. We contribute to these conversations by answering three research questions: (1) Are grants to NTBF answering to supply-sided financing constraints? (2) Why do NTBF apply for grants? (3) Are grants signaling NTBF to investors? We address these questions by studying the financing path of eight grant-supported NTBF during 3 years after incorporation through case studies. Our findings may be grouped around three themes. First, supply-sided financing constraints exist but are rare. Most of the time, firms attracted equity if they wanted to do so. Second, opportunism and the will to limit dilution support the overwhelming majority of grant applications. Third, we do not observe a certification effect from grants to investors. It rather seems that having attracted outside investors or promising first sales play an important role in obtaining or increasing grant support.

Keywords New technology-based firms · Equity gap · Public grants · Pecking order theory · Signaling

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1 Introduction

New Technology-Based Firms (NTBF) boost the economy and innovation (Acs, Audretsch, & Strom, 2009; Acs, Autio, & Szerb, 2014). More than creating jobs when growing, they transfer technologies from local universities, accelerate absorption of foreign knowledge and densify regional technology ecosystems (Stam & Wennberg, 2009; Fontes & Coombs, 2001). Their financing needs are however high due to pre-sales developments. They also face high level of uncertainty, technological complexity and intangibility of their assets (Rojas & Huergo, 2016; Gompers & Lerner, 2006). Accordingly, their financing is a challenge. This situation is amplified in Europe where most equity markets, except the United Kingdom and Germany, are less vivid than in the United States (Revest & Sapio, 2012; Schwienbacher, 2008).

This leads European policy makers to provide grants to preserve regional spillovers by alleviating NTBF financing constraints as prescribed by Public Sponsorship Theory (Cantner & Kösters, 2012; Storey, 2006). Despite their multiplication, the evaluation of these initiatives is not unanimous. In this paper, we investigate three particular streams of criticisms on the necessity and effectiveness of grants.

First, it has been argued that most financing constraints would not be supply-sided, i.e. due to a lack of investors, but demand-sided, i.e. due to the immaturity of NTBF. If so, grants would actually prevent entrepreneurs from becoming aware of these weaknesses (Mason & Kwok, 2010). This leads to our first research question: *"Are grants to New Technology-Based Firms answering to supply-sided financing constraints?"*

Second, Pecking Order Theory suggests that grants, being free and non-dilutive, may be used by entrepreneurs without actual financing constraints (Revest & Sapio, 2012; Myers & Majluf, 1984). Doing so, opportunism would divert grants from their objectives. This leads to our second research question: *"Why do New Technology-Based Firms apply for grants?"*

Third, the ability of grants to help NTBF reach the next financing round and ultimately attract investors by signalling their quality has been questioned (Kösters, 2010). If so, the intervention would only offer a short-term solution to entrepreneurs without helping them developing and generate regional spillovers. This leads to our third research question: *"Are grants signalling New Technology-Based Firms to investors?"*

We address these questions by following a qualitative strategy supported by case studies. Our focus of analysis is the 30 early financing rounds occurring within eight grant-supported NTBF during 3 years after incorporation. Operationally, we define financing rounds as any organized attempt, imagined as one single effort by the entrepreneurial team, to raise external funds that support the launch or further development of activities.

We identify and analyse these rounds by triangulating perspectives from entrepreneurs, investors and public servants in Brussels, a typical western European interventionist region. In the end, our findings confirm scepticism towards the relevance and effectiveness of grants. While there may exist, supply-sided financing constraints are actually rare. Despite this, grants are frequently used by entrepreneurs opportunistically and/or to avoid or limit dilution. Finally, we did not observe certification from grants towards investors. We even observe the opposite phenomenon: attracting outside investors or achieving promising first sales play an important role in obtaining or increasing grant support.

This paper is organized as follows: Sect. 2 presents a literature review setting the theoretical framework and empirical background of our research questions. Section 3 details our research methodology. Section 4 presents our findings. Finally, Sect. 5 discusses and reconnects findings with our research questions while Sect. 6 concludes with contributions, implications and opportunities for future research.

2 Literature Review

In this section, we first state NTBF financing challenges and the market failures that can harm them. Second, we present public intervention, its objectives, empirical evaluations and our research questions.

2.1 Financing Needs of New Technology-Based Firms and Market Failures

The financing process of New Technology-Based Firms (NTBF) is known to be challenging (Acs et al., 2009, 2014; Stam & Wennberg, 2009). Their needs are high due to pre-sales development while the technological intensity along with uncertainty strongly limit available financing sources (Rojas & Huergo, 2016; Gompers & Lerner, 2006).

In addition, market failures may exist and make this process from difficult to next to impossible. Three failures have been highlighted regarding NTBF and will be presented hereunder: asymmetric information, liability of newness and knowledge spillovers.

First, asymmetric information refers to situations where co-contractors do not have the same information. Sellers can thus be encouraged to lie about the products and buyers will be wary to the point of eventually paralyzing the market (Akerlof, 1970). While playing a role in the discovery and exploitation of opportunities (Shane & Cable, 2002; Shane & Venkataraman, 2000), asymmetric information may also deter investors (Cantner & Kösters, 2012; Kösters, 2010). Odds of this scenario are increased for NTBF since technologies and quality of the entrepreneurial team are too complex to be assessed by most financial players (Gompers & Lerner, 2006; Colombo & Grilli, 2005). They will therefore consider the projects too risky and postpone investment to a later stage of development.

Second, liability of newness posits new ventures suffer from a lack of legitimacy due to their absence of track record (Baum, 1996; Stinchcombe, 1965). This penalizes NTBF in their relations with first customers and in the attraction of key resources such as investors or skilled staff (Söderblom, Samuelsson, Wiklund, & Sandberg, 2015; Zimmerman & Zeitz, 2002; Aldrich, 1999). A vicious circle then engages and deprives NTBF, due to a lack of legitimacy, of the resources and achievements needed to increase the latter.

Third, full appropriability of R&D projects is imperfect (Acs et al., 2009). Research results indeed usually spill over and benefit firms not having borne the investments. This may be particularly relevant for NTBF since they have limited budgets to protect intellectual property (Baumol, 1993). While this feeds innovation, it also causes a loss of private return that may scare investors and lead inventors to reconsider future research (Söderblom et al., 2015; Cantner & Kösters, 2012).

2.2 Public Sponsorship Theory as the Framework for Public Intervention

Elements presented above may jeopardize NTBF development and associated regional spillovers, and that, particularly in a European context where equity markets are generally less developed than in the United States (Revest & Sapio, 2012; Schwienbacher, 2008). In Europe, where policymakers are rather interventionist, this leads to the creation of numerous aids, including grants, to alleviate NTBF financing constraints (Cantner & Kösters, 2012; Storey, 2006).

Public Sponsorship Theory (PST) sets the framework for this intervention. According to it, market failures justify public support and instruments should pursue joint ‘buffering’ and ‘bridging’ objectives presented hereunder (Autio & Rannikko, 2016; Jourdan & Kivleniece, 2014; Amezcua, Grimes, & Bradley, 2013).

2.2.1 The Buffering Objective

The buffering objective aims at isolating NTBF from turbulences of the outside world by providing resources such as grants to alleviate constraints (Jourdan & Kivleniece, 2014). However, the assumption that the constraints are supply-sided, i.e. due to a lack of investors, has been disputed. According to some authors, the insufficient quality of most deals, namely their investment readiness, would cause rejections (Fraser, Bhaumik, & Wright, 2015; Mason & Kwok, 2010; Freel, 2007; Mason & Harrison, 2001; Mason & Harrison, 2003). If financing constraints were demand-sided, i.e. due to the poor quality of deals, public intervention would create distortions by masking these weaknesses and preventing entrepreneurs from working on them. Our qualitative approach allows assessing the maturity of projects at the time of equity and grant applications to address our first research question: *Are* *grants to New Technology-Based Firms answering to supply-sided financing constraints?*

Additionally, grants might also be diverted from their original purpose by entrepreneurs. Indeed, the free and non-dilutive nature of grants would make it particularly attractive to entrepreneurs regardless of actual financing constraints according to Pecking Order Theory (POT).

In a context of asymmetric information with potential investors, POT posits that managers will prefer internal to external financing and debt over equity to limit cost of financing and dilution of shareholders (Myers & Majluf, 1984; Myers, 1984). The theory has been empirically validated for incumbents and the preference for internal funds is confirmed for NTBF (Revest & Sapio, 2012; Cosh, Cumming, & Hughes, 2009). The study of external fund preferences however produced mixed results. On the first hand, an inverted pecking order suggested equity would be preferred to debt for two reasons (Minola, Cassia, & Criaco, 2013; Minola & Giorgino, 2008; Hogan & Hudson, 2005; Sjögren & Zackrisson, 2005). First, NTBF lack track record and tangible assets which leads banks to ask entrepreneurs' assets as collaterals (Paul, Whittam, & Wyper, 2007). Second, entrepreneurs would benefit from venture capitalists' or business angels' experience and advices on strategic and financial issues (Colombo & Grilli, 2010; Cumming, 2010). However, these studies have been mostly based on ex post analysis of NTBF financing mixes. This is at risk of confusing preferences, i.e. what entrepreneurs wanted, with contingencies, i.e. what they got (Vanacker & Manigart, 2010). On the other hand, some authors confirmed a classic *pecking order* with debt coming before equity to avoid a loss of control (Vanacker & Manigart, 2010; Cassar, 2004; Giudici & Paleari, 2000; Manigart & Struyf, 1997). Reduced financing options due to the failures presented above could thus mask that classic pecking order also applies to NTBF.

Grants could thus be used regardless of constraints to avoid dilution and henceforth substitute itself to private money (Romero-Jordan, Delgado-Rodriguez, Alvarez-Ayuso, & de Lucas-Santos, 2014; Zuniga-Vicente, Alonso-Borrego, Forcadell, & Galan, 2014; Revest & Sapio, 2012; Cantner & Kösters, 2012; Kösters, 2010). Ultimately, this might even dry up investors' deal flow and crowd them out. The triangulation of interviews of entrepreneurs, investors and public actors for each financing round allows to identify the various motives, sometimes simultaneous, that lead entrepreneurs to apply for grants and henceforth answer our second research question: *Why do New Technology-Based Firms apply for grants?*

2.2.2 The Bridging Objective

The bridging objective states public intervention should connect NTBF with investors either directly, via networking events, or indirectly by signaling promising projects and henceforth increasing their legitimacy (Autio & Rannikko, 2016; Söderblom et al., 2015; Lerner, 2012; Zimmerman & Zeitz, 2002). The financing path of NTBF is indeed known to be staged and progressive. As they grow, the nature and extend of their financing needs as well as available sources evolve

(Harrison, 2013; Berger & Udell, 1998). Grants are part of this process and should help NTBF develop and attract investors to move from one financing round to another.

On that respect, selective allocation of grants by a jury of public and private actors would act as a signal and help attract investors (Meuleman & De Maeseneire, 2012; Colombo, Grilli, & Murtinu, 2011; Kleer, 2010). According to Söderblom et al. (2015), this certification would be even more important than the amount of money actually awarded. However, promising NTBF are difficult to identify ex ante and public institutions may lack staff able to carry this selection. Indeed, non-competitive compensation schemes compared to the private sector may prevent public institutions to attract skilled staff as has already been highlighted for public venture capital funds (Revest & Sapio, 2012; Leleux & Surlemont, 2003; Lerner, 2002). As a result, it has been argued that if even venture capitalists, considered as the most skilled to evaluate NTBF, experience high failure rates, it is illusory to think that public authorities can be more effective at making this selection (Nanda, 2016).

To overcome this challenge, policy makers may rather end up 'picking winners'. Doing so, they devote most support to successful NTBF and increase their support as they develop (Cantner & Kösters, 2012). If not always explicit, this strategy may be implicit in order to exhibit good results. Public opinion is indeed highly demanding and expects from public servants that their actions create new firms and, more importantly, new jobs (Lerner, 2012). Picking winners thus outsource the selection to investors and customers and reduce the failure rate of grant portfolio (Cantner & Kösters, 2012; Kösters, 2010). This 'safe bet' nonetheless raises concerns. First, it does not offer solutions to less successful NTBF that are actually constrained. Second, it provides successful NTBF with public money while they might be able to get funds from banks or investors (Cantner & Kösters, 2012; Santarelli & Vivarelli, 2002). On that respect, Koski and Pajarinen (2013) found that grants did not help Gazelles grow while it helped startups to become Gazelles. Analyzing financing rounds and their succession allows answering our third research question: *Are grants signalling New Technology-Based Firms to investors?*

3 Methods

3.1 Research Approach and Setting

We followed a qualitative and inductive research strategy supported by case studies. Our level of analysis was the financing rounds within NTBF. This approach appeared to be the most suitable given our research questions (Yin, 2013; Bryman & Bell, 2011; Eriksson & Kovalainen, 2008). Our approach is indeed well suited to identify the potentially various financing patterns including grants that may coexist along with their underlying causes. Doing so, we respond to a call for more qualitative approaches to better document the context surrounding complex entrepreneurial phenomena and improve understanding (Welter, 2011; Gartner & Birley, 2002).

Our research setting is the Brussels-Capital Region (BCR) which is located in the heart of Belgium with a population of 1.2 million inhabitants spread over an area of 161 km^2. BCR can be considered a typical western European interventionist setting to study grants for three reasons. First, according to the Global Entrepreneurship Monitor (2017), Belgium is an average entrepreneurial ecosystem that nevertheless stands out in terms of commercial and legal infrastructure, entrepreneurial finance and support and relevance of governmental policies. Second, BCR hosts multiple academic institutions and research centers and is considered as a Strong Innovative Cluster in Europe (Stockholm School of Economics, 2011). Third, Brussels policy makers have developed numerous initiatives aimed at supporting NTBF, including grant schemes, for more than 15 years (Innovative Brussels, 2006, 2012, 2016). Among these schemes, amounts range from tens to hundreds of thousands euros and may be allocated to cover all or part of the expenses related to R&D or business development projects.

3.2 Sampling

Our sample has been purposefully built to exhibit diversity of financing rounds and paths. Firms have been identified via a focus group with public actors and their inclusion was confirmed after first interview with the entrepreneur. Ultimately, we selected eight NTBF gathering 30 financing rounds with heterogeneous financing patterns and different level of grant support. On that respect, five were university spinoffs having received pre-incorporation grants while the remaining three were not. Additionally, we unsuccessfully looked for Brussels firms that developed without any grant at all to contrast our findings. However, as explained by a public servant: *"it would be stupid to start a business without ever trying to benefit from grants"*.

Demographically, the eight NTBF were created after 2008 and operating for at least 3 years in any industry except drug development. This exclusion is justified by the peculiarities in terms of financing needs and development time of the pharmaceutical industry. A description of the sample is provided hereunder at Table 1 and highlights funding diversity both after the first round and after 3 years. Names were invented to preserve confidentiality.

3.3 Data Collection and Analysis

Data collection and analysis took place in parallel until saturation was reached. At this stage, adding new data no longer changed our understanding of the events (Bryman & Bell, 2011).

Table 1 Description of the sample

	Industry	Market orientation	University spin-off	Funds raised after the first round Total (k€)	Funds raised after the first round Grants (k€)	Funds raised after 3 years Total (k€)	Funds raised after 3 years Grants (k€)	Rounds after 3 years (#)	FTE except founders after 3 years (#)
SoftOne	Software development	B2B	Yes	969	260	1362	286	3	11
HealthOne	Healthcare	B2C	Yes	539	75	1570	456	5	13
MobOne	Mobility	B2C	No	331	197	1161	561	4	9
MarkOne	Marketing	B2B	No	183	123	593	533	4	14
EngiOne	Engineering equipment	B2B	Yes	1205	370	4922	652	4	8
HumanOne	HR management	B2B	No	49	30	749	229	3	2
SoftTwo	Software development	B2B	Yes	19	0	524	380	4	2
ScienceOne	Scientific equipment	B2B	Yes	19	0	161	142	3	0
				3314	1055	11,042	3239	30	59

Table 2 Summary of collected data

	Interviews entrepreneurs	Interviews grant officers	Interview investors	Interviews incubators	Documents	Total
SoftOne	2	2	1	1	8	14
HealthOne	3	1	3	1	7	15
MobOne	1	1	1	1	8	12
MarkOne	2	2	1	1	6	12
EngiOne	2	1	2	0	8	13
HumanOne	2	1	0	1	11	15
SoftTwo	3	2	2	1	8	16
ScienceOne	2	1	2	1	5	11
	17	11	12	7	61	108

3.3.1 Summary of Collected Data

Data has been collected from 47 semi-structured interviews with entrepreneurs, investors and public servants from grant and support agencies[1] and 61 written documents gathering grant applications, business plans, financial statements and investment notes. Details of the research material for each firm are presented hereunder at Table 2 while the interview guides are available in Annex 2.

Interviews have been transcribed and imported in Nvivo, a specialized analysis software tool, with the written documents. Within Nvivo, data have then been aggregated, coded and triangulated as described in the next subsection.

3.3.2 Data Analysis

Data analysis move from intra-case to cross-case as described hereunder. Intra-case analysis implied three phases contributing to isolate a set of constructs needed to answer our research questions. Operationally, coding has been realized by the first author of this paper. At the end of each phase, the second author systematically assessed codes before we moved to the next phase.

First, we coded data to chronologically identify the financing rounds organized by NTBF. For each of them, we documented their sequence, the financing sources applied for and obtained, the amounts collected. On that respect, we distinguished between four categories: (1) the so-called “Friends, Fools and Family” (3F) that cover funds from entrepreneurs and relatives, (2) debt represents bank and public loans (for private loans backed by public guarantees, the non-guaranteed part is considered as debt while the guaranteed part is seen as grant), (3) equity from business angels and private, public and university venture capitalists, and (4) multiple types of grants. This last category gathers four types of grants available in Brussels: (i) ‘R&D grants’ that support part of R&D expenses and usually amount from a few

[1]Including incubators, technology transfer offices and coaching agencies.

tens to hundreds of thousands of euros. The rest of the budget is to be self-financed by the firm or covered with external funds, (ii) ‘Award grants’ of 300k euros without financial counterpart. These grants are distributed as awards after presentation by the firm of a strategic development plan to a jury, (iii) ‘guarantees’ that allow entrepreneurs to obtain bank loans and (iv) ‘miscellaneous grants’ which cover total or part of expenses related to export, design and translation of a website or hiring staff with amounts ranging from a few thousands to tens of thousands euros. The 30 rounds ultimately identified are presented in Sect. 4.1 of the Findings.

Second, we coded data to track investment readiness (IR) at each round. In particular, we monitored a three dimensional index of IR that evaluates management, market and technology readiness based on works of Brush, Edelman, and Manolova (2012) and Douglas and Shepherd (2002) and presented in Annex 1. To be investment ready, firms had to meet the minimum criteria for each dimension.

Third, we did a final coding focused on the rounds involving grants to identify the reasons that prompted entrepreneurs to apply for this particular funding source. Several reasons could simultaneously support an application and these reasons have then been differentiated according to the type of grants requested.

At the end of these three phases, respondent validation of all codes has been offered to entrepreneurs and realized with seven of them via a telephone interview. We contacted the last entrepreneur, MobOne, three times but he always refused because, first, the NTBF was under due diligence and, then, his investors refused him to communicate on any strategic or financial topic. The articulation between these constructs, our analytic strategies, and our research questions is presented hereunder at Table 3.

Once these intra-case analyses completed, we moved to the cross-case analysis in order to identify patterns and commonalities between cases. Conversely, these comparisons also highlighted some particular cases or led us to deepen intra-case analysis or carry out new research in the literature. In Sect. 4, we systematically present tables gathering the results from these comparisons for each research question.

4 Findings

In this section, we first present the 30 financing rounds before answering our three research questions.

4.1 Financing Sequences and Rounds over the Period

Figure 1 hereunder presents sequences of the 30 rounds of which 22 involved grants. Financing sources are referred as: “F” for 3Fs, “E” for Equity, “D” for Debt and “G” for Grants. We used circles to indicate when sources had been requested and whether

Table 3 Articulation between constructs, analytic strategies, and research questions

	Financing rounds	Intraround sequences	Reasons for grant applications	Financing path	Cumulated financing mix	Investment readiness	Analytic strategy
Q1—Are grants to NTBF answering to supply-sided financing constraints?	X	X	X			X	Obtaining equity implies there is no financing constraint. If equity is however refused, two alternatives are possible: • First, the firm is investment ready. The constraint is thus supply-sided, i.e. related to investors. • Second, the firm is not investment ready. The constraint is thus demand-sided, i.e. related to the firm.
Q2—Why do NTBF ask for grants?	X	X	X				We identify for each round involving a grant application the motives that lead the entrepreneur to this choice. These findings are then compared cross-rounds and consolidated at the level of the type of grants.
Q3—Are grants signaling NTBF to investors?	X	X		X	X		We use the position of equity and grants within the financing sequences and path. Two situations are distinguished: • First, no signal if equity came before grants. • Second, equity can be allowed after grants or during the same financing round. In that event, further analysis of research material help disentangle between effective signaling and independent events.

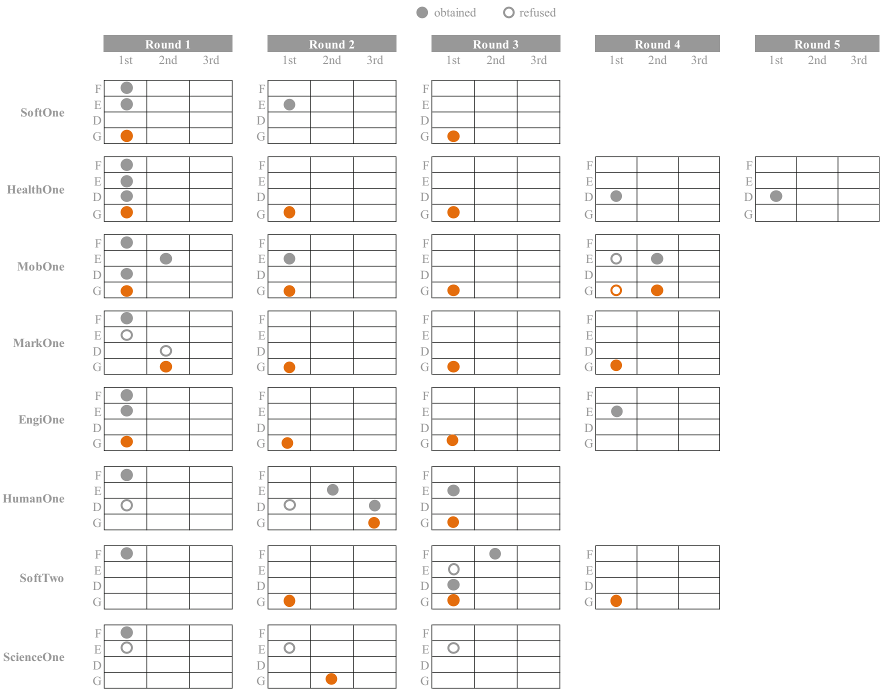

Fig. 1 Overview of the 30 financing rounds over the three first years of operations

it was the first, second or third choice of the entrepreneurs. Additionally, solid circles indicate successful requests while hollow circles indicate refused ones. Finally, we use orange to highlight grants. As an example, the first round of MarkOne is to be read as: the entrepreneurs initially unsuccessfully tried to attract equity in addition to their initial financial commitment. They then successfully applied for a grant co-financed by a public loan that was ultimately refused.

There were from three to five rounds per NTBF with all sources requested from first round and rare refusals. Only 10 out of the 57 applications were refused and only the third round of ScienceOne was ultimately unsuccessful due to the waiver of entrepreneurs. This failure rate is rather low compared to what would be expected according to the literature and might be explained by the numerous grants available.

4.2 *Are Grants to NTBF Answering to Supply-Sided Financing Constraints?*

We only observe one case of a supply-sided constraint leading to a grant application. ScienceOne indeed failed to convince investors that considered the project too immature while being investment ready. In all other cases, investment ready firms

Table 4 Financing constraints

	Round	Investment ready?	Successful request?	Conclusion
SoftOne	1	No	Yes	No constraint despite investment unreadiness
HealthOne	1	Yes	Yes	No constraint
MobOne	1	Yes	Yes	No constraint
MarkOne	1	Yes	No	No constraint since potential deal was canceled by entrepreneurs
EngiOne	1	No	Yes	No constraint despite investment unreadiness
HumanOne	2	No	Yes	No constraint despite investment unreadiness
SoftTwo	/	/	/	/
ScienceOne	1	No	No	Demand-side constraint
	2	Yes	No	Supply-side constraint
	3	Yes	No	No constraint since potential deal was canceled by entrepreneurs

got equity if they wanted to while even three investment unready ones got support from investors. These findings are detailed below at Table 4 where we present equity solicitations until success.

Over the period, only SoftTwo did not look for equity while seven firms did so and five ultimately got it. Among the latter, only HealthOne and MobOne were investment ready at equity injection while SoftOne, EngiOne and HumanOne were not.

Regarding SoftOne, the firm was technology and market unready at first round. At that time, the entrepreneurs were raising money to develop a proof-of-concept of their solutions to be then tested with potential customers.

Regarding EngiOne, the firm was both technology and market unready when applying for its first round. However, investors explained that the firm was a university spinoff launched in a period of enthusiasm after the recapitalization of university VC funds.

Regarding HumanOne, the entrepreneur attracted business angels from his network for the second round although the firm was unready on all sub-dimensions. As he explained:

> *Business angels agreed to finance 80 to 90% of the development of the product. At that time, we had nothing. It was not until early 2012 [i.e. 6 months later] that we had a first version and, from that point on, we started looking for customers and a market.*

In addition to these successful endeavors, two firms unsuccessfully applied for equity. The first, MarkOne, was investment ready at first round but finally gave up due to expected unsatisfying terms as stated by the entrepreneur:

> *We looked for 3 months and saw about ten people or funds who could invest. Unfortunately, we saw that it would not work or if it was possible, it would be very complicated and we*

would have to give 50% of our shares for 300.000€. We thus decided that it would be simpler to do it ourselves and did not go further.

The second, ScienceOne, wiped two failures and finally canceled a round. Regarding failures at first and second round, the firm was viewed as too immature by investors. If true for the first round, the firm was theoretically ready at second round with close to 200k euros of sales over the year. For the third round, the entrepreneurs were not convinced by business angels' offers and refused them. In particular, they criticized the terms offered and the mismatch between the firm's needs and the business angels' skills.

While supply-sided financing constraints should justify public intervention, we observe that these are rare. Equity is indeed available and entrepreneurs often succeed in convincing investors to support them.

4.3 Why Do NTBF Apply for Grants?

Grants were used for three reasons: opportunism, to avoid or limit dilution and the absence of alternative. Those are detailed in the subsections below and can apply simultaneously as shown hereunder at Table 5.

4.3.1 Seizing Opportunity

The most common reason why entrepreneurs ask for grants is opportunism. This has been reported for R&D, award and miscellaneous grants. Grants are then used alone or in combination with other funds. Regarding R&D and award grants, entrepreneurs highlighted that it allowed them to finance activities that they planned to conduct anyway. Obtaining the grant then simplified or accelerated the process:

"We asked for grants because access was relatively easy and because this was to finance activities we were going to do anyway. This was to cover fixed costs that we would have had to bear anyway." Entrepreneur—EngiOne

"We anyway wanted to carry out the actions within the plan and the opportunity to receive the grant presented itself so we took advantage of it." Entrepreneur—SoftTwo

"As a software company, we needed a lot of money to do everything we wanted to do and grants were available so we took them." Entrepreneur—SoftOne

Table 5 Reasons to apply for grants

	Opportunism	Avoid/limit dilution	No alternative
R&D grants	X	X	X
Award grants	X		
Miscellaneous grants	X		
Guarantees		X	

Regarding miscellaneous grants, since the amounts involved are lower, entrepreneurs consider speed and simplicity of the granting process as crucial to apply:

> *"Right now, we have less need for money. But if we see grants that are easy and fast to get, we always take them."* Entrepreneur—MarkOne

> *"The challenge is to find money: you need grants and customers. [. . .] Seeking people is difficult but it is not a huge pressure, the real problem is finding money. To do this, you must first go for the easiest and fastest grants."* Entrepreneur—MarkOne

4.3.2 To Avoid or Limit Dilution

The second reason of entrepreneurs is the desire to avoid or limit dilution. This has been explicitly observed with R&D grants and guarantees while award and miscellaneous grants do not seem to be concerned. Indeed, award grants are too unpredictable while miscellaneous grants cover activities and amounts too small to justify the organization of a round with investors.

Most entrepreneurs were thus reluctant to lose control and unsatisfied by the valuations offered by investors:

> *"Initially, I wanted debts and grants to start my business without being diluted by a business angel."* Entrepreneur—MobOne

> *"As I was telling you, we were really not motivated to open up the capital. We did not want investors. It was really a back-up plan."* Entrepreneur—SoftTwo

> *"We took the minimum amount of equity so that we could then go for a maximum of grants and debts."* Entrepreneur—HealthOne

> *"We have not asked for grants because there was no alternative but because they were non-dilutive and almost free."* Entrepreneur—ScienceOne

This willingness of entrepreneurs is sometimes known by public actors:

> *"They do not look for external capital because they want to remain masters on board and I think they will continue like this. The day they open the company's capital will be to sell it. What they want is to get the highest valuation as possible."* Grant officer about MarkOne

> *"The company has been approached by the fund X to acquire a stake in the capital at the time of its creation. However, entrepreneurs decided not to pursue this route given the low valuation that would undoubtedly have been determined and the fact that they wanted to keep control of the company."* Public lending officer about SoftTwo

4.3.3 Absence of Alternative

As mentioned above, the absence of a financing alternative, the theoretical rationale for public intervention, is only observed once with ScienceOne for a R&D grant application. At that time, the entrepreneurs had unsuccessfully sought equity while being investment ready. According to them:

"The project had a R&D dimension so it fitted into the guidelines and we had no money to fund all the development ourselves." Entrepeneur—ScienceOne

4.3.4 Reasons to Use Grants Are Mostly in Opposition with Theoretical Prescription

The study of the reasons that lead entrepreneurs to use grants highlight that the absence of an alternative, the theoretical justification for public intervention, is actually rare and only applies marginally to R&D grants. Conversely, the three other types of grants are only used by opportunism or to avoid dilution.

4.4 Are Grants Signaling NTBF to Investors?

We find no evidence of a signaling effect of grants. It rather appears that financial and non-financial support by investors or experienced entrepreneurs play an important role in getting R&D or award grants. Table 6 below details these findings.

As a reminder, two scenarios may indicate a signaling effect of the public intervention: either grants are provided in a previous round or they combine with private investors within the same round. If equity precedes grants, the signaling effect is de facto impossible. This last case has not been observed.

Over the period, five firms raised equity. Among them, SoftOne, HealthOne, MobOne and EngiOne experienced simultaneous equity and grant entry at first round. However, the analysis of these rounds indicates that grants did not influence the investors but that, for three of them, the presence of the latter had a strong influence in the grant allocation process. As explained by a grant officer regarding SoftOne:

Table 6 Signaling of grants

	Round	Sequence	Conclusion
SoftOne	1	E and G at same round	Inverted signaling, equity and surrounding helped attract grants
HealthOne	1	E and G at same round	No signaling
MobOne	1	E and G at same round	Inverted signaling, equity and surrounding helped attract grants
MarkOne	/	/	/
EngiOne	1	E and G at same round	Inverted signaling, equity and surrounding helped attract grants
HumanOne	2	G then E	No signaling, investors attacted using the entrepreneur's network
SoftTwo	/	/	/
ScienceOne	/	/	/

At that time, they were extremely optimistic but we had no reason not to believe them since they were supported by a well-designed shareholding team. [. . .] There was no reason not to believe them because their business plan had been validated by their board and these people were good.

According to the entrepreneur at MobOne:

Attracting the business angel has been central to convince the other players [including grants].

Another grant officer explained how they got involved in the creation of EngiOne:

The investment fund of the university called us, they wanted to see us. [. . .] They came saying that they needed to finance 1.2 million euros. [. . .] They had already raised 600.000 euros and came us because they wanted that we commit ourselves. [. . .] It was to help them to develop and industrialize the product.

The last firm, HumanOne, received grants prior to equity. However, these were small miscellaneous aids and the subsequent equity injection was build, as explained by the entrepreneur, using his personal network to attract business angels. Grants thus do not appear to have played a role. Moreover, the firm received its biggest grant, 121k euros, at third round after an investment fund entered the capital. This had an influence according to a grant officer:

The business model was weak but there was this fund that had put money in the project to finalize development and the product was innovative so we thought we could take the risk.

Together, these elements indicate a certification from the investors towards public officers rather than the reverse as is recommended by theory.

5 Discussions

As a reminder, public financial intervention aims at alleviating the effects of market failures that may penalize new technology-based firms' development. Public Sponsorship Theory states two objectives for this intervention: to isolate firms from financing constraints and to help them attract other funds and investors in subsequent rounds. However, irrelevant or ineffective intervention may create distortions and bring the entire regional system to a sub-optimal state (Cantner & Kösters, 2012; Santarelli & Vivarelli, 2002). Assessing the relevance and impact of grants was our goal and lead to three research questions.

First, we investigated whether NTBF were financially constrained and, if so, the origin of this constraint. This interest was based on criticism that financing constraints of NTBF would not come from a lack of investors but rather from their immaturity (Mason & Kwok, 2010). In order to do so, we compared the investment readiness of NTBF at the time of equity application and the result of that request. Ultimately, we only observe one situation of grant intervention as an answer to supply-sided constraint, i.e. a lack of investors. Grants indeed appeared to be the only alternative available for this firm despite being investment ready. Additionally, we found one evidence of demand-side constraint for the same firm while no other NTBF experienced constraints if they wanted to attract equity. This contradicts the theoretical prescription according to which market failures only would justify public intervention.

Second, we looked for the reasons that lead entrepreneurs to apply for grants. The free and non-diluting nature of these aids indeed lead to fear of opportunistic behaviors from entrepreneurs (Revest & Sapio, 2012). Ultimately, we highlight the willingness to seize opportunities, i.e. to enjoy low hanging fruits, and to avoid or limit dilution as the main reasons for grant application. In particular, we observe different strategies from entrepreneurs for the first financing round compared to the following rounds. At first round, entrepreneurs may be divided in two categories. On the one hand, those who chose to create a firm with minimum fund and, on the other hand, those who chose to build a financing platform by attracting equity investors. The former wanted to focus on first sales and preserve ownership while the latter wanted to accelerate development and get guidance on strategic issues. After this first round, they however all tend to prefer non-dilutive sources such as grants or debts as expected according to Pecking Order Theory (Myers & Majluf, 1984; Myers, 1984). On that respect, most grants beyond first round were solicited without attempt to attract additional external sources. This financing strategy is recognized by entrepreneurs and often known by grant officers. This contributes to the debate on NTBF's pecking order in three ways. First, since the characteristics of grants make them similar to internal financing, they are therefore highly attractive for entrepreneurs, and that, regardless of financing constraints which matches with previous results on the preference for internal financing (Cosh et al., 2009). Second, we stress that there is no 'one-size-fits-all' pecking order applicable to entrepreneurs. Financing strategies of NTBF are indeed influenced by entrepreneurs' individual preferences and biases regarding ownership or growth ambitions (Atherton, 2009; Berggren, Olofsson, & Silver, 2000; Fraser et al., 2015). Third, we highlight that these preferences may evolve with the firm development.

Third, we examined whether grants signaled promising NTBF to investors. Theoretically, grants should indeed help NTBF attract investors by acting as a quality signal (Söderblom et al., 2015). However, the ability of public servants to ex ante identify these promising firms has been questioned (Nanda, 2016). We thus examined financing sequences and paths and ultimately found no evidence that grants were seen as signals by investors. Moreover, it rather seems that signaling operated from private to public sources, i.e. a "picking the winner" strategy. Having clients, attracting investors or being surrounded by successful entrepreneurs appeared to be important elements in convincing grant officers to back the firm up or increase support. As indicated in the literature, if this behavior leads to little substitution, its additionalities are however doubtful (Cantner & Kösters, 2012; Santarelli & Vivarelli, 2002).

Beyond the traditional limitations of qualitative research (Yin, 2013; Bryman & Bell, 2011; Eriksson & Kovalainen, 2008), this work also suffers from limitations that offer opportunities for future research. First, our sample has been built with public actors and might over-represent the role played by grants. However, we were not able to identify NTBF that survived 3 years without using grants at least marginally. Carrying research in other settings with less public support could overcome this. Second, being focused on the impact of grants on the financing path of NTBF, we did not study firms that did not survive 3 years. They however also deserve to be studied to identify the causes of their failures, in particular potential financing constraints, and contrast our findings. Third, we limited ourselves to the financial aspect of NTBF development. It would be interesting to expand the analysis to human and social resources, strategies and commercial performance to investigate their interactions with grants. Fourth, replicating this study on larger samples and/or for a longer period would also be relevant.

6 Conclusion

Findings and discussions presented above allow to answer “yes” to the title of this paper. There indeed appear to be too much grants in a typical western European region like Brussels. While some grant interventions are in line with theoretical prescriptions and objectives, we also highlight distortions such as opportunism by entrepreneurs or picking the winner allocation strategy by public actors that question both the necessity and impact of these aids. These findings contribute to the scientific community and have implications for both policy makers and entrepreneurs.

Regarding our contributions, our work advances academic debates around grants in two ways. First, we provide a qualitative approach on a topic that has been mostly studied quantitatively. Doing so, we offer a deeper understanding on how the financing process unfold and the entrepreneurs’ motivations to use grants. Second, we contribute to discussions about entrepreneurs’ pecking order by highlighting the diversity of preferences and their evolution. Doing so, we offer a way to unify antagonistic point of views until now.

Our findings also have implications for practitioners. To entrepreneurs, we highlight the importance of building a stable financing platform via sales or investors as soon as possible and surround them with entrepreneurial experience. This would help them securing access to grants. To policy makers, we advise to limit the number of grant schemes to ease their administration, to more systematically couple public intervention with private intervention and to develop financial alternatives such as public loans or equity. Finally, non-financial measures to raise investment readiness might help since equity seems available to mature projects.

Annex 1: Investment Readiness Index

In our analysis, New Technology-Based Firms had to be ready on each sub index to be considered investment ready

- **Technology readiness (With Intellectual Property: min 6/7 Without Intellectual Property: min 3/4)**
  - Development stage (**from 1 to 4**):
    - Technological concept identified (1)
    - Developing prototype (2)
    - Testing prototype (3)
    - Product ready (4)
  - Regarding IP:
    - Is IP applicable to the product? (**0/1**)
    - If so, is IP pending approval or approved? (**0/1**)
    - Is the NTBF enjoying exclusive right on the product? (**0/1**)
- **Market readiness (min 4/6)**
  - Market research (**from 1 to 6**):
    - Unchecked hypothesis (1)
    - Hypothesis checked via desk research (2)
    - Hypothesis checked via focus groups/survey (3)
    - Hypothesis checked via real tests with potential customers (4)
    - First customers (5)
    - Recurring customers (6)
- **Management readiness (min 3/4)**
  - Technical background within the team (**0/1**)
  - Business background within the team (**from 0 to 2**): none (0), business education (1), business experience (2)
  - Surrounded by an advisory board and experienced peers (**0/1**)

Annex 2: Interview Guide

	Interview with entrepreneurs	Interview with investors	Interview with grant officers	Interview with support officers
General introduction	– What is your firm doing? – How did it started?	– How did you get in touch with the NTBF?	– How did you get in touch with the NTBF?	– How did you get in touch with the NTBF?
Financing rounds	– How many financing rounds did you organize?	– How many times did they ask you for funds?	– How many times did they ask you for grants?	– How many times did they ask for your help?

(continued)

	Interview with entrepreneurs	Interview with investors	Interview with grant officers	Interview with support officers
Intraround sequences	For each round: – Which financing sources did you ask for? – In which order? – For what amount? – Did they accept? – Did you get help?	For each round where involved: – How much did they ask? – How did the round go? – Why did you accept/refuse? – Did you had contacts with other actors involved in the round?	For each round where involved: – How much did they ask? – How did the round go? – Why did you accept/refuse? – Did you had contacts with other actors involved in the round?	For each round where involved: – What did you do to support them?
Causes of financing choices	For each round: – Why these financing sources?	For each round where involved: – Why did they ask you for funds?	For each round where involved: – Why did they ask you for grants?	For each round where involved: – Why did they build the round this way?
Investment readiness	For each round, evaluation of: – Management readiness – Market readiness – Technological readiness			

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The Development of ICT Industry in Belarus: Impact of Educational and State-Support Policies

Aksana Yarashynskaya

Abstract The Chapter is focused on the analysis of the educational and state-support policies as the main drivers of the successful development of ICT sector in Belarus. It contributes to the existing literature on ICT ventures development in Central and Eastern European countries in general and on ICT industry in Belarus in particular. The research is mainly targeted to the academic audience (students and faculty), although the practitioners (VC and businesses looking for the offshore outsourcing destinations) could gain some useful insights from this research, as well.

Keywords ICT development · Education · State-support policy · Belarus

1 Introduction

During the last 20 years, Belarus positioned itself as one of the significant players in the global ICT market (Brantley, 2014) and Belarus ICT industry is considered as the "largest IT cluster" in the Central and Eastern European (CEE) countries region (Pobol, 2013). Belarus has the highest rank among the Former Soviet Union (FSU) countries (outpacing some EU countries as well) in terms of ICT development index calculated by the International Telecommunications Union and is recognized as the one of the "most dynamic countries" in FSU region (Measuring. . ., 2015). In terms of the more global comparison, the Belarus software export per capita outpaced the one USA, India and South Korea in 2012, and since then, it is "1.5 times higher than in USA and India, and 2 times than in South Korea" (Chuvakin, 2016). In its recent news (March, 2016 and March, 2017) Reuters questioned whether the Belarus could be the "new Silicon Valley" and Euronews and Financial times paid their attention as well, to the incredible progress of Belarus ICT industry (Belarus. . ., 2016; Belarus 2.0. . ., 2016; Belarus tech dream. . ., 2017).

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How did it happen that Belarus achieved such a significant progress in ICT industry development and which factors influenced it? Using the theoretical concepts and empirical data analysis this research provides the analysis of the educational and state-support policies as the main drivers of the success of the Belarussian ICT sector and key factors for its future development.

2 ICT Education in Belarus

The importance of the proper educated and well-trained labor force is considered as a one of the key factors of the successful development of ICT industry in every country (Heeks & Nicholson, 2004; Radosevica & Wadea, 2014) and therefore the proper educational system and well-functioned educational policy are the important drivers for the perspective ICT development.

Belarussian ICT educational system comprises **(i)** fundamental **University education, (ii) short-term educational courses/modules provided by ICT ventures** for their employees and "outside" students, and **(iii) courses, trainings and bootcamps provided by the other ICT-education providers**.

ICT education provided by Belarussian Universities is based on the well-preserved Soviet educational infrastructure, when Belarus was considered as an "assembly line" for the advanced technological projects for the military, energy, global communications, nuclear and space industries of the former USSR (Bougiouklis et al., 2009). Since the end of the Cold War and followed demilitarization, the technology-oriented University departments were re-oriented and started to produce graduates for the rapidly developing ICT industry.

In total, 14 Universities (out of all 55 Belarussian Universities) provide the ICT relevant educational programs, granting the BSc and MSc degrees in numerous ICT specializations. Most of these Universities are concentrated in Belarussian capital city Minsk (4 Universities), the rest are quite homogeneously dispersed among the other Belarussian regions: around 1–2 Universities in each of the other five regions (oblast'). Some ICT education is also provided by the Belarus scientific-research institutes (MS and PhD studies), although their main focus is on the advanced R&D work.

More than 15,000 "Engineering and technology" specialists graduate annually from these educational establishments, taking approximately the 17% share of all University graduates in Belarus. Graduates with BSc in "Engineering and technology" has a 17% share in total BSc graduates (ranking the second popular educational degree after 42% share of the Law and Economics graduates), MSc and PhD graduates has the 18% and 12% share in all MSc and PhD graduates pools respectively (Education. . ., 2017).

In general, the quality of Belarussian University-based ICT education is considered as "strong", as well as the quality of Belarussian ICT graduates is considered as been "indisputably and globally recognized"—e.g., Belarus took the 6th place by the number of the certified specialists in IT industry (leaving behind the UK, Germany, Sweden and Norway) and the 4th place by the number of the Master-level certified specialists out of 50 countries pool (Belarus' potential . . ., 2012).

Despite the sound quality and effectiveness of the University-based ICT educational system, it also has some deficiencies, which in the long-term run could jeopardize the sustainable development of the Belarussian ICT industry. One of these problems is the substantial gap between the standard University programs, which focused on the important fundamental ICT courses and rapidly emerging numerous (almost countless) new technologies, which are not the part of the standard University curricular.

This gap is bridged by the short-term courses, trainings, and boot-camps provided by the reputable educational centers established by the leading Belarusian ICT companies and other ICT education providers, operating independently from the Belarussian ICT companies. Their curricular offers the wide range of training courses narrowly focused on the very specific ICT skills or newly emerged technologies—the former is important for the ICT job market "newcomers" with no (or little) previous experience in ICT industry, and the latter is crucial for the upgrading of the skills of experienced workers to catch-up with the numerous newly emerging and rapidly developing technologies. While the quality of the education provided by the leading ICT companies is considered as almost undisputable, the relevance and applicability of the independent ICT educational providers rises some concerns, leading to a discussions about the necessity of the introduction of all-national certification of the these courses, which could be provided by the state-authorities or by the main Belarus ICT stakeholders from the educational and industry sectors.

Another way of addressing the gap between the fundamental ICT education and rapidly changing ICT technologies is the establishment of the training laboratories at the Universities by the ICT companies, which enables students to learn the rapidly upgrading and newly emerging ICT technologies. This joint University-industry cooperation proved itself as a very successful initiative and the number of these joint—laboratories more than doubled in 10 years—from 30 in 2006, to 80 in 2016.

Finalizing the analysis of the structure and impact of ICT education on ICT industry development, it is possible to conclude that the positive impact of ICT education (inherited from the Soviet time, but well-preserved and effectively developed) on ICT industry development is based on the (i) finding the proper balance between the fundamental (University based) and basic ICT education (stand-alone short-term courses, trainings and boot-camps), and (ii) close cooperation among the all stakeholders involved in ICT education. The former means, that in Belarus, the main attention is focused on the fundamental University-based ICT education (crucial for long-term progressive development of ICT industry), however the importance of ICT courses, trainings and boot-camps is not undermined as well, because nowadays, they are the essential source of supply of the workforce re-trained from the other (non-ICT) educational backgrounds and also play the crucial role in providing the up-to-date knowledge about the newly emerging ICT technologies, which is important for the short- and long-term sustainability of

Belarussian ICT industry. The latter implies, that the Universities and providers of short-term ICT training courses are partners, not competitors (unlike in some other countries), and both work in close cooperation with the ICT ventures, specifically tailoring their curricular to the different (not-overlapping) needs of the ICT ventures.

Considering the good fundamental basis and effective mechanisms of the adaptation to the current challenges, it is possible to conclude that Belarussian ICT education system has a significant potential and considerably good prospects for its future developments.

3 State-Support Policy for ICT Sector Development in Belarus

The supportive governmental, legislative and institutional environment is an essential requirement for the growth of the high-tech industry (Block, 2011; Hughes, 2008; Lazonick, 2008; Mazzucato, 2013; Radosevica & Wadea, 2014; Storey, 2006). In Belarus, during the last two decades, state authorities created a **network of governmental bodies** and implemented the broad **range of ICT policy measures** to provide the unified national legislative and institutional environment to boost the development of the ICT sector.

The network of national governmental bodies in Belarus includes many types of organizations and institutions of state and mixed (public-state and private-state) origins, which includes: (i) Governmental organizations, (ii) bridging organizations, and (iii) professional unions and associations.

The most important role in defining the perspectives of the ICT development in Belarus is played by the governmental organizations (i.e.—governmental Ministries) with their national and regional branches. The Ministry of Communications and Informatization of Belarus is the key organization which is legally responsible for the management of the ICT development in Belarus, and which coordinate the work of the other governmental establishments in this regard. The bridging organizations are the intermediaries between the government and the rest of the Belarussian ICT system, with the Interdepartmental Commission on Informatization Issues at the Cabinet of Ministers acting as the stand-alone main intermediary organization in the Belarus and the specific Councils on Informatization inbred in the other governmental bodies. Professional unions and associations play a substantial role in the development of the ICT industry (mainly in consulting and implementation) and their pool includes 11 organizations, which memberships range from 13 up to 100 Belarussian legal entities (Brandon et al., 2010).

The main ICT relevant policy measures in Belarus were the state programs, state strategies, and Presidential Decrees. Although the creation of the ICT governance system in Belarus has been started in early 1990th (by establishing the Fund for Financial and Technical Support of the Development and Fostering of

Informatization Processes in Belarus), the introduction of the most important legislative initiatives has been started since 2000.

Over 12 ICT-relevant legislative initiatives were implemented in 2000–2015 (Brandon et al., 2010). Among the most important of them were the following: the National ICT Program of the Republic of Belarus "e-Belarus" for 2003–2010, State Program of Innovative Development of Republic of Belarus for 2007–2010, Electronic and Optics Program for 2006–2010, INFOTECH Program for 2006–2010, Strategy of Information Society Development in Belarus until 2015 and Presidential Decree from 22.09.2005 "On the Hi-Tech Park".

All these policy measures were not narrowly focused only on the ICT-relevant sectors, but covered the wide range of the educational, research, public and social issues, helping to advance Belarussian ICT industry, preserve and improve the quality of ICT education, integrate Belarussian ICT sector into the global ICT community and successfully develop (almost from the scratch) public ICT infrastructure in Belarus. The overall positive effect of these governmental policies is widely acknowledged by the ICT industry practitioners (Bougiouklis et al., 2009). From the academic point of view, these governmental policies could be considered as the mainly "mission-oriented" ("technology push"), rather than "diffusion oriented" (according to Ergas, 1986), and therefore although they have a positive short and medium-term impact on ICT development in Belarus, their sustainability in the long-term run could be questionable.

The most important governmental legislative initiative, which influenced remarkably the boost of ICT industry in Belarus, was the establishment of the High Technology Park (Hi-Tech Park) in 2005. The main goal of the creation of the Hi-Tech Park was the creation of the specific institutional and economic environment favorable for the development of the ICT sector in Belarus. The specific financial and organizational benefits were granted to Hi-Tech Park residents and investors—e.g. exemption from or reduced rates for some taxes and fees.

The analysis of the results of Hi-Tech Park work for the last 15 years shows that all of these goals were successfully achieved. Currently, 164 companies are registered in the Hi-Tech Park, which constitutes only 2% share of ICT companies, but 55% share of all ICT labor force in Belarus. More than 50% of Hi-Tech Park companies are the companies with foreign capital (some from the Fortune 500 listed companies). The overall volume of Belarus ICT export tripled during the last 15 years due to the Hi-Tech Park establishment, with the overall share of the Hi-Tech Park export in total Belarus ICT export of about 65%. Most of the Hi-Tech Park ICT export is directed to the USA and Canada (44%), 50% to the European countries, and 4.1% to Russia and other former USSR countries (Avtushko-Sikorskij et al., 2017; HTP..., 2013; Information..., 2015). Due to this unparalleled success, the Hi-Tech Park is considered as the acceleration hub for the whole Belarus ICT industry.

However, despite such a successful history and significant role in the Belarussian ICT sector development, the future of the High-Tech Park seems to be somewhat ambiguous due to the two main challenges: absence of the long-term perspective and not very positive public perception of the favorable tax and legislative status of the High-Tech Park.

The absence of the long-term perspective is based on the unclear future for the High-Tech park residents, due to the fact that preferential tax and legislation regimes were granted by the Presidential Decree only by the year 2020, and the prolongation of these regimes "is not so obvious by far" (Avtushko-Sikorskij et al., 2017). This dubious and unclear situation raises concerns about the future perspectives, constraints the long-term business planning for the High-Tech residents and could possibly lead to the exit of some companies from the High-Tech Park.

Another challenge, which fuels the growing concerns about the High-Tech Park future is the negative public opinion of the High-Tech Park as a "tax haven" with a too preferential economic and legislative regimes for the selected companies, which is considered to be the not necessarily of high importance for the future development of the High-Tech Park and is also to be the unfair to the rest of other Belarussian companies. Although these attitudes are not considered as of "direct danger" to the High-Tech Park residents by far (Avtushko-Sikorskij et al., 2017), they rise the additional concern for the long-term prospects of High-Tech Park development.

However, despite the existing problems and challenges, the main ICT sector stakeholders agree, that the state-support policies (and especially the creation of the High-Tech Park) had the positive impact on ICT sector development and due to their proper implementation, nowadays, the Belarussian ICT sector is the well-developed industrial cluster, which could be the acceleration hub for the rest of the Belarussian economy. The overall analysis of the Belarus ICT sector shows that the incredible progress in its development, was achieved due to the proper educational system and state-support policies, and if Belarus will continue on this path, the notion of Belarus becoming a CEEC region "Silicon Valley" would not sound unrealistically.

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Part IV
Academic Entrepreneurship

Defining Academic Spinoffs and Entrepreneurial University

Maksim Belitski and Hanna Aginskaya

Abstract The traditional vision of the university as a teaching institution still prevails in many countries. Typical of this vision is the high-risk aversion to knowledge commercialization due to lack of institutional support and market knowledge. Therefore, university scholars and seem more interested in publishing and graduates are more interested in secured life-time employability instead of commercialising their research and ideas on the market which does not contribute to technology transfer (TT) process and economic growth.

This chapter aims at providing insights into the important success factors of creation of academic spin-offs and entrepreneurial university, by carrying out a systemic review of eclectic literature on knowledge commercialization a technology transfer. It reveals that technology transfer offices (TTOs), centres for entrepreneurship and entrepreneurship education as important success factors for academics spin-offs and knowledge commercialisation. Practical implications for entrepreneurship university and other stakeholders and discussed.

Keywords Knowledge transfer · Entrepreneurial university · Spin-offs · Knowledge commercialization · Researcher

1 Introduction

Universities are currently implementing far-reaching changes to become more entrepreneurial. Technology transfer offices (TTOs) are being set up to promote the commercialisation of the results of academic research in a form of academic spin-offs. Along with creating an entrepreneurial ecosystem in education where

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entrepreneurship skills are taught and developed, the process of knowledge commercialisation has attracted the attention of researchers and policy makers with its capacity to foster social and economic development and exploit industrial innovation.

In terms of demand for technology, the European context shows two particular features (Abramo, D'Angelo, Di Costa, & Solazzi, 2011; Abramo, D'Angelo, Ferretti, & Parmentola, 2012). The first is the high-tech de-specialisation of most industrial sectors and the consequent reduction in competitiveness in high-tech industries. The second is the sizeable presence of small and micro firms that are usually reluctant to introduce product and process innovations. Both these aspects underline the difficulty in absorbing the results of public research into the national production system. This difficulty could be amplified by university technology outputs that are often underdeveloped for industry (Markman, Phan, Balkin, & Gianiodis, 2005).

The Western European context also has some peculiarities in relation to technology supply. According to the European Knowledge Transfer Report (EC, 2013), US Public Research Organisations (PROs) show better TT performance in invention disclosures, patent applications, licence income and start-ups per capita than their European counterparts. In particular, Western PROs—including universities—are the chief suppliers of knowledge technology. Thus, university TT processes and promotion of "entrepreneurship university" are of pre-eminent importance for driving business innovation and spin-offs—which is commercialisation of ideas by scientists, graduates and entrepreneurs (Mustar, 1997; Mustar et al., 2006). This aim of this study is the systematic literature review and define the strategies which enable an increase the likelihood of academic spin-off and knowledge commercialization by universities.

The number of strategies will be discussed in this chapter to enhance knowledge commercialization including the introduction of The Bayh–Dole Act—type regulation in many other countries (Kenney & Patton, 2009; Shane, 2004) as well as further investigation of both institutional and environmental factors which support academic spin-off and knowledge commercialization. This is important task as the traditional vision of the university still prevails in many countries, including West and East Europe. Typical of this vision is the high-risk aversion due both to the negative perception of failure and long-life employment (Chiesa & Piccaluga, 2000). Therefore, researchers seem more interested in publishing instead of commercialising their research results on the market with is obviously reasonable for fundamental researches, but seems to be a barrier to TT process in applied science.

This chapter aims at providing insights into the creation of academic spin-offs and making university more entrepreneurial, by investigating the role of success factors of entrepreneurship ecosystem at a university on the base of systematic literature review. More specifically, we define important mechanism such as TTOs, centres for entrepreneurship and entrepreneurship education which are crucial success factors for academics spin-offs and entrepreneurial university.

We make the following two contributions to entrepreneurship education and knowledge transfer literature. First, it offers a synthesis of eclectic literature examining the critical success factors of technology transfer as a critical condition for academic spin-off. Second, we build on entrepreneurship education and best practices to examine and discuss success factors of academic spin-offs at university which serve as a conduit of knowledge commercialisation: engagement of all stakeholders within university-industry-government partnership, building infrastructure and entrepreneurship community; Technology Transfer Offices (TTOs) and centres for entrepreneurship as conduits for knowledge spillover. Finally, we contend that knowledge commercialisation through academic spin-off are driven by important mechanisms: technology transfer offices and centres of entrepreneurship and expanding entrepreneurship education and skills within researchers and students, making university overall more entrepreneurial.

2 Theoretical Framework

Despite the growing interest demonstrated in recent years, there is no perfect agreement on the definition of academic spin-offs and the notion of entrepreneurial university, with a vague understanding of instruments available in the entrepreneurship ecosystem to support knowledge diffusion between business and university (Algieri, Aquino, & Succurro, 2013; Clarysse & Moray, 2004; Fontes, 2005; Mustar, 1997; Wright, Clarysse, Lockett, & Binks, 2006). Much of the disagreement is related to the relationship between the university and the new venture, especially in reference to ownership of intellectual property. Indeed, on this point, while it has been shown that an inventor ownership regime generates a greater number of spin-offs than a university ownership regime (Kenney & Patton, 2009), ownership regimes do vary across universities. Another disagreement is on the role of TTOs and centres for entrepreneurship which build entrepreneurship culture and infrastructure in the university.

In line with the definition provided by Netval (2014), an “academic spin-off” is intended as a new high-tech venture promoted and launched by an academic researcher that aims to exploit the results of previous research projects on academic spin-offs and provide insights on creating an ecosystem supporting creation of academic spin-offs in regions as a relatively recent phenomenon, which exists since the year 2000.

According to Netval (2014), a firm may be described as a spin-off from university when the following four conditions are satisfied: (1) the presence of at least one academic researcher in the shareholding; (2) performance by this academic researcher of multiannual research activities in the university of origin (at least 3 years); (3) engagement in a profit-oriented business enterprise; (4) the production and/or selling of products and/or technologies and/or high-tech services in the same field in which the academic researcher developed his/her skills.

There is still no consensus regarding how to measure the entrepreneurial university and create successful enablers of entrepreneurialism in a university. From the systematic literature review we defined that Clark (1998), Etzkowitz (2004), Hindle

(2010), and Mavi (2014) measured the Entrepreneurial University based on the level that it achieves developing the factors that foster start-up activities. In other words, they measure the factors that create the Entrepreneurial University. Other literature, for example Guerrero and Urbano (2010) and Gibb (2012) offer a set of indicators for understanding the entrepreneurial university. Former literature aligns these results with a mission of the university: teaching, research and entrepreneurship altogether. In fact, they identify different indicators for measuring the teaching outcome, research outcome and the entrepreneurship outcomes. Amongst the entrepreneurialism one can find creation of entrepreneurial infrastructure, entrepreneurial culture, and spin-offs, cooperation and formal networks between entrepreneurs and scientists. The literature review demonstrated that creating entrepreneurial culture and infrastructure is most important and is related to the economic development (Etzkowitz & Leydesdorff, 2000; Jacob, Lundqvist, & Hellsmark, 2003; Meyer, 2011), which in turn is based on academic entrepreneurship activities (Etzkowitz & Leydesdorff, 2000; Philpott, Dooley, O'reilly, & Lupton, 2011). Therefore, as entrepreneurship education is the mechanism for promoting ideas and chasing opportunities it may lead to the most appropriate Entrepreneurial University outcomes. Accordingly, a literature on academic entrepreneurship and knowledge commercialization (Caiazza, Audretsch, Volpe, & Debra Singer, 2014; Philpott et al., 2011; Siegel, Wright, & Lockett, 2007) aligned entrepreneurial education with spin-offs as outcomes, but also the importance of development infrastructure (e.g. centres for entrepreneurship, TTO, etc.) as an input. Another gap in a literature is that most of scholars have analyzed entrepreneurial universities and entrepreneurship support infrastructure based on role models from the USA and other European countries (Audretsch & Caiazza, 2016; Caiazza & Volpe, 2016; Markuerkiaga, Caiazza, Igartua, & Errasti, 2016) with few studies providing comparative analysis across countries (Etzkowitz & Leydesdorff, 2000). In addition, the notion of entrepreneurial universities could be geographically biased and is associated with Western economies (Shane, 2004), while neglecting the fact of important best practices, models and enablers while still little attention has been paid to the European countries (Audretsch & Caiazza, 2016; Markuerkiaga et al., 2016).

The importance of analysis of a spin-off and entrepreneurial university together comes from a literature review which evidenced that commercialization of university-based knowledge does not happen automatically (Audretsch & Caiazza, 2016; Caiazza, 2016; Caiazza & Volpe, 2016; Markuerkiaga et al., 2016). For example, several US states with large and prize-awarded universities demonstrate low entrepreneurship activity (Chinni & Gimpel, 2011), despite the high levels of human capital, creativity and knowledge discovery. The University's immediate business environment may not be able to help should the entrepreneurship educational be weak and prospective stakeholders be not interested or not enough motivated to engage with the university. This includes researchers, entrepreneurs and policy-makers who are often excluded from university-industry-government partnership (Giunta, Pericoli, & Pierucci, 2016).

There is growing awareness of the importance of research commercialization and entrepreneurial education as a major missing pillar for entrepreneurial university

(Audretsch, Hülsbeck, & Lehmann, 2012; Fini, Grimaldi, Santoni, & Sobrero, 2011). We found that in both developed and developing countries, universities have embarked on prioritising entrepreneurialism and students' employability with a focus on greater visibility and development of entrepreneurial skills. The system of Higher Education funding in the UK, for example, has undergone major reforms and changes in the last few years (BIS, 2014) aiming to increase employability along with facilitating knowledge transfer between university and industry under government support. In the UK, graduate employability is becoming a key factor influencing subject and university choice. As foreshadowed in the recently published green paper 'Fulfilling our Potential', the UK Government intends to further reinforce employability as a key metric' (BIS, 2015).

In addition to development of employability and entrepreneurial skills in students and faculty needs resources allocated for research funding which has also seen significant changes in the UK, most notably through the increased importance of 'impact' funding and technology co-creation between university and industry through research councils, such as Higher Education Funding Council for England, Economic and Social Research Consortium, Local Enterprise Partnerships (LEPs), Knowledge Transfer Partnership schemes and the European Union 2020 Horizon programme. Success in research translation to industry, and specifically in the commercialisation of university research, is of ever greater importance (BIS, 2015). This policy is supported by scientific evidence which demonstrates that the world's best institutions at creating impactful innovation are also the leading institutions where academics attract private funding and create spin-offs (Audretsch & Caiazza, 2016; Caiazza et al., 2014; Ewalt, 2015; Times Higher Education, 2016).

Investments in research translation initiatives and in the regional economic development in the UK regions welcome initial steps in creating the Entrepreneurial Universities and Universities' entrepreneurial ecosystem, but these investments need to be incorporated into a broader vision for entrepreneurship at the micro-level within centers for entrepreneurship, TTOs and university management.

3 Technology Transfer Offices and Entrepreneurship Centres

In entrepreneurship literature the role of the TTO and entrepreneurship centres in formation of spin-offs is sparse. It remains unclear which TTOs' structures and engagement strategies with business are most conducive to knowledge commercialization and spin-offs. It is not surprising as distilling factors may take long, given various TTOs' structures and strategies are highly correlated with each other when attempting to build a strong university-industry-government partnership (Markman et al., 2005). Our literature review reveals a complex set of relationships between TTO structure and strategies and the role that centres for entrepreneurship also known as centers for entrepreneurial excellence have played in knowledge commercialisation, public and industry policy (Audretsch & Belitski, 2013; Audretsch & Caiazza, 2016; Markman et al., 2005).

In highly competitive environment centres for entrepreneurship foster the formation of entrepreneurial mind-set within the university ecosystem. It becomes clear that success of entrepreneurial university settings is often determined by how well technology is transferred from the labs to their startup firms. University technology transfer offices function as "technology intermediaries" in fulfilling this role expanding teaching, research and extra-curricular activities quickly and successfully. In addition to TTOs, centers for Entrepreneurship enhance university-industry-government collaboration by promoting entrepreneurial ideas and outreaching local business communities in a region. Faculty and students in the university acquire strong practical applications and co-curricular activities with support of TTOs and Centres for Entrepreneurship. Former have remained a central component of the university based entrepreneurship ecosystems, focused both on the co-curriculum activities with business community development across and beyond university campus. Business outreach is achieved through promotion of knowledge exchange activities where entrepreneurs, scientists and students participate, such as entrepreneurship days, events, engagement with TTOs, workshops for business (Lockett, Wright, & Franklin, 2003), finally, providing access to new funding opportunities to students and scientists (e.g. equity and reward-based crowdfunding, angel investments).

TTOs structures and strategies require to bridge the gap between university research and industrial testing of new technologies and business model as emphasized in Caiazza and Audretsch (2013), however a lack of funding and product developmental support remains a main challenge while spin-offs and knowledge commercialisation. We therefore draw scholars and policy-makers attention to the importance of creation of an ecosystem of entrepreneurship in education where venture initiation is supported by industry and private investors. Products and technologies which are developed outside the university are at risk to remain small and never spin-off. In their study Caiazza and Audretsch (2013) and Caiazza (2016) highlighted an importance of idiosyncratic approach to understanding and classifying spin-offs across internal, relational and external dimensions and drawing on various theoretical perspectives to explicitly distinguish important support required by the ecosystem for spin-off growth.

Entrepreneurial university aims to develop collaborative links between three major stakeholders: government, university and entrepreneurs where universities' TTOs and centers of entrepreneurship work together and outreach local business community and policy-makers. For example, many spin-offs benefit from their collaboration with university and government, including indirect (e.g. students' placement, internships, workshops, etc.) and direct support (e.g. funding from government consortiums, Research Councils, LEPs, European Commission and consultancy).

4 Entrepreneurship Education and Entrepreneurial University

Entrepreneurship education is at the heart of entrepreneurial university. It is seen to be a strategic blend of consulting, education, coaching and research with complimentary knowledge created within an entrepreneurship ecosystem which could be further monetised. The performance enhancement in entrepreneurship education is directly related to better understanding market opportunities and hence spillovers knowledge for entrepreneurship (Audretsch & Belitski, 2013; Audretsch et al., 2012). Much of performance enhancement could be learnt from the most famous business schools, such as Harvard University, London Business School, INSEAD, Stanford, University of Pennsylvania, MIT, Cambridge, Oxford, London School of Economics and Political Science, Bocconi in Milan[1] to name a few by building on the significant foundation that has already been laid by those schools should be used.

Following the existing best practices it is important not just embrace entrepreneurship education on the surface, but to create a highly attractive campus experience to all stakeholders of entrepreneurial university, including local policy-makers, entrepreneurs and would-be entrepreneurs, students, scientists and business. Building on systematic literature review, we specify the following strategies discussed in order to increase the likelihood of academic spin-off and knowledge commercialization.

First, *expanding the footprint of entrepreneurial education across the university*. We suggest that it be made mandatory that every single undergraduate programme at the university have an entrepreneurship stream made available. This could be through increasing access to the existing university-wide general modules in entrepreneurship or by creating more subject-specific modules to be included as core within established programmes (e.g. Entrepreneurial Management for Food scientists, Entrepreneurial Management for Creative Artists, Enterprise education for Biosciences). This can be done through the introduction of theory-practice mixed learning in the respective departments. As in Gibb (2002: 258): "perhaps the foremost [purpose of raising awareness about entrepreneurship] is to move the focus of entrepreneurship teaching and research away from the narrow business orientation towards the notion of the development of the enterprising person in a wide range of contexts and the design of organizations of all kinds to facilitate appropriate levels of 'effective' entrepreneurial behaviour".

Second, is *action learning and scientists' engagement in entrepreneurial modules.* Action learning involves challenging assumptions and finding problems to solutions. Deeper learning occurs when conflict is encountered which requires specific environmental factors to be deeply considered and their impact upon theory questioned and analysed. This occurs not only in an educational learning context but also in an organisational learning context (Argyris & Schon, 1978).

[1] Based on the QS World University Rankings by Subject 2016.

Actioned-based approach introduced by Babson College (Gibb, 2002; Neck & Greene, 2011) suggests that teaching should provide the experience of entrepreneurship and move from being overwhelmingly lecture-based to increasingly practice-based with a greater engagement of scientists, where students pursue projects jointly with scientists on campus or in incumbent forms or in spin-offs contributing to spin-off legacy, or in consultancy projects with start-up entrepreneurs. Evidence of the advantages of active learning is in "Entrepreneurship Theory and Action" approach, where students follow major four principles of learning: Action trumps everything, start with your means, build partnerships, do not be the best-be the only. Since 1982 this method has helped thousands of entrepreneurial educators and scientists to look different at the role of entrepreneurial education and engage in Action rather than theorization of knowledge (Neck & Greene, 2011; Neck, Greene, & Brush, 2014). 'Entrepreneurs. . .learn by copying, by experiment. . .by problem solving and opportunity taking; and from mistakes' with learning involves 'reflection, theorizing, experiencing and action' (Taylor & Thorpe, 2004: 204).

Third, *to practise theory-based capability development* is important. As Fiet (2001a) proposed that in order to assist students to become skilled in theory-based competencies, there is a need to develop new approaches to practise theory-based skills. Such approaches as Fiet (2001b) posits "should attempt to address the problem of anecdotal teaching, which is limited because the type of situation an entrepreneur is likely to encounter will probably not fit the type described in the classroom, nor will studying entrepreneurial profiles from case studies inspire potential entrepreneurs' unless they fit the same profile".

Pittaway and Cope (2007) suggest a suitable situation for developing entrepreneurial capabilities, for which they have empirical evidence, is in the planning and activation of new venture enterprise courses that build on the observation that 'people learn from experience where they are involved in problem solving. Development of entrepreneurial capabilities and mind-set should improve the campus-based experience of students and businesses, but also engage would-be entrepreneurs with scientists and business to advance and promote further knowledge commercialisation.

Fourth, it is *providing infrastructure for engagement with entrepreneurial community and policy-makers*. Opening up the centers for entrepreneurship network and events to local entrepreneurship community and inviting policy-makers as keynote speakers will facilitate the knowledge exchange and transition of research initiatives from the university to incumbents and entrepreneurs. This is likely to further improve research commercialization outcomes and matches between scientists, business and government. These activities reflect the extent to which knowledge transfer and business engagement is supported by university (Fernald, Solomon, & El Tarabishy, 2005) and requires significant allocation of resources to get scientists engaged across the university departments.

Several authors have noted the importance of providing learning opportunities for entrepreneurs on campus. In so doing, entrepreneurs are able to use students and scientists to elicit feedback, whilst students and scientists can learn vicariously (Bandura, 1986) from close observation of the entrepreneur.

Fifth, it is *providing facilities for networking with students and alumni*. The traditional campus is a place that is busy during term time and deserted otherwise, a place students visit for 3 years and then return once a year for reunions in the Western system. This tradition is perishing in European and the UK universities, while still remain strong in the US top colleges. An entrepreneurial university to be able for knowledge and ideas to spin-off requires finding a space and building a network channel for ongoing engagement with businesses, scientists and alumni. In particular, along with building the number of incubators on campus and investment should be put in both development of formal infrastructure (facilities, amenities, trees, office equipment, water and electricity supply), but also informal infrastructure and network capacity building with alumni (Hayter, 2013). An impressive example is "Entrepreneurship Tuesdays" in the Engineering department at Cambridge University organized by the center for entrepreneurship Learning. At the same time a controversial study of Kolympiris and Klein (2017) on the number of incubators established in the US institution results in drop of commercialization through licensing is interesting. In particular they draw the attention on quality of innovation, but we do not find the result surprising as incubators are likely to target network capacity building and pre-start-up stage of business. Incubators became a popular tool to introduce scholars and graduates to entrepreneurial opportunities and other instruments of knowledge commercialization (e.g. pitching to investors, participating in government programs, etc.). These are important issues for both knowledge and ideas exchange as well as for financing entrepreneurship start-ups and academic spin-offs. Financing for entrepreneurship activity could be raised from various networks, including internal university entrepreneurship community for product commercialization resources, external entrepreneurship community, sponsorships from key university stakeholders such as angel investors and VCs and from donations from university alumni, government funding grants. Many universities have gone the route of alumni clubs and networking but few managed to use them for product validation experiments, external sources of fundraising, public outreach, knowledge exchange, job placements and other.

All five approaches taken together will contribute to formation of far-reaching entrepreneurship ecosystem in education. Creating an entrepreneurial university aims at easing a process of market entry, technology testing and engaging with external stakeholders (Times Higher Education, 2015). Creating an efficient entrepreneurship ecosystem in education is about changing its mode of delivery entrepreneurship education to a more practice-based approach, and enabling various forms of knowledge commercialisation e.g. start-ups, scale-ups and spin-offs, improvements in the amenities, educational infrastructure and networks with alumni and entrepreneurship society, expanding entrepreneurship education across most of departments, engaging local and national policy-makers who aim to facilitate knowledge transfer and regional economic development.

5 Conclusion

In recognizing that literature on academic entrepreneurship and entrepreneurship education remains undertheorized and fragmented (Audretsch & Caiazza, 2016; Caiazza, 2016; Markman et al., 2005), this study aimed at a review of the eclectic literature and proposes important success factors for alignment of entrepreneurial university and spin-off activity. Building on entrepreneurship theory we revised and redefined the understanding of entrepreneurial university in the extent literature, emphasizing the importance of knowledge commercialisation. TTOs, centres for entrepreneurship and entrepreneurship courses aiming at changing entrepreneurship skill-set, risk attitudes, university-business relationship and action-based entrepreneurship education approaches to more embed spin-off activity within entrepreneurial university framework (Azagra-Caro, Archontakis, Gutierrez-Gracia, & Ferńandez-de-Lucio, 2006; Caiazza et al., 2014; Markman et al., 2005).

First, we make a contribution to the entrepreneurial university definition and key success factors by offering eclectic literature analysis and examining the critical success factors of entrepreneurial university across countries. Our review reveals the variety of conceptualizations associated with entrepreneurial university and spin-offs as important criteria for commercialization of knowledge. Second, we determine and discuss the role of three important enablers of entrepreneurial university and spin-of activity: engagement of all stakeholders and creating an entrepreneurship culture in universities through entrepreneurship education and business outreach, creation of formal and informal infrastructure and networks; TTOs and centres for entrepreneurship to become conduits for knowledge spillover from university to market. These pillars do not depend on the location or size of university, business community or a region and go beyond identifying entrepreneurial opportunities to tacit knowledge exchange and commercialization by scientists and entrepreneurs (Fernald et al., 2005).

Third, our practical contribution is emphasizing the role of entrepreneurial university and the expansion entrepreneurship education strategies which could be extended for both developed and developing countries (Etzkowitz & Leydesdorff, 2000; Neck et al., 2014).

Future research should extend our understanding of the role of entrepreneurial education in academic spin-off (Fini et al., 2011; Mustar et al., 2006), employability and commercialization of knowledge. Building on the best entrepreneurship education practices future research may wish to explore the leading entrepreneurship university models in the developing countries aiming to synthesize the assumptions, enablers and mechanisms available to stakeholders within the university ecosystems to further develop and facilitate knowledge spillover of entrepreneurship in universities. When discussing strategies of entrepreneurship education more attention should be paid to stakeholders' connectivity and embeddedness within university-industry-government collaboration framework. We posit on the importance to include all stakeholders in the discussion on efficient criteria of entrepreneurial university.

More research on entrepreneurship education delivery methods with focus on development of entrepreneurial culture and skills, new approaches to entrepreneurship education (Caiazza & Volpe, 2016; Neck & Greene, 2011) and the importance of providing learning opportunities for entrepreneurs on campus for spin-offs.

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The Impact of Entrepreneurship Governance and Institutional Frameworks on Knowledge-Based Spin-Offs

Reza Asghari and Britta Kokemper

Abstract This chapter focuses on different approaches and methods aiming to optimize the institutional framework for academic-spin-offs in the different stages of the entrepreneurship process. A brief description of the main argument, the establishment of an Entrepreneurial University, will enable a better understanding of its complex structure and will provide an insight into the mutual interdependencies in the spin-off value chain. Research-intensive spin-offs generated by universities and research centers are one of the most important innovation motors and the vehicle for disruptive innovations. The large number of scientific results and inventions that frequently remain passive assets of the universities in the form of intellectual properties, could create an enormous potential for starting successful and sustainable enterprises. Besides creating new ideas and innovations, a key factor for success is an appropriate institutional framework along the whole spin-off value chain. A permanent and sustainable Entrepreneurship Culture requires a holistic Entrepreneurship Governance throughout the entire transformation process, from research to the marketable product.

In the following chapter the authors will analyze the concept of the Entrepreneurial University and describe the characteristics of Entrepreneurship Governance which may accelerate the process of knowledge-based spin-offs in the universities and research centers. The authors will rely on empirical findings in leading entrepreneurial universities and show how an overall entrepreneurship institutional framework may function. In a next step institutional requirements for each stage of entrepreneurship process will be discussed and the determining factors will be described.

Keywords High-tech spin-offs · Entrepreneurship Governance · Entrepreneurship Education · Entrepreneurial University · Spin-off value chain

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1 Introduction

The essential precondition for technological advances is often attributed to research, which is focused on the creation and diffusion of new knowledge (Bathelt, Kogler, & Munro, 2010; Bercovitz & Feldman, 2006). The large number of scientific results and inventions that frequently remain passive assets of the universities in form of intellectual properties, could create an enormous potential for starting successful and sustainable enterprises (Etzkowitz & Leydesdorff, 1995). The transformation of knowledge into marketable products and services is one of the most relevant forces for economic growth, employment creation and global competitiveness (Guerrero & Urbano, 2012). In this context, universities and research centers play an essential role: as a source of new knowledge, as disseminating institutions and as incubators for technological-based innovations (Guerrero & Urbano, 2012; Mian, 1996). Research and teaching comply with the Humboldtian model of higher education and the majority of the university principles in Europe are still based on this concept (Ash, 2006; Dobbins & Knill, 2009). Consequently, the high potential of universities and research centers for sustained economic growth and thus the entrepreneurial education has been neglected for a long time (Rothaermel, Shanti, & Jiang, 2007). The traditional understanding of the university is no longer appropriate to the increasingly knowledge-based economies and societies (Etzkowitz, Webster, Gebhardt, & Terra, 2000). The transformation of industrial economy to knowledge economy has changed the paradigms and regulations for creating wealth and prosperity (Stehr, 2001). Input and output factors of the global economy have become more knowledge based. A wide range of immaterial goods and patents get used to generate the increasing number of knowledge-based products and services. The process of digitalization, especially the recent all-encompassing innovation of Internet of Things makes the new understanding of entrepreneurial university necessary.

Besides creating new ideas and innovations, a key factor for success is an appropriate institutional framework along the whole spin-off value chain (Bercovitz & Feldman, 2006). Therefore, a brief description of the entrepreneurial university approach and the interrelation between universities, industry and government will enable a better understanding of its complex structure (Etzkowitz & Leydesdorff, 2000; Graham, 2014). The authors will rely on empirical findings in leading entrepreneurial universities (e.g., Stanford and MIT) and show how an overall entrepreneurship institutional framework will function (Graham, 2014; OECD, 2012). Subsequently, if the course for an appropriate institutional framework is set, the practical requirements for an effective university spin-off building system will be met.

In addition to the strategic orientation, the institutional arrangement for each stage of the entrepreneurship process will be discussed and the determining factors will be described. Based on the venture capital investment stages, the spin-off process can be illustrated similarly (Aram, 1989; Sohl, 2010). The early stage might be split up into pre-seed-, seed- and spin-off-stage (Kollmann, 2003). These phases have a major impact on the success of the spin-off building process (Degroof & Roberts, 2004; Stankiewicz, 1994) and therefore the early stage will be a major subject in the following chapter. The later stage, including a growth stage and an exit phase, is mostly beyond the influence of the universities. Based on literature review, various effective criteria for success have been identified (Graham, 2014; Meyer, 2003; OECD, 2012; Sternberg, 2014). These criteria can be used to create a stage model, as recommended guidelines taught by Entrepreneurship Universities. In addition to the possibility to integrate entrepreneurship education in the curricular lectures and offering entrepreneurship workshops for professors and Ph.D. students, among others, the quality of campus infrastructure, degree of support from the parent organization, an entrepreneurial network (Graham, 2014; Meyer, 2003), a tailor-made coaching and mentoring program as well as the availability of venture capital are decisive for successful academic spin-offs (OECD, 2012; Van Geenhuizen & Soetanto, 2009).

2 Entrepreneurship University: Institutional Framework for University-Based Entrepreneurial Ecosystems

2.1 Revolution of the Higher Education System

At the beginning of the nineteenth century, Wilhelm von Humboldt formulated the principle of unifying teaching with research (Ash, 2006; Dobbins & Knill, 2009), a concept still employed by most European universities. Consequently, the high potential of universities and research centers to serve as starting point for founding enterprises is only poorly exploited (Rothaermel et al., 2007). Considering the increasingly knowledge-based economies and societies around the world, the traditional role of university is no longer sufficient (Etzkowitz & Leydesdorff, 2000). Etzkowitz et al. (2000) describe the academic development as a three-stage process: *"The entrepreneurial university is the outcome of centuries of academic development, including two academic revolutions, the first making research an academic mission and the second its contribution to economic and social development."* (ibidem). The 'third mission' describes the start of commercialization of academic research results in addition to research and teaching (Etzkowitz et al., 2000). The continuous development and improvement of appropriate institutional arrangements resulted in the concept of "The Entrepreneurial University" (Etzkowitz, 2004).

The outstanding progress of information and communication technology contributed decisively to emerge the knowledge-driven economy in which the university self-conception had to be adapted to the new requirements. Concerning new growth theory, innovation is responsible for sustainable economic growth (Romer, 1994). Universities and research centers breed and create new knowledge, which is indispensable presupposition of innovation. In this case the university spin-offs play a key role to initiate and accomplish the innovations.

A number of studies pointed out the characteristics of an Entrepreneurial University and its development (Etzkowitz, 2003; Graham, 2014; OECD, 2012). So far, there is no common definition of an Entrepreneurial University (Etzkowitz, 2004; Rothaermel et al., 2007). Therefore, the following guiding framework for creating university-based entrepreneurship ecosystems has been designed around four clusters which map most of the commonly identified characteristics of an Entrepreneurial University (Etzkowitz, 2003; Graham, 2014; OECD, 2012). These four clusters are “Entrepreneurship Governance”, “Entrepreneurship Education”, “External Relationship and Technology Transfer” and “Entrepreneurial University—Internationalization”.

All in all, the self-conception of the universities has to change from traditional to entrepreneurial in order to meet the challenges of the future (Etzkowitz, 2003). The following framework should be seen as providing guidance and as inspiration for developing an Entrepreneurial University rather than a comprehensive tool (Fig. 1).

Fig. 1 Entrepreneurial University—guiding framework (Source: authors’ own illustration based on OECD, 2012)

2.2 A Guiding Institutional Framework for University-Based Entrepreneurial Ecosystems

'*Higher education is facing unprecedented challenges in the definition of its purpose, role, organization and scope in society and the economy. The information and communication technology revolution, the emergence of the knowledge economy, the turbulence of the economy and consequent funding conditions have all thrown new light and new demands on higher education systems across the world.*' (OECD, 2012). A number of studies highlight that university spin-off activity is a reflection of institutional behavior (O'Shea, Chugh, & Allen, 2008; Walter, Auer, & Ritter, 2006). All consistently cited as leading Entrepreneurial Universities, Stanford University, Massachusetts Institute of Technology (MIT) and University of Cambridge (Etzkowitz, 2003; Graham, 2014; Röpke, 1998), have already identified the importance of innovation, commercialization of research results, entrepreneurship and the development of regional, social and economic value for their communities. As a result, these universities epitomize the benchmark in concept and practice for highly efficient start-up ecosystems.

In order to change the self-conception of a university, institutional governance and leadership play a major role (Anderseck, 2004). The university management has the most impact of laying the foundation for the strategic focus of the future (Graham, 2014). Besides being authorized to develop the university mission statement, the management board decides on the deployment of human and financial resources which[1], in turn, determine the type and the scope of all entrepreneurial activities (Gibb & Hannon, 2006; Graham, 2014). In addition to the 'top-down approach' or 'university-led' approach (Graham, 2014), spreading an entrepreneurial culture particularly by encouraging more entrepreneurial awareness, mindset and skills, the 'bottom-up model' (Graham, 2014), while a "community-led approach" is another key aspect of the Entrepreneurial University. Furthermore, external relationships (Porschen, 2012; Walter et al., 2006) and knowledge-transfer with a range of entrepreneurial stakeholder (Etzkowitz, 2003) as well as being an international institution will increase the entrepreneurial success.

According to North, institutions are the humanly devised constraints that shape political, economic and social interaction and consist of both informal constraints (values, norms, customs, traditions, and those which influence the behavior of human being unconsciously), and formal rules (constitutions, laws, economic rules, property rights, and contracts) (North, 1990). Entrepreneurial University can be analyzed in both informal and formal institutional frameworks. The formal institutional framework consists the central government or federal state laws which

[1]Ferlie, Musselin, and Andresani (2009) pointed out: "*By 'steering', we here mean the externally derived instruments and institutional arrangements which seek to govern organizational and academic behaviours within HEIs. They are usually but not always emanating from the state.*" Publicly funded higher education institutions largely depend on the state for financing. Beside to the governmental regulations, the university still have influence on its guiding principles (Ferlie et al. 2009).

regulate the behavior of universities and defines the major requirements and regulations of universities. In Germany, for instance, the federal state governments are mainly responsible for higher education policy and determine the formal institutional framework for university activities in the field of research, education and technology transfer. According to the fact, there is no nationwide requirement that all 16 federal states have already integrated entrepreneurship governance in their specific higher education laws (Porschen, 2012).

Moreover, the self-conception of a university strongly based on university requirements and tasks defined by federal state Government. To develop and establish an Entrepreneurial University, the interplay of all four clusters is promising.

2.2.1 Entrepreneurship Governance

In many cases universities and research centers include the word 'entrepreneurship' in their mission statements (Graham, 2014). However, this has to be expressed not only in words as a reference but also in actions. *"Universities should see themselves as entrepreneurial organizations and environments held together by common values/missions and not detailed control systems."* (OECD, 2012). In order to implement an entrepreneurial culture in an institutional environment, strong university leadership, actively promoting a clear entrepreneurship agenda as well as good governance are crucial (OECD, 2012). According to the 'top-down model' someone at the level of the university senior management should be made responsible for the entrepreneurial agenda (Graham, 2014). Consequently, the entrepreneurial strategy should be known at all levels of the hierarchy of the institution, should be shared by internal communication efforts across departments, faculties and other centers (Etzkowitz, 2003) and perceived as a priority by staff and students. Furthermore, developing an Entrepreneurial University strategically could imply specific objectives for entrepreneurship with corresponding indicators (e.g., strengthen entrepreneurial awareness (Bramwell & Wolfe, 2008); generating entrepreneurial competences and skills; support of commercialization research results through technology transfers and spin-offs (Zahra, Sapienza, & Davidsson, 2006).

German Federal Government started 2011 the grant-based EXIST Program which aimed to enhance entrepreneurship governance in German universities (BMWi, 2011). The program invited the universities to create new incentives and regulations to intensify the entrepreneurship engagement for lecturers and students (Kulicke, 2015). Explicit entrepreneurship acknowledgements of university leaders motivate the researchers to take endeavors to commercialize their research results.[2]

[2]Due to this program TU Braunschweig and Ostfalia University developed a holistic joint concept to establish the entrepreneurship cultures at their universities. They defined new university internal regulations for using engineering labs and supporting those university members who are engaged in spin-offs (Asghari et al. 2012). Successful German role-models for integrating entrepreneurship successfully in their missions are the TU München as well as the TU Berlin in Germany. The MIT and Stanford University are two pioneers in development and implementing an entrepreneurial university mission and worldwide leaders in high-tech entrepreneurship (Mach 2016).

In accordance with the comprehensive study by the OECD (2012), "A Guiding Framework for Entrepreneurial Universities", another key factor for developing an Entrepreneurial University are fewer bureaucratic barriers to overcome and the provision of greater autonomy. This allows shorter decision-making processes and accelerates entrepreneurial activities like forming new centers and structures.

In addition, within the scope of a global study by MIT (2014) on "creating university-based entrepreneurial ecosystems" there is another determining factor identified in particular with intellectual property (IP) in technology-based start-ups: *"[...] universities often downplay the importance of IP ownership and startup affiliation, regarding these as secondary to the overarching goal of developing the broader ecosystem. However, with many E&I*[3] *activities operating outside the university itself, the model can face difficulties when the university seeks to regulate and institutionalize its entrepreneurship profile."* (Graham, 2014). As a consequence, a transparent and founder-friendly university invention licensing process should be included in the entrepreneurship policies. Therefore, a consistent entrepreneurship and innovation strategy in collaboration with the technology transfer office is crucial (Etzkowitz, 2003).

2.2.2 Entrepreneurship Education

An Entrepreneurial University is characterized by offering their entrepreneurial education (Clark, 2001; Porschen, 2012) and thus creating an entrepreneurial awareness and an entrepreneurial mindset for the university as a whole (Etzkowitz, 2003; Graham, 2014), including all staff and students. The impact of entrepreneurship education on entrepreneurial attitudes and skills is well documented (Etzkowitz, 2003; Oosterbeek, van Praag, & Ijsselstein, 2010; Solomon & Matlay, 2008). As a first step, entrepreneurship education is mainly meant to increase students' awareness (Fisher, Graham, & Compeau, 2008) and recognition of the growing need for entrepreneurship arising from the complexities created by globalization. Consequently, the institution raises widespread awareness concerning the importance of entrepreneurial activities for technological process and economic growth as well as supporting the career paths of would-be entrepreneurs (OECD, 2012). This opportunity-driven approach (Williams, 2009) focuses on unlocking the entrepreneurial potential of staff and students in general. Afterwards, the entrepreneurship education encompasses skill-building courses in creative thinking, business model and new product development, business management and leadership, etc. (Fisher et al., 2008).

Organizational structures are crucial to be entrepreneurial in their approach and not only as a delivery institution for entrepreneurial learning (Bruton, Ahlstrom, & Li, 2010; Etzkowitz, 2003). Therefore, universities should have a Professor of Entrepreneurship who is involved at the strategic level and at least responsible for

[3]E&I = Entrepreneurship and Innovation.

the entrepreneurship development at the faculty level (OECD, 2012). Consequently, the university has the opportunity to reach all could-be entrepreneurs while deciding to commit to entrepreneurship or to get hired. *"Developing entrepreneurs is often focused on the provision of opportunities and facilities rather than the inspiration and motivation that is necessary for individuals to move from ideas to action. Creating widespread awareness amongst staff and students of the importance of developing a range of entrepreneurial abilities and skills is therefore an important function of an Entrepreneurial University."* (OECD, 2012). Most of the potential founders of technology-based spin-offs often have purely technical backgrounds and many scientists have no access to specific curricular lectures (Graham, 2014). Consequently, there is often a lack of awareness of commercialization research findings, on the one hand, and a lack of entrepreneurial skills on the other hand. Therefore, the Entrepreneurial University should offer entrepreneurial education across all departments e.g., interdisciplinary teaching approaches where students develop a product from research results to business concepts with a clear focus on its commercial potential. (Etzkowitz, 2003; Graham, 2014). *"Entrepreneurial behaviour is encouraged and supported throughout teaching and in extracurricular activities."* (OECD, 2012). In addition to the possibility to integrate entrepreneurship in the curricular lectures and offering entrepreneurship workshops for professors and Ph.D. students, it is also important to integrate 'real entrepreneurs' with practical insights into the entrepreneurial education program. Furthermore, case studies, studies of business failure and providing an inventory of good practice are an extract of the variety of teaching methods (Solomon & Matlay, 2008).

The numerous examples of teaching approaches, on the one hand, and the self-organized start-up communities, entrepreneurship ambassadors and student clubs, on the other hand could be seen as the result of successful implementation of multifaceted entrepreneurial education (Etzkowitz, 2003; Graham, 2014).

2.2.3 External Relationships and Knowledge Transfer

The university-based entrepreneurial ecosystem is characterized by a wide range of stakeholders covering regional and local organizations, entrepreneurs, businesses, alumni, public sector, and venture capital companies, etc. (Gibb & Hannon, 2006). Creating an entrepreneurial network as well as an appropriate infrastructure for knowledge transfer are key drivers for accelerating entrepreneurial success (Walter et al., 2006). Students and scientists usually do not have the networks that institutes for entrepreneurship, university incubators and technology and business parks have taken years to create (OECD, 2012). The networks are necessary to provide the university start-ups with venture capital and experienced mentors who train the students in a very practical way. They are also urgently needed to be win the first market references.

The contribution of networks with key partners and collaborators is essential in achieving the full potential of a university, in entrepreneurship in research, teaching, commercialization of research results, especially of establishing a sustainable spin-off building process (Walter et al., 2006).

The knowledge created by students, research and education, industry, entrepreneurs and the wider community needs to be absorbed back into the institutional environment. There need to be central mechanisms by which the university can absorb knowledge and best practice from the wider entrepreneurial ecosystem (Bercovitz & Feldman, 2006; OECD, 2012).

In addition, the traditional emphasis of Technology Transfer Offices has been on licensing and patenting (Etzkowitz, 2003) and in particular concerning the commercial exploitation of research results for starting new businesses, many of the students and scientists have a lack of clarity over their IP ownership rights (Graham, 2014). In order to enhance the technology-based spin-off rate and the institutional framework for university-based entrepreneurial ecosystem, forward-looking strategic technology transfer policies are crucial.

2.2.4 Entrepreneurial University: Internationalization

An international orientation at all levels has been identified as one of the characteristic clusters of an Entrepreneurial University (Gibb & Hannon, 2006). "*It is not possible for a university to be entrepreneurial without being international but the university can be international without being entrepreneuria*l." (OECD, 2012). The majority of universities consider internationalization in their strategies. Besides paper agreements, the university should ensure that the commitments set out in the internationalization strategy reflect the entrepreneurial objectives of the institution (Graham, 2014).

Integrating a global dimension into the function of education can increase universities ability to compete on the international market (Gibb & Hannon, 2006). This should include lectures with an universal dimension, supporting the mobility of the own staff and students, e.g., studying abroad, international exchanges and internships. Furthermore, spin-offs could get access to university incubators or technology parks abroad for expansion of their network and wider market opportunities (Mian, 1996).

In addition, universities should explicitly set out to integrate international and entrepreneurial staff. As well, in order to share knowledge and best-practice approaches (Gibb & Hannon, 2006), strategic international partnerships are an important part of an entrepreneurial institution. Therefore, universities should have good relationships with other international networks and innovation clusters.

3 Spin-Off Value Chain: From Research to the Marketable Product

Based on the stages of venture capital investing (Brander, Amit, & Antweil, 2002) as well as on a literature review on identifying various effective criteria for entrepreneurial success (Van Geenhuizen & Soetanto, 2009; Ndonzuau et al., 2002), the following stage model can be used to illustrate the stereotypical spin-off value-added process. The early stage might be split up into pre-seed-, seed- and spin-off-stage (Cumming & Johan, 2009), and the later stage into growth- and exit-stage. This theoretical stage-model aims to show adequate methods and possibilities that help technology-based start-ups in developing innovative products and services. Stage models of complex interrelationships such as the university spin-off process could tend to incompleteness or other weaknesses (Rassmusen, 2011). Moreover, this stage model pointed out the factors that could accelerate technology-based university spin-offs for each stage within the early-stage and could be used as recommended guidelines taught by Entrepreneurship Universities. The later stage is mostly beyond the influence of the public universities (Dobbins & Knill, 2009) and will not be further described (Fig. 2).

3.1 Pre-seed Stage: Creating an Entrepreneurial Mindset

The pre-seed stage could be seen as pre-step of founding an enterprise (Heinonen & Poikkiojoki, 2006). This stage is, as already mentioned (see Sect. 2.2.2), characterized by creating an entrepreneurial mindset amongst university staff, scientists and students. Especially scientists and engineers with purely technical backgrounds have

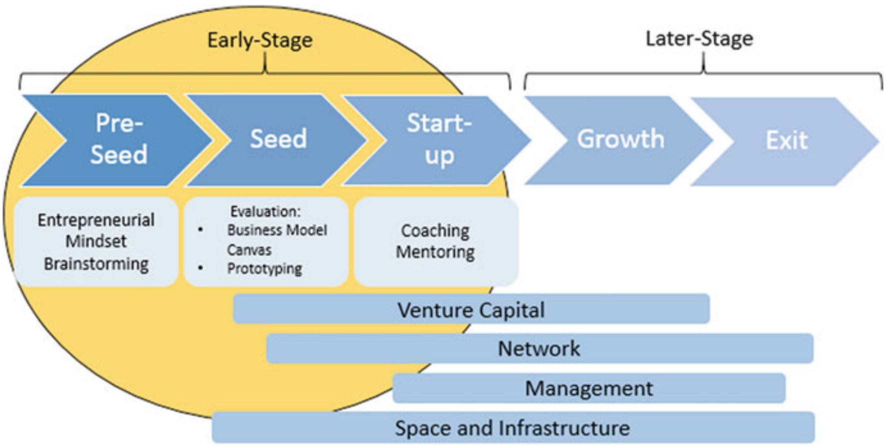

Fig. 2 Schematic academic spin-off process (Source: authors' own illustration)

mostly *"[...] a complete lack of commercial understanding and no desire to get involved in anything but fundamental research"* (Graham, 2014). If the university governance lays the entrepreneurial foundation as already described (see Sect. 2.2.1), the particular challenges to the further expansion of entrepreneurial mindset education could be advanced using different methods:

- Explaining the growing need for entrepreneurship arises mainly from the complexities and uncertainties created by globalization (Gibb & Hannon, 2006) impacting on institutions and individuals of all kinds and in all contexts. Thus scientists should be sensitized for being an active part/problem solver that individuals may be affected in their work, community and consumer future life (Hsieh, Nickerson, & Zenger, 2007)
- Providing opportunities to experience entrepreneurship: maximizing the opportunity for experiential learning, experimental games or simulation (Etzkowitz, 2003; OECD, 2012) and engagement in the 'community of practice' (Peters, Rice, & Sundararajan, 2004). In particular creating space for learning by doing and redoing (Zahra et al., 2006). Projects will need to be designed to stimulate entrepreneurial behaviors—access to real life problems (OECD, 2012)
- Enhancing the student's ability to think and respond entrepreneurially e.g., by combining an entrepreneurial lecture element (business model creation, design thinking, market research and problem solving) with a concrete research project where mixed teams of students and scientists develop a new product concept for a regional company (Gibb & Hannon, 2006; Graham, 2014).
- Getting inspired by real experiences of 'real' entrepreneurs as guest lectures: Selected venture founders could report of their failure and success stories (Kuratko, 2005)

3.2 Seed-Stage: Initialization Phase

Once students and scientists understand the advantages of becoming entrepreneurial, the next step of the spin-off value chain could follow. The seed-stage encompasses the concretization of an initial idea (Rassmusen, 2011) and is characterized by establishing suitable structures involving market research, prototyping and creating a business model canvas (Etzkowitz, 2003; Gibb & Hannon, 2006). Therefore, the university should provide a range of teaching methods aimed at stimulating entrepreneurial skills and attitudes as wells as different support services. A number of studies highlight entrepreneurial skills which should be interiorized (Fisher et al., 2008; Gibb & Hannon, 2006; Solomon & Matlay, 2008). Fisher et al. (2008) summarizes a variety of skills preparing the ongoing entrepreneur in terms of founding a spin-off successfully:

- Marketing Skills, e.g., conducting market research, assessing the marketplace, marketing products and services, learning to persuade, getting people excited about your ideas, communicating a vision
- Resource Skills, e.g., creating a business model canvas, creating a rough financial plan, obtaining financing, securing access to resources
- Opportunity Skills, e.g., recognizing and acting on business opportunities and other kinds of opportunities, product, service, concept development skills
- Interpersonal skills, e.g., leadership, motivating and managing people, listening and resolving conflict
- Learning skills, e.g., active learning, adapting to new situations, coping with uncertainty
- Strategic skills, e.g., setting priorities and focusing on goals, defining a vision, developing a strategy, identifying strategic partners

In addition to the personality-based education, there are other basic key growth drivers for successful systematic transformation of research results to new high performance products: availability of venture capital, access to physical resources such as space and infrastructure (Graham, 2014; Degroof & Roberts, 2004; Steffensen et al., 2000) and access to entrepreneurial networks (Walter et al., 2006).

Firstly, it has to be noted that technology-based spin-offs need capital-intensive investments for development and research, prototyping, starting with the pre-series and delivering the first lot of the new product. Hence, supporting access to venture capital is crucial. In addition, the founding team requires physical resources such as space and an appropriate infrastructure such as business and technology parks and university incubators (Mian, 1996). Third, networking events bring together groups of highly-skilled and talented (would-be) entrepreneurs from different experience levels and backgrounds as well as other entrepreneurial stakeholders e.g., investors, designer, SMEs, who are united around the idea of communication, sharing, creating and developing business ideas (OECD, 2012).

3.3 Start-Up/Spin-Off-Stage: Transition to Free Market System

University technology-based spin-offs face two kinds of difficulties during the start-up stage. The first hurdle involves the transition from the initial idea in a non-commercial environment to becoming established as a competitive company (Vohora, Wright, & Lockett, 2004). Second, conflicting interests of key stakeholders such as the university, the founding team and suppliers of financial support such as venture capitalists may affect the venture's ability to make the transition from one phase to the next (Etzkowitz, 2003).

In order to set up and launch a new venture, university spin-offs have to overcome several bureaucratically, organizational and legal barriers of entry (e.g., consultation on and arrangement of partnership agreements, business registration, patent application, building relationships to customers, suppliers and strategic partners, compliance with legal regulations, required certifications, the lack of appropriate office and production space, finding suitable employees). Entrepreneurs may have strong competencies in the area of technology and perhaps they have acquired skills in the area of business vision, but usually lack organizational, management and legal skills (Zedtwitz, 2003). Due to the fact that most of the entrepreneurs are starting a new venture for the first time, experienced coaches should guide the entrepreneurs through the necessary steps that a newly founded spin-off must take (Mian, 1996). Crucial for accelerating the start-up process are supportive institutional frameworks including office support such as secretarial services and computer network support as well as a one-to-one tailor-made mentoring program and access to further entrepreneurial network including local firms, investors, and successful entrepreneurs and to tax consultants and lawyers (Gibb & Hannon, 2006; OECD, 2012). The institutional support should ensure that basic organizational resources are in place to save time for concentrating on the core competencies to get going quickly.

In addition, a tailor-made mentoring program by experienced industry-specific entrepreneurs such as business angels of sector-specific venture capitalists raises the success rate as well. Usually, experienced mentors already know and leverage key individuals as wells as determining factors for success of their business. Therefore, mentors could help to define the business plan considering best practice sharing, offering management support, assistance with negotiation and they usually have a large network of potential customers and suppliers and investors.

Beyond that, technology-based spin-offs require large amounts of capital (Gompers, 1995). Depending on the specific technology and industry, costs of amongst others producing the first set, logistic, marketing, patents and trademarks as wells as employees could be immense. Thus, the university should support access to further venture capital—usually a combination of public funds and outside capital invested by business angels or venture capitalists (Sohl, 2010).

The institutional support for overcoming the hurdles from the initial idea in a non-commercial environment to becoming established as a competitive company in a free market economy depends on the needs and preferences of the entrepreneurs. In order to avoid possible conflicting interests of key stakeholders the institutional framework should comply with the spin-off process requirements at the strategic level of university and should aim to support the founding process from the beginning till leaving the university environment.

4 Summary and Outlook

The transformation from industrial economy to knowledge driven economy underlines the necessity of entrepreneurship governance in universities and research centers. The governments have to conceptualize and implement appropriate policies and programs to anticipate entrepreneurial outcome through higher education system. Moreover, the entrepreneurship education should contribute to create an entrepreneurial mindset which enables the young academia to overtake risks for generating new innovative start-ups.

Universities can effectively enhance start-ups when they are integrated in the regional and over-regional entrepreneurship networks. They are necessary to provide students interested in founding a company as well as the start-ups with entrepreneurial education, tailored coaching, experienced mentors and venture capital.

The entrepreneurship governance includes the entire entrepreneurship value chain and aims to fix sustainable rules and structures which motivates the students in the early entrepreneurship stage and provide them with appropriate knowledge and properties in the start-up stage to enable them to act later as successful corporates at the market.

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Bridging the Gap Between Invention and Innovation: The Role of University-Based Start-Up Programs and Private Cooperation

Andreas Liening, Jan-Martin Geiger, and Ronald Kriedel

Abstract Within their activities in research and teaching, universities generate significant resources for creation and invention processes. Unfortunately, inventions often cannot be transformed into innovations, and therefore lack the market commercialisation. Reasons for that might be missing resources of universities for further prototyping and testing ideas. At this point, also known as 'Valley of Death', the main university task (namely conducting research) ceases, and as a result entrepreneurial potential remains unexploited. This chapter elaborates on two possible options how to overcome the 'Valley of Death'. In a first step, several aspects of potential resources and their meaning for an innovation process are derived from literature. German entrepreneurship initiatives, which are explored empirically through their business models in order to gain an insight of how invention processes are supported, could be one option. A second option may be private start-programs like venture capital and corporate incubation that approach the innovation process from a commercialised perspective. The findings indicate that university initiatives have to shift their finances in order to sustain their start-up activities. In this context, the role of public private partnerships seems to be a viable option to be discussed.

Keywords University-based entrepreneurship · Start-up programs · Venture capital · Corporate incubation

1 Introduction

Universities play a decisive role when it comes to advancing the invention and development of innovative technologies. Students as well as employees create something new during their process of research and education. The assessment of university-based patents is used for instance to rank and indicate a university's scientific output. However, it is a long way from developing an invention to establish

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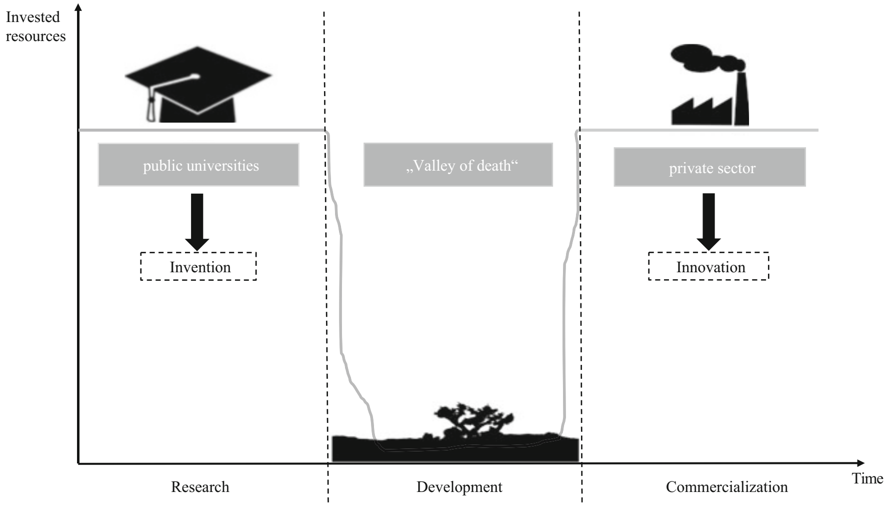

Fig. 1 The ‘Valley of Death’ between invention and innovation

a marketable innovation. Especially, technology-based inventions often require a huge amount of infrastructure and resources to be implemented. Ideas and opportunities are often not further pursued because the development of prototypes is too expensive or inventors see themselves as non-entrepreneurs, who cannot (or do not want to) generate a business model. Thus, a gap may occur between academic findings and the exploitation of these findings in the market. This phenomenon is commonly described as ‘Valley of Death’ (Fig. 1) (Beard, Ford, Koutsky, & Spiwak, 2009). In university-based technology innovations the ‘Valley of Death’ is understood as a sequential process. Like young plants which need sun and water to grow, growing innovative ideas are dependent on their resources which may consist of intellectual capital, network or even financial support. Needless to say not every idea is worth the effort, but in some cases meaningful innovation potential will not be realized.

This paper focuses on the ‘Valley of Death’ with a two-sided approach. Approaching the two sides provides insights into obstacles as well as improvement opportunities for push- and pull-approaches. In particular, it should become clear to what extent public and private provision of resources for entrepreneurial activities are available. Analysing these activities enables the decomposition of different facets of resources like knowledge or financial support and their importance. Furthermore, understanding the ‘Valley of Death’ offers new insights into public-private-partnerships in the academic sector. In a first step, potential aspects of the ‘Valley of Death’ and their importance for innovation processes will be explored in Sect. 2. Afterwards, the role of academic entrepreneurship initiatives, which can be understood as push-factors for innovation, is explored in Sect. 3.1. Remarkable among these programs is the ‘business-model’ which can be seen as an indicator for the degree of support of innovative processes. The Business Model Canvas by Osterwalder and

Pigneur (2010) constitutes a conceptual framework which is used for the analysis of academic entrepreneurship initiatives. Furthermore, the 'Valley of Death' will be approached from the cliff of successful commercialization of an academic invention which can be understood as a pull-factor from the view of innovators. In this context, the focus is especially on the role of established companies. These are able to operate several support initiatives for start-ups in the form of venture capital or corporate incubation programs. For this reason, 119 German enterprises are examined regarding their activities concerning entrepreneurial support in Sect. 3.2. These findings are provided in Sect. 4 and contain descriptive results concerning the business model of academic entrepreneurship initiatives as well as private support initiatives for start-ups. Finally, this article closes with a reflection on the explored aspects of the 'Valley of Death' in Sect. 5 and derives practical implication for an approximation to this.

2 'Valley of Death' in University-Based Entrepreneurship

2.1 Innovation as a Process

There are several viewpoints within the process of venture creation and development. Much research has for instance been carried out on investigating phases of causal and effectual processes in entrepreneurship (Brettel, Mauer, Engelen, & Küpper, 2012; Chandler, DeTienne, McKelvie, & Mumford, 2011; Dew, Read, Sarasvathy, & Wiltbank, 2009). According to Sarasvathy's concept of effectuation (Sarasvathy, 2001, 2008), during the creation of artefacts like firms, markets and economies many parameters are unknown and therefore traditional methods of causal reasoning and planning may be inappropriate. While the causal logic assumes that pre-defined goals will be attained by the selection of appropriate means, effectual logic assumes that goals are created out of the available means. The effectual approach delineates the understanding of entrepreneurship as a linear process which is divided into separate stages (Levie & Lichtenstein, 2010; Sarasvathy, 2001). This differentiation is related to the discussion of entrepreneurial processes as being either linear or non-linear (Lichtenstein, Carter, Dooley, & Gartner, 2007). A linear understanding of venture creation considers a simple, but also complicated order like financing → production → sales → revenues, for instance. In contrast, complexity and dynamic approaches would suggest that venture creation is a process of emergence which relies on the interdependence between the system elements like financing, production, sales, revenues. Those approaches assume that these elements would not follow a fixed order, but affect each other.

Planning and organizing the process of innovation and business creation is addressed by linear and non-linear concepts and in concrete support by causal and effectual methods. Writing a business plan, for instance, is a common planning method which includes the assumption of existing market shares, potential customers, revenue streams etc. and is an adequate instrument to reflect on one's goals. Addressing the adoption of business creation as a process where many aspects are unknown, where early-stage-partners may become competitors in later stages, where revenue streams may switch from direct selling to retail stores, other methods like business model development and customer development may become more appropriate. Instead of predicting the future, planning aspects of the business and selecting the necessary means, thinking in business models allows reflecting different aspects of a venture through self-actualization. Beside these common methods, there is a variety of methods for fostering entrepreneurial challenges and for visualizing the venture creation- and development-process. This variety proves that different phases within the venture creation process require different methods and resources.

With regard to technology ventures, Beard et al. (2009) assume that innovation is a sequential process. According to this understatement, the early phase of innovation is characterized by forming the idea of an invention and undertake basic research. During this phase innovators in a university-based environment (push-factor) are supported by infrastructure like laboratories, raw materials and the knowledge of scholars. The transformation of the invention into an innovation is described as the most critical process where technology has to be adjusted for industrial practice (Auerswald & Branscomb, 2003). Prototyping and testing requires new needs which are usually not provided by a university. These requirements are explored within academic entrepreneurship initiatives in the following section.

2.2 Aspects of Entrepreneurial Resources

Obstacles like a lack of resources may lead to the circumstance that a market potential of innovations and entrepreneurial activities will not be realized. According to Block, Brockmann, Klandt, and Kohn (2009) such resources can be described as those that occur on the personal level of the entrepreneur and represent his intellectual capital, like skills and attitudes. These kinds of requirements are delineated in Sect. 2.2.1. Resources outside the personal level can be found in several markets like financial resources, labour or a network of retailers, for instance. These types of resources are explored within Sect. 2.2.2, Fig. 2 displays facets of entrepreneurial resources.

2.2.1 Resources on the Personal Level

There have to be several levels of professional skills with regards to the entrepreneur's profession. If the business model contains IT-solutions like in many nascent businesses, at least one of the start-up team members should be familiar with programming and software development. If they produce chemicals for surface coating, they should have an engineer or professional chemist within their team. The professional level is crucial for the business model and represents the core of the innovative process that a start-up team is shaping up. In contrast to other disciplines,

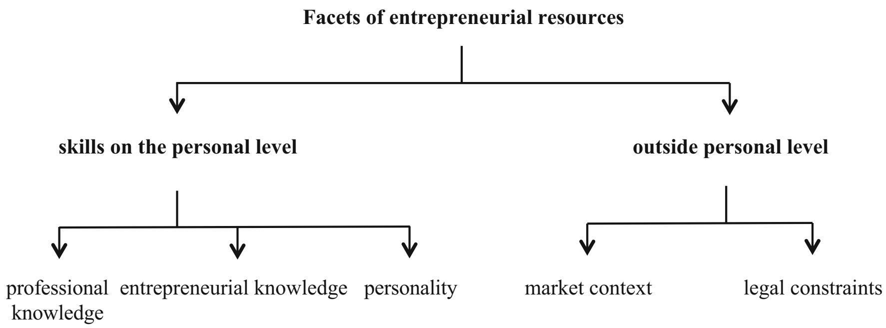

Fig. 2 Aspects of entrepreneurial resources

especially technology-driven innovations are characterized by complexity and the effort of time and money.

On the other hand, processes of innovation and creation require a lot of entrepreneurial skills. In an early phase it might be important to acquire capital first or convince potential shareholders of the idea. According to Sarasvathy (2001), it might be important to act effectually driven by the available resources and to accept that unpredictable events are a natural part of entrepreneurial processes. This might result in new opportunities. Later stages of a venture might be characterized by growth which demands fulfilling tasks like attracting venture capital or human resource management. These jobs have to be done by the founder team or by employees. Much research has been carried out in the field of cognitive and motivational facets of an entrepreneurial mindset which allows individuals to perform successfully (Abatecola & Uli, 2016). Entrepreneurs discover opportunities or create them, they have to deal with uncertain environments and should be prepared for business challenges.

2.2.2 Resources Outside the Personal Level

The extent to which a start-up has access to several markets can be seen as a critical factor for nascent businesses. One reason why young firms fail is the lack of financial resources for growth or for the investment in marketing activities. In particular, highly specialized innovation processes like those in technology-based ventures have to deal with the circumstance that testing and prototyping may become very expensive. Schwienbacher (2015) provides an overview of potential financial resources and distinguishes between debts like loans from financial institutes, families or friends etc. and equity like crowdfunding, venture capital and stock markets. A study about capital composition of young firms (Robb & Robinson, 2014) states that more than 50 percent of the initial financing resources come from external sources like bank loans. This points out the importance of financial markets as a key access point for financing the early stages of a business.

Resources like laboratories, high-tech machines and expensive raw materials are necessary for the product creation process and are therefore indispensable. The latter shows the importance of gaining access to supply markets covering the need of such special equipment. Depending on the stage of development, it may also be necessary to professionalize a team, for instance by hiring employees or drawing assignments. Hence, entrepreneurs have to gain access to a pool of professional competences, which can typically be found on the labour market or can be supplied by consulting companies.

One major challenge for nascent ventures is to generate revenue from their products and services through a thorough revenue model. Hence, entrepreneurs should develop distribution channels and build partnerships. This process means separating the wheat from the chaff because it reveals to which extent the conversion from an invention to innovation was successful.

The main reason for pointing out the importance of the availability of resources is that a lack will harm the process of innovation development. It implicates that the occurrence of obstacles and barriers is negatively correlated with the success of nascent ventures (Gelderen, Patel, & Thurik, 2010). In a best-case scenario, the lack of resources prevents a transformation process from a start-up which is not yet sufficiently developed and therefore unmarketable. Unfortunately, this means, on the other hand, that highly innovative products and processes cannot be realized as actually desired. The following section addresses this problem by discussing how the 'cliffs' of the 'Valley of Death' in university-based innovations can be approached.

3 Overcoming the 'Valley of Death'

Like mentioned above, the underlying assumption within this article is that there may exist a 'Valley of Death' between the academic environment and the private economy. One way of approaching the left cliff might be realized by academic entrepreneurship initiatives, which are discussed in detail in the following Sect. 3.1. One possible solution regarding the right cliff might be offered by corporate programs, which will be discussed in sect. 3.2.

At this point, it should be mentioned that, beside positive effects, entrepreneurship can also have negative effects for the economy, especially in the start-up world. There may be, for instance, the risk of losing subsidies or there may be a lower job security for employees which results in lower investments from the employees (Kritikos, 2014). Nevertheless, the negative aspects will be not discussed further within this article since the focus will be on the opportunities through entrepreneurship to overcome the 'Valley of Death'.

3.1 The Cliff to Push Over: Business Models of Academic Entrepreneurship Initiatives

Two aspects can be derived from the (German) academic entrepreneurship world. On the one hand, there is a growing number of entrepreneurship chairs and consequently more entrepreneurship research is conducted in Germany (Schmude, Welter, & Heumann, 2008). On the other hand, at least 21 academic entrepreneurship initiatives have arisen since 2012 through the EXIST IV founding (Kulicke, Dornbusch, & Schleinkofer, 2011; Velling, 2010). One explanation—beside the funding—could be the common believe that economic development is directly linked to innovation and innovation is directly linked to entrepreneurship (Bilbao-Osorio & Rodríguez-Pose, 2004; Wong, Ho, & Autio, 2005). Though, when universities foster entrepreneurship, innovation and thus economic development, will be encouraged in the long run (Carree & Thurik, 2005; Kritikos, 2014; Valliere & Peterson, 2009). This leads to the question, which strategies and activities universities actually pursue for this purpose.

In the following, entrepreneurship initiatives will be in the focus of interest because they deal with the application and implementation of entrepreneurial activities, which are in turn important for bridging the 'Valley of Death'. From concepts and ideas in science, research and education towards concepts that are ready for the market, university-based (academic) entrepreneurship programs are important transformation points (Grandi & Grimaldi, 2005). One of the main success factors is the entrepreneurship education (entrepreneurship initiatives) which takes over the function of sensitising and preparing students and researchers for the potential launch of a company (Hockerts & Wüstenhagen, 2010; von Graevenitz, Harhoff, & Weber, 2010).

Beside several smaller entrepreneurship initiatives in Germany, there are at least 21 EXIST 'Gründerhochschulen' (PID Arbeiten für Wissenschaft und Öffentlichkeit, 2015). These are initiatives funded by the German Government and European Commission in the context of the German EXIST program. According to the formulated aims of EXIST (Velling, 2010), the aims of the entrepreneurship initiatives are the following:

- to sustain the anchoring of the founding profile within the university strategy (structural principles, development plan, incentive systems);
- to establish complementary administrative structures and regulations;
- to provide ideal start-up conditions, especially for start-ups with high growth potential (foundation- and founder-friendly environment);
- to strengthen entrepreneurial thinking and acting (entre- and intrapreneurship);
- to ensure effective usage of the potential of knowledge- and technology-based start-ups located at the university as an element of knowledge and technology transfer.

Overall, through the subsidised entrepreneurship initiatives, the EXIST initiative aims to implement a founder-friendly environment at the participating universities.

The entrepreneurial initiatives strive to implement this aim, for instance through workshops, networking events and consulting (PID Arbeiten für Wissenschaft und Öffentlichkeit, 2015).

For a deeper understanding of the entrepreneurship initiatives, a general structure of the initiatives should be derived. To gain a deep understanding of an organization or company, an overall understanding of their business model might beneficial. Zott, Amit, and Massa (2011) point out that the business model is a “unit of analysis” and offers a “systemic perspective” of how the business should be organized and which activities need to be carried out by the company itself or by its partners. Moreover, the business model focuses on the value creation and on capturing the value (Zott et al., 2011). Nevertheless, the business models of initiatives are the center of interest to derive a profound understanding of how they are organized or how they create, deliver, and capture value for the university members (Osterwalder & Pigneur, 2011).

There are several ways to display a business model (Gassmann, Frankenberger, & Csik, 2013; Johnson, 2010; Maurya, 2012). Within these research project, the authors have chosen the Business Model Canvas (Fig. 3) from Osterwalder and Pigneur (2011) as it is one of the most recognized models in the practical field of entrepreneurship at the moment (Blank & Dorf, 2012).

The Business Model Canvas (Fig. 3) consists of nine blocks which are divided into two parts. On the one side is the front stage which consists of five blocks. The first block shows the *value proposition*. This represents the products and services

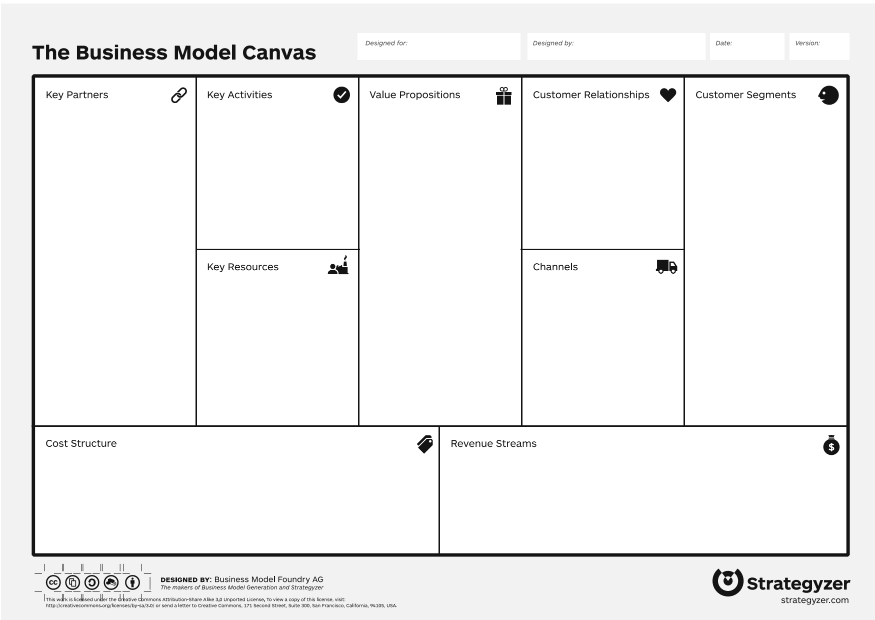

Fig. 3 The Business Model Canvas (downloaded at www.strategyzer.com)

which generate value for the customer. It is important to mention that this does not exclusively refer to the 'raw' products or services. It refers to 'why' the customer 'hires' the product or service to solve her/his 'jobs-to-be-done' (Bettencourt & Ulwick, 2008). The *customer segments* demonstrate the different customers who 'hire' the product or service. The *channels* illustrate where the customers buy the product or service, for instance in stores or a web shops. The *revenue streams* demonstrates all revenues which the company gains through their sales while the *relationship* shows through which relationships the customers receive the product or service, for instance through automated or personal contacts. The backstage part is divided into four parts. The *partner* is important to produce or deliver the company's value and to reduce the risk, but the *partner* is not directly shareholder of the company. The *key resources* are necessary to produce the product or service. The next block bundles the *key activities*, which the company has to fulfil to create the value for the customer. The fourth block is the *cost structure* which includes all relevant cost aspects that the company needs in order to produce their value. All blocks can be seen in Fig. 3.

The authors believe that by concentrating on these nine blocks it is possible to understand the business model of an organisation or company. Therefore, a Business Model Canvas has been constructed of five entrepreneurial initiatives through an analysis of the homepage and a follow-up call with a responsible person of the entrepreneurial initiative. For a suitable comparison of the business models, a list of 37 terms has been developed which allows to pool similar task under the same term. That means, when at least three initiatives had got a similar task but a different wording for it, one term had been introduced and all similar tasks had been labelled with this umbrella term. By comparing the five business models, a final model has been derived, which demonstrates how entrepreneurial initiatives—according to the sample—address the left cliff to overcome the 'Valley of Death'. The final results will be presented in Sect. 4.

3.2 The Cliff to Be Reached: Venture Capital and Corporate Incubation Activities of Established Enterprises

Corporations are forced to innovate and reinvent themselves again and again (Govindarajan, 2016). Due to e.g. the decreasing life-cycle of products (Jou, Chen, Hwang, Lin, & Huang, 2010), more and more competitors have to face the threat to become "netflixed" (Kaplan, 2012) due to micro-multinationals (Dimitratos, Amorós, Etchebarne, & Felzensztein, 2014) or disruptive technologies (Christensen, von den Eichen, & Matzler, 2011). Kaplan (2012) introduced that term for corporations like 'Blockbuster' which were not able to transform their business through innovation or acquiring new technologies to deliver a constant value to customers.

Corporations have identified entrepreneurial activities as a main source of sustainability and innovation (Covin & Miles, 1999). Corporations are forced by the problem that their organizational structure does often rely on linear and causal processes (Levie & Lichtenstein, 2010), but a lot of innovative ideas and start-ups would not exist, if they had always followed a linear plan (Lichtenstein, 2011). A few companies are able to manage existing products and services as well as the invention of new products and services (O'Reilly III & Tushman, 2004). Wales, Monsen, and McKelvie (2011) describe three different ways of how organizations deal with organisational change and adaptation processes. They differentiate the cyclical-wave-model where companies, depending on the economic forces, switch between a state of stability and a highly fluid state. That means when disruptive innovations or new competitors threaten the company through an adaptation process, the company tries to react to the new situation. Without forces from outside, the organization keeps the existing stable state. The second model is the continuous-morphing-model where the company continuously strives for adaptation of changes in the environment. The last model is the ambidextrous-model where the company acts as a 'two handed organisation'. The organization exploits the existing products and services through management tools and simultaneously explores new opportunities through entrepreneurial methods. The ambidextrous organization, which incorporates the exploitation and exploration from products and services, is a difficult task for organizations because both aspects have to be organized differently and have different underlying assumptions (Raisch, Birkinshaw, Probst, & Tushman, 2009). The process of exploitation is based on research, management, experiences and predicting the future, whereas exploration is based on experimentation, entrepreneurship, understanding and controlling the future (Miller, 2007; Sarasvathy, 2001). Due to the difficulty of incorporating structures of exploration and exploitation at the same time, corporations are looking for other solutions to deliver constant or new value to their (new) customer.

This situation demonstrates a possible right cliff of the 'Valley of Death'. Corporations are looking for innovative ideas and opportunities which allow them to develop their company continuously further and remain (become) competitive in their existing/in new markets. Right now, many companies agree that the ambidextrous organization is favourable, but the transformation from an organisational single structure of exploitation to an ambidextrous structure of exploration and exploitation is challenging. This could be the reason why companies seem to address the problem with another solution. They are offering start-ups three different ways (e.g. Corporate Venture Capital, Corporate Incubation, and start-up programs) to cooperate with their company. The main idea is the creation of a win-win situation through the cooperation. The start-up obtains access to one or more key factors like market entrance and networks (Becker & Gassmann, 2006), financial support (Grimaldi & Grandi, 2005), mentorship (Mian, Lamine, & Fayolle, 2016), or knowledge (Grimaldi & Grandi, 2005). The corporations, on the other hand, gain access through new ideas (Jesch, 2004), new technologies (Kobe, 2007), networks and new solutions to 'old' problems (Kawohl, Rack, & Strniste, 2015).

In order to gain a deeper understanding of the right cliff of the 'Valley of Death', the 119 bigger companies have been analyzed regarding *Corporate Venture Capital*, *Corporate Incubation*, and *Start-up Platforms*. The three different types have been defined as follows: *Corporate Venture Capital* means that companies offer start-ups venture capital to gain a financial return later on. Since companies also have strategic aims (Weiblen & Chesbrough, 2015), *Corporate Venture Capital* is a special feature to them. In addition to investment companies through corporate venture, capital start-ups also gain management support or mentorship. Therefore, *Corporate Venture Capital* can be called 'intelligent capital' (Jesch, 2004). Through this support not only the start-up members gain knowledge, but also the managers and mentors gain insights from the start-ups. The second option, the *Corporate Incubation*, means that start-ups in the early stage receive resources like rooms and infrastructure for a small amount of money or even for free (Allen & McCluskey, 1990). *Corporate Incubation* means that the initiator of the incubation program is a company (Weiblen & Chesbrough, 2015). Within *Corporate Incubation* programs start-ups have got an idea and need resources and support to 'bring their idea to life'. This differentiates the *Corporate Incubation* from the third program which represents a platform for start-ups. Within such a *Start-up Platform* the company provides technologies, patents or special resources, while start-ups try to transform these resources into a business model (Weiblen & Chesbrough, 2015). The company expands in an effectual approach their 'means' through the start-up teams and offers the company resources (inventions) and catalysts through new innovations.

At the end, by a detailed comparison of the companies and the academic entrepreneurship initiatives an insight into how the 'Valley of Death' will be addressed from the two parts to enhance the technology transfer between the public and private companies. The results of the research will be the topic of the next section.

4 Results and Implications

4.1 Business Models of University-Based Entrepreneurship Initiatives

Five entrepreneurial initiatives out of the 21 EXIST Gründerhochschulen have been investigated.[1] Three initiatives from universities with more than 20,000 students and two initiatives from smaller universities have been selected. One of the five is a university of applied sciences. Through the composition of the sample, the distribution is similar to the 21 EXIST Gründerhochschulen. Through detailed homepage-analyzes the business models have been displayed and verified by a phone call with a responsible person of the initiatives. Due to the circumstance that entrepreneurship initiatives are addressing external interested parties like students or researchers, programs and activities should be visible on their homepages. During the research process one entrepreneurial initiative denied collaboration. Therefore only the data

[1]Detailed information about the sample can be enquired with the authors. At this point, a lot of thanks to Jonas Hunka and Jonathan Klinkhammer for their support with the data collection.

from four initiatives will be shown. Like mentioned in Sect. 3.1, the business models have been displayed through the nine building blocks of the Business Model Canvas. Wherever activities from the entrepreneurship initiatives delivered the same content but were named differently, a common umbrella term has been used. By means of this procedure 37 common terms have been created. On the basis of the four individual business models a finale aggregated business model has been created. Whenever at least three initiatives have mentioned an activity or factor, these have been transferred to the aggregated business model. The final result is displayed in Fig. 4. The aggregated business model represents a first insight into how entrepreneurial initiatives conduct their work. The nine building blocks will be explained in detail in the following, so that a thorough understanding of the design of academic entrepreneurship initiatives can be ensured. Moreover, interesting, missing, or remarkable aspects will be mentioned.

- *Partner*

  The final results of the partner-block show that the academic entrepreneurship initiatives have got at least 43 partners. It seems to be an important success factor for the business model of initiatives to have partners and cooperate with them. A closer look at the value proposition makes the quantity of partners comprehensible. The quantity of the different programs, activities and workshops with different topics, experts and role models can only be fulfilled by partners. This is reasonable since, on the one hand, role models are quite important for future entrepreneurs and, on the other hand, not every content can be presented directly from team members. Through partnership with e.g. lawyers or banks these topics can be presented first hand from real experts.
- *Key Activities*

  The mentioned key activities can be summarized in conducting workshops, consultancy, or in organising such events etc. However, activities such as attending events or fairs to build a network and get in touch with new partners could not be derived from the findings. The same applies to meeting gatekeepers like professors, faculty members or other personnel from the university to promote the programs from the entrepreneurial initiative.
- *Key Resources*

  The mentioned key resources can mainly be subsumed under staff and infrastructure. Especially the infrastructures in universities are a main resource for the entrepreneurial initiatives because through rooms, facilities and equipment it will be possible to realise entrepreneurial activities etc.

  Not mentioned are contents (books, slide decks etc.), mailing/address lists, social media community etc. Those factors are crucial for the successful operation of an entrepreneurial initiative.
- *Value Proposition*

  Within the value proposition-block mainly programs, activities, and final papers are mentioned: altogether activities offered by the entrepreneurship initiatives.

Value Proposition
- At least 43 partners (e.g.)
- Economic development agencies, technology centres, external consultants
- External consultants
- Politics and regional banks
- Investors
- Chambers
- Management consultancies
- Funding agencies
- Companies
- Network partners
- Media
- Sponsors
- ...

Key Activities
- Provision of consulting services (4/4) [3]
- Bringing together people interested in founding (4/4) [4]
- Practicing the qualification of entrepreneurs (4/4) [10]
- Offering an area for founding [5]
- Helping with obtaining capital (3/4) [3]
- Making the topic entrepreneurship visible (4/4) [4]
- Acquisition of third-party funding (3/4) [1]
- Coordination activities (4/4) [10]
- Provision of other supporting services (4/4) [8]

Key Resources
- Own staff (4/4)
- Staff of partners (4/4)
- Investors (4/4)
- Rental of premises (3/4)
- Own infrastructure (4/4)
- Infrastructure of university (4/4)
- Infrastructure of partners (4/4)

Value Proposition
- Start-up consultancy (4/4)
- Specialist advice (3/4)
- Team acquisition (4/4)
- Job market (4/4)
- Regulars‘ table (3/4)
- Founder promotion (4/4)
- Summer Schools (with CP) (3/4)
- Lectures (with CP) (4/4)
- Series of workshops (without CP) (3/4)
- Final papers (withCP) (3/4)
- Doctoral programs (3/4)
- Incubators (3/4)
- Office (4/4)
- Laboratory (3/4)
- Research funding (3/4)
- Own competition (4/4)
- Private funds

Relation
- Automatic contacts(Homepage (4/4), Newsletter (4/4), Facebook (4/4), Youtube (3/4))
- Personal contacts (start-up consultancy (4/4), specialist advice (3/4), regulars‘ table (3/4), summer schools (3/4), lectures (4/4), series of workshops (3/4), final papers (3/4), own competition (4/4), local appearances (4/4), networks (4/4))

Channels
- Homepage (4/4)
- Newsletter (4/4)
- Facebook (4/4)
- Youtube (3/4)
- Own competitions (4/4)
- Public appearances (4/4)
- Networks (4/4)
- Qualification of entrepreneurs (with CP) (4/4)

Customers Segments
- Students (4/4)
- Doctoral candidates (4/4)
- Graduates (4/4)
- Founders (4/4)
- People interested in founding (4/4)
- Investors (4/4)
- Start-ups (4/4)
- Companies (4/4)
- Scientific staff (3/4)

- Co-payments (3/4)
- Personnel costs (4/4)
- Deficient rental of premises (3/4)

- Aid money (4/4)
- Participation fees (2 with obligatory prices) (3/4)
- Rental income (4/4)

Fig. 4 Results of the aggregated business model of the academic entrepreneurship initiatives

Right now, a deeper dive into the activities in value proposition is missing. Especially the underlying ideas, concepts, and extents behind the activities (why, how often, and how the activities are designed) will provide a deeper insight. Because at the end, the configuration of the activity linked to the success (number of participant, satisfaction-rate of participants etc.) of the activity will provide enormous insights.

- *Relationship*

  In the relationship block we differentiate between personal and automated contacts. That means customers will be reached either through direct contacts or through a digital format like the homepage, mailing lists, final papers, or lectures.

  An unmentioned aspect so far is the indirect relationship, e.g. successful start-ups which arose from past activities, fairs, or consultancy projects. Through these indirect "contacts" the entrepreneurial culture will be fostered and emerge. The entrepreneurial culture is the basis for entrepreneurial initiatives because through an entrepreneurial culture the awareness for topics like funding, start-ups and self-employment rises.
- *Channels*

  Channels are, on the one hand, social media and digital content platforms and, on the other hand, internally-provided as well as externally-provided qualification programs. The participants from the initiative are able to attend all programs as well as events like business competitions from partners, which are often organized by regional offices for economic development.
- *Customers*

  Customers are the entire university community. At the end of the entrepreneurship initiative, it is important to differentiate between those customers who are consuming the content and those customers who are taking over the role as gatekeeper for potential customers. This could be, for example, a professor, who allows the promotion of entrepreneurial activities in her/his lectures or designs joint lectures with the initiative. In addition to the lectures, it is quite important for students to gain credits for the participation in activities of the entrepreneurship initiative. These credits ensure that more students are interested in attending entrepreneurial activities.
- *Cost Structure*

  Not surprisingly, the cost structures are mainly representing personnel costs, because personnel are the main success factor when organizing and conducting activities. Without personnel the entrepreneurship initiative will not work out.
- *Revenue Streams*

  The revenues are mainly represented through the funding. Other revenues are missing. Beside all interesting factors like value propositions or partners, the most important aspect for a lasting business model is the revenue (Zott et al., 2011). Within the field of revenues three aspects have been mentioned. First of the all the funding which is provided by the government. The second aspect combines the fees and charges for rooms. The interviews have shown that the subsidies are the main factor of revenues. Thus, for a sustainable business model a sustainable revenues model has to be found.

The results present a first overview of the business model of academic entrepreneurship initiatives. They are trying to overcome the 'Valley of Death'. It is important to mention that like in the business development a business model development is an iterative process which is never finalized. With this first business model only a rough concept is given. But through this research project a first starting-point is given. As expressed in the summary of the findings within the nine blocks, especially remarks regarding the "how" are missing. This directly leads to the key question for start-up business models as well as for entrepreneurship initiatives: How can a structure be sustainable and how can the business implemented model be reliable. That means a working revenue model without funding capital. So the business model has to overcome the phase where third parties are subsidising the initiatives. This question can only be answered with the business model being displayed in much more detail.

4.2 Cooperation Forms Between Established Companies and Start-Ups in Germany

4.2.1 Sample

119 established bigger German firms have been investigated in order to explore their engagement within start-ups. These are the 30 biggest stock companies (with respect to their market capitalization) which are listed in the stock index "DAX", the biggest 50 mid cap stock companies which are listed in the "MDAX" index, the biggest 30 technology companies which are listed in the "TecDAX" index and 9 bigger companies which are not listed on the stock exchange. The data was collected during March 2016 through the homepages and social media appearances in the first instance. Follow-up telephone interviews have been conducted in those cases where questions from the data collection process via the homepages remained unanswered. For the data collection process the categories *Corporate Venture Capital*, *Corporate Incubation*, and *Start-up Platforms* have been considered, as introduced in Sect. 3.2. Other forms have explicitly not been taken into account (e.g. corporate spin offs).

4.2.2 Findings

Out of the 119 investigated companies, a total number of 30 currently cooperate (or offer the opportunity to cooperate) with start-ups through one of the mentioned categories. A majority (12) falls on companies listed in the DAX, 7 on private limited companies, 6 on MDAX-companies and 5 on businesses listed in the TecDAX. The distribution of cooperation forms is listed in Fig. 5.

The most common form of cooperation is *Corporate Venture Capital* (23 programs), followed by *Corporate Incubation* (17 programs). *Start-up-Platforms* occur as the rarest form (2). A majority of cooperation is operated by companies listed in

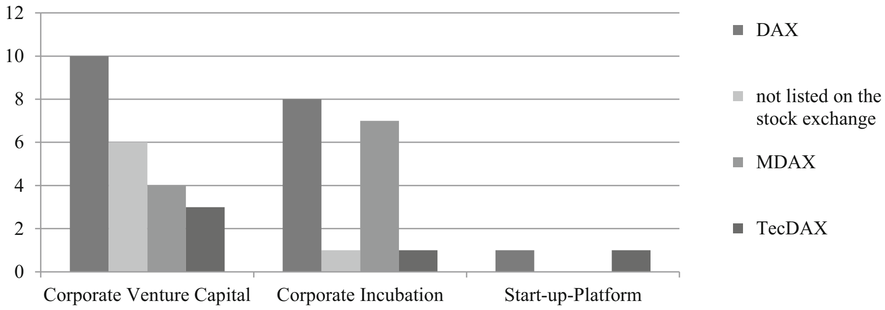

Fig. 5 The distribution of cooperation forms

Table 1 Amount of venture capital invested per start-up

Company	Capital invested per venture (in million €)
Holtzbrinck Digital	0.5–2.5
Robert Bosch Venture Capital	0.5–5.0
Vorwerk Direct Selling Ventures	0.5–5.0
Commerzventures	2.0–10.0
Siemens Venture Capital	2.0–5.0
Evonik Venture Capital	Up to 5.0
Boehringer Ingelheim Venture Fund	Up to 2.0

the DAX which can be explained by their size and financial power. It is also noticeable that companies, which are not listed on the stock market, are rather engaged within *Corporate Venture Capital* than within *Corporate Incubation*. 9 corporations run both *Corporate Incubation* and *Corporate Venture Capital*.

With regard to the amount that is invested by the companies in venture capital, data could be collected only for 7 of 23 total cases like illustrated in Table 1.

Beside financial investment, established firms also provide other forms of support within their venture capital programs. This includes know how concerning management and human resource management, access to the industry network, research and development, and legal support. Start-ups are also partially allowed to use distribution channels of the company. The provision of support is a meaningful strategy from an investor's perspective to protect and promote the employed resources.

With regard to *Corporate Incubation* and acceleration programs there is also financial support, which is in contrast to venture capital programs usually no equity. Most of the programs advertise by offering access to the professional network of the established corporations and its distribution channels. There is further support within the provision of infrastructure like offices, of mentors and coaches and of know how like financing, marketing etc.

Start-up-Platforms are provided by only two companies (Software AG and SAP) which provide free access to software as well as programming resources. This format implicates that developed products are based on or are at least strongly connected to the established companies. This implies an indirect benefit for the companies.

The results reflect that established companies strongly focus on innovations outside their business in order to gain benefit by participating through revenue or by taking them over in order to innovate their own business models and products.

5 Conclusion

First of all, this chapter offers insights into different aspects of the ‘Valley of Death’. Even though not every invention has a high market potential, there are many inventions and research results that have the potential to meet customer needs. But without a transformation process and people who take up the entrepreneurial role, the opportunity will not come into existence. The article provides two possible explanations, derived from the analysis of academic entrepreneurship initiatives and start-up programs from corporations, how to overcome the ‘Valley of Death’:

First of all, understanding university entrepreneurship initiatives as a supporting push-factor, a greater amount of academic personnel and students will be ‘infected’ with the innovation-spirit. The accompaniment by university initiatives also offers more professional and objective know-how to entrepreneurs and helps them to realize their ideas. The explorative analysis offers a reasonable starting point and first insights into how entrepreneurial initiatives in Germany are structured. Moreover, it proves that initiatives have similar business models. Secondly, overcoming the ‘Valley of Death’ is possible if established corporations serve as a pull-factor from the perspective of academics to transform their research results within a start-up into an innovation. By receiving financial resources, network access and know-how, innovations are more likely to come into existence and to be tested in a customer context. The research shows that such initiatives are most likely provided by bigger companies due to the extensive effort.

The pushing and pulling activities and the detailed design of the activities are subject to uncertainty. Entrepreneurship initiatives have to offer a variety of activities that have to vary depending on the discipline (e.g. technology innovations need other support than cultural innovations). The initiatives also have to take into consideration the phase in which the start-up (innovation process) actually is. This implicates that universities have to offer broad resources to foster transformation processes and fulfil their task. Referring to the investigated business models of the entrepreneurship initiatives, it is obvious that at least the revenue streams are limiting factors for sustainable entrepreneurial support. One solution may be public private partnerships with corporations which have an interest in fostering innovations.

Established corporations do not offer cooperation for charity purposes. They expect a return on investment, either monetary or in the form of gaining access to technology and process innovation which will finally also flow in monetary amounts. Thus, there may be a conflict between the ambition of entrepreneurship initiatives and corporations. But like the saying: ‘A bird in the hand is worth two in the bush', the collaboration of entrepreneurship initiatives and corporations could lead to a win-win situation. By being offered the possibility to transfer inventions and research results to marketable innovations, new companies can emerge and the university start-up culture is strengthened.

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Part V
Interaction Between Established Firms and NTBFs

How Technology Travels from Old to New Firms: The Role of Employees' Entrepreneurship in Technology Ventures

Matteo Landoni and dt ogilvie

Abstract A driving force in the creation of new firms resides in the developments of novel technology by members of current companies. When this happens, an employee gains the incentive to quit the parent company and start a new business venture (i.e. spin-out). Research on entrepreneurial employees and their spin-outs is fragmented and misleading. This chapter finds theoretical gaps and enlarges the understanding of the conditions that allow technological knowledge to give rise to entrepreneurial employees. The analysis of 23 entrepreneurs and 10 spin-out companies in the internet and bio-tech industries shows the pattern of creation of new technological enterprises. It recognizes the role of employees' entrepreneurship in the formation of innovative ventures. Eventually, the new technology moves again when an existing company acquires the spin-out along with the entrepreneur. This research solves conflicting views in the literature and gives insights into how entrepreneurs actively transfer technologies from one company to another. Entrepreneurial employees create new ventures in a different industry, combine multiple experiences in mature businesses, and pursue acquisition. These conclusions push scholars and practitioners to look at employees' accumulation of knowledge and business experience as a source of innovation.

Keywords Spin-out · Corporate venturing · Employees' entrepreneurship · Technology entrepreneurship · Technology ventures

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1 Introduction

In this chapter we aim to shed light on the exploitation of experience and knowledge accumulated within an organization by an employee through a new venture, the spin-out company. The lack of understanding of the process about employees' ability to convert experience into a new venture is a considerable weakness in both the theory of the entrepreneur and the theory of (spin-outs) business venturing.

We argue that we can observe the pattern of creation of new technological enterprises when knowledge flows from incumbent firms to new ventures through employees' entrepreneurship. The objective is to understand how the previous experience of the entrepreneur affects the potential innovativeness of a spin-out. The present chapter aims to determine if the new business started by the former employees is in the same business or if it is business-related to the parent company, to consider the role of knowledge recombination in entrepreneurial teams, and the behavior of this particular kind of entrepreneur. The chapter applies different theoretical perspectives to the analysis of distinctive case studies with the goal to refine the theory and open a new path of research.

Innovations introduced to the market by the entrepreneur are the result of discoveries or awareness about opportunities others did not see. Entrepreneurs exploit discoveries through new ventures. The process that leads to the exploitation of opportunities starts with a discovery (Kirzner, 1973, 1997) by an entrepreneur that (1) creates new knowledge, (2) exploits market inefficiencies because of information asymmetry, and (3) introduces alternative uses for resources (Drucker, 1985). When an employee or group of employees has a discovery, they can leave an existing entity to form an independent start-up firm without any formal linkage with the parent company, i.e. a spin-out.

Several scholars see spin-outs as the main source of innovation (Anton & Yao, 1995; Christensen, 1993; Henderson & Clark, 1990; Klepper, 2001; Tushman & Anderson, 1986; Wiggins, 1995). In particular, in the most innovative industries, some employees bargain a lower wage in exchange for the opportunity to gain knowledge in an organization with the aim of starting their own business. Experience in a business is seen as an investment in the human capital they will acquire as a byproduct of their employment (Klepper, 2001). In doing so, employees create opportunities for a discovery in the course of their employment in an incumbent firm. Thus, the occurrence of a spin-out and its performance is related to the prior experience of the entrepreneur who spins out the new firm. The contribution this research hopes to provide to the theory is related to the process that transforms knowledge accumulation in its tacit form embodied in individuals operating within an organization into a successful new venture.

2 Theoretical Framework

2.1 *Employees' Entrepreneurship and Spin-outs*

The innovative contribution of the entrepreneur is fundamental in explaining the occurrence of new and small businesses. Scholars interested in high-tech innovation pay great attention to both spin-offs' and spin-outs' spread phenomena in local contexts, such as Silicon Valley for IT (Brittain & Freeman, 1986). We characterize spin-offs as independent businesses that companies intentionally create as part of their strategy (Agarwal, Echambadi, Franco, & Sarkar, 2002). Spin-offs and spin-outs are interesting subjects in entrepreneurial theory. Indeed, entrepreneurship is not only an individual, spontaneous phenomenon, but it can also occur within an existing organization (Casson, 1982). Hence, because of their importance in the diffusion of innovations, new ventures started within an existing organization are studied intensively. Despite the amount of research on spin-offs, the level of analysis considered is, in most of the cases, the firm (Anton & Yao, 1995; Chandy & Tellis, 2000; Christensen, 1993; Franco & Filson, 2000; Henderson & Clark, 1990; Klepper, 2001; Tushman & Anderson, 1986; Wiggins, 1995), with very little consideration of the individual. Nevertheless, spin-out creation is pursued to exploit opportunity driven by knowledge creation within the parent company and exploited by individual entrepreneurs.

Spin-outs are the result of a valuable discovery made by an employee while he or she is working for a company or organization. However, even if the discovery can be more profitably developed by the employer in the form of a spin-off than a firm started by the employee, because of scale, scope, tax, technology, or other informational advantages, the employee may have an incentive in starting his or her own business on account of this asymmetric information. The difference in shared knowledge between the employee and the company about the discovery made, especially because of the difficulties in the transfer of tacit knowledge (Polanyi, 1966), creates difficulties in the ability of the employee to contract the value of the discovery made with the company. Hence, the employee has three options: (1) contract with the parent company the ownership of the discovery before revealing it, (2) reveal the discovery and contract with the parent company, or (3) develop it by his or her own efforts (Anton & Yao, 1995).

2.2 *Knowledge Spillovers and Learning Theory*

The spin-out company was the subject of previous research about its potentiality in starting new businesses through knowledge diffusion (Rohrbeck, Döhler, & Arnold, 2009). Other research studied how employee mobility affects knowledge flow (Franco & Filson, 2005). Research also considered the role of the incumbent firm in creating knowledge and training opportunities for their employees (Agarwal, Echambadi, Franco, & Sarkar, 2004; Klepper & Sleeper, 2005).

The notion of 'knowledge spillovers' is connected to the mobility of workers and the tacit knowledge they embodied and took from one firm to another (Feldman, 1999). For example, labor mobility generates "pure knowledge spillovers" if and only if, as workers move from one firm to another, they help in creating a pool of knowledge (Breschi & Lissoni, 2001). Nevertheless, some workers can choose not to move to a different firm; rather they can start a new venture by themselves or jointly with other employees or entrepreneurs. In the latter case, employees start a new venture thanks to the combination of knowledge accumulated in their parent companies.

Theory on spin-outs has investigated their nature, the nature of their parent companies, their timing, and their performance. Starting a new firm is the only way an R&D worker can capitalize on his or her discovery (Franco & Filson, 2000). Further, according to learning theory, spin-outs will produce the same product as their parents (Franco & Filson, 2000), so they focus on the same markets and strategies.

2.3 Organizational Limitations

The exploitation of innovation in a spin-out firm is not necessarily a threat for the parent company. Organizational theory implies that parents are not threatened by their spin-outs because they either could not or would not have chosen to pursue the same innovation as their spin-outs did (Klepper, 2001). Indeed, organizational theory implies spin-outs will develop innovations their parents do not want to pursue, suggesting that parents will not initially perceive spin-outs as a competitive threat (Klepper, 2001). Spin-outs benefit from innovation that the parent company is slow to pursue because of organizational limitations or a different strategy.

According to that theory, in innovative industries spin-offs and spin-outs are the only possibility for entry. Spin-outs can enter the market thanks to lower costs and thus need less market share to be profitable since they produce products similar to but differentiated from that of their parent companies (Klepper, 2001). Thus, Klepper and Sleeper (2005) pointed out that spin-outs will not use the same technologies of the parents and produce identical products, in contrast to what was stated by Franco and Filson (2000). Nevertheless, Klepper and Sleeper (2005) see spin-outs as a learning model of a differentiated product.

The parent company may have no uncertainty regarding the value of a discovery, but it cannot determine if any particular employee has made a valuable discovery before it is revealed. Thanks to the secret dimension (Polanyi, 1966) of the new knowledge accumulated, the employee starting his or her new business is more likely to do so if that innovation does not require distinctive complementary assets owned by the parent company. However, not only companies suffer from the organizational limitations in exploiting innovative discoveries. Employees who made the discovery can also find difficulties in turning it into a new business. In fact, many of the R&D workers employed in a current organization may not have the organizational skills needed to start and run a new firm (Balkman & Gilson, 1999).

2.4 Spin-outs' Industries

Regarding industrial sectors, spin-outs are supposed to appear mainly in less mature industries (Garvin, 1983), while in the more mature industries innovation is more focused on production processes and companies' know-how is more embedded in physical-assets than in knowledge (Klepper, 1996), with fewer opportunities for autonomous discovery in the form of new tacit knowledge embodied by the employee.

The nature of the parent company determines in which kind of industry spin-outs are more likely to appear. Learning theory predicts that the more innovative firms will spawn more spin-outs, while organizational theory finds more evidence of spin-outs occurring in firms experiencing crises (Brittain & Freeman, 1986; Cooper, 1985). Thus, timing in spin-outs follows the evolution of industries, the younger and more dynamic industries will produce more spin-offs/outs then the more mature ones (Garvin, 1983).

In regard to spin-outs' influence on parents' performance, both Franco and Filson (2000) and Klepper and Sleeper (2005) predict a positive relationship, while Dyck (1997) suggests that parental involvement will improve the performance of both.

There are empirical studies on spin-outs: the research by Brittain and Freeman (1986) on spin-outs of Silicon Valley semiconductor producers in 1955–1981, Franco and Filson (2000) on US commercial rigid disk drive producers in 1977–1997, and Klepper and Sleeper (2005) on US commercial laser producers in 1961–1994. The findings in these works suggest that spin-outs did not generally introduce significant innovations in their products and that their products are closely related to ones their parents produced, in accordance with learning theory. Founders of spin-outs commonly reported frustration with their parents as a major reason for leaving to start their own firms (Klepper, 2001, p. 18).

3 Spin-out Entrepreneurs: An Empirical Exploration

3.1 Methods and Data

To find confirmation of either learning or organization theory, we analyzed several case studies. The main reason in favor of case-analysis research lies in the difficulties of collecting a sufficient amount of data due to the secret dimension of knowledge accumulation, responsible for a great underestimation of the real value of the phenomena. The choice of case studies is generally justified by 'how' and 'why' research questions (Yin, 2003). Theoretically, the reason (the 'why') an employee quits a company to start a spin-out is to exploit a discovery made, we want to control the relevance of theory, observing 'how' prior experience affects the formation of spin-outs. Indeed, as suggested by Breschi and Lissoni (2001), studying more in depth the career paths of a few key professional figures is an extremely interesting avenue of research. It helps to understand the mobility of technologists and scientists as a crucial mechanism through which knowledge spreads.

The sample consists of 10 spin-out companies, six in the internet-based industry and four in biotechnologies. Twenty-three entrepreneurs started the spin-out companies, 14 in the IT sector and 9 in the bio-tech sector. The analysis compared spin-out companies and entrepreneurs with their parent companies according to their industry classification and covers a 40-year period. We collected data from online databases mixed with first hand-search on corporate and personal websites for data on entrepreneurs' careers.

The research explores multi-levels of analysis (firms, teams, and individuals) by comparing 10 firms and 23 entrepreneurs in descriptive-longitudinal case studies (Table 1, and Table A1 in the Appendix), a method that distinguishes individual entrepreneurs' characteristics and the conditions for the spin-out to appear.

The analysis concerns the characteristics of spin-out entrepreneurs' experiences. For this purpose, the taxonomy provided by Pavitt (1984) is useful for distinguishing research-intensive activities. The data mixed secondary sources about companies with first-hand information on the entrepreneurs' careers based on their biographies and curricula. Then, we examine the industry choice of the entrepreneurs, focusing in particular on sector mobility. For this purpose, we compared spin-outs with their parent companies according to their industry classification, using the North American Industry Classification System (NAICS) as the reference.

This chapter explores the entrepreneurial history of each spinout, examining the formation and composition of entrepreneurial teams to take into account different

Table 1 Characteristics of the entrepreneurs, companies, and founding teams

Observations	Sample	Bio-Tech	Internet
Total entrepreneurs	23	9	14
Entrepreneurs in same industry	6	0	6
Entrepreneurs in different industry	17	9	8
Entrepreneurs with research experience	18	7	11
Entrepreneurs without research experience	5	2	3
Entrepreneurs left after acquisition	15	9	6
Entrepreneurs stayed after acquisition	8	0	8
Total companies	10	4	6
Single-founder companies	2	0	2
Multi-founder companies	8	4	4
Founding teams sharing same experience	3	1	2
Founding teams sharing different experience	5	3	2

Authors' own elaboration

knowledge recombinations. In the last stage, we investigated the behavior of the entrepreneurs if the new venture became part of a bigger company through acquisition (see Table A2 in the Appendix). We considered whether the spin-out entrepreneurs chose either to leave or stay in the company after acquisition. We distinguish serial entrepreneurs who keep leaving and founding new companies from entrepreneurial employees who seek acquisition as the main goal of their venture effort.

3.2 Case-Analysis

Through the case analysis, some observations led to findings that partly fit with the theory, and in part shed light on literature gaps that need to be tested empirically. Concerning the definition of 'successful' spin-outs, we follow a new approach in the literature that considers the goal of an innovative venture to pursue acquisition by an incumbent firm (Gans & Stern, 2000; Henkel, Rønde, & Wagner, 2010). According to this perspective, we consider the successfulness of spin-outs as being acquired by other companies (Cabral, 2003). All of the spin-out companies selected were eventually acquired by an incumbent company. This research strategy tests if the entrepreneurial choice to sell a company is influenced by the previous reason to start a spin-out and what is the entrepreneurial behavior after acquisition. A spin-out entrepreneur who sells his or her company can choose between keeping a position within the new company or leaving to start a new business venture. In the second case, it might prove that the entrepreneur feels dissatisfaction in working as an employee.

Furthermore, a collection of case studies will be of help in the evaluation of the feasibility of the research, providing good indications for further studies based on different surveys and variables. Although cases cannot prove a theory, they can easily falsify theories and provide further insights about existing theories, be an inspiration for new ideas, and show how the conceptual argument might actually be applied to reality (Siggelkow, 2007).

The cases presented here are related to two well-known industries characterized by a small-to-medium start-up dimension, spin-outs diffusion, and innovative products. Starting from a sample of entrepreneurial firms, we consider variables such as the previous history of the entrepreneur in order to understand whether these companies started in the same business of the parent company, in a downstream market, or in a business unrelated to the parent firm.

3.3 Observation in the Internet-Based Industry

In the internet-based industry, in only one company (YouTube) all the entrepreneurs come from the same company (PayPal), which operates in the same industry of the

Table 2 Experiences of internet entrepreneurs

Experience of internet entrepreneurs	Previous research-intensive experience	Non research-intensive	Total
Entrepreneurs in different industry	5	3	8
Entrepreneurs in same industry	6	0	6
Total	11	3	14

Authors' own elaboration

Table 3 Founder experiences in spin-outs

Experiences in spin-outs	Different experiences	Same experiences	Total
Single founder companies	2	0	2
Single founder entrepreneurs	2	0	2
Multi-founder companies	2	2	4
Multi-founder entrepreneurs	6	6	12
Total internet companies	4	2	6
Total internet entrepreneurs	8	6	14

Authors' own elaboration

spin-outs, although with a clearly different market application (YouTube competes in the video-hosting market while PayPal is an e-commerce application.). However, in the remaining five companies, most of the entrepreneurs come from industries different than an internet-based industry. Largely, they have business experiences in software and computer hardware industries; in a few cases they come from the financial service sector (Table 1).

The analysis of the previous experience of the spin-out entrepreneurs in the internet-based industry considers research-intensive (RI) activity, every activity involving a routine that increases an employee's capabilities as engineer, professor, technology expert, designer, or analyst. Of the 14 entrepreneurs selected, 11 had a previous RI position in the parent company. Five of them chose a different market. The other six that came from a research intensive position started spin-outs in the same industry, in accordance with learning theory (Table 2).

Two internet-based companies have a single founder, while four companies have multiple founders and a total of 12 entrepreneurs. In the four multi-founders spin-outs, the entrepreneurs combine different previous experiences in just one case. In the remaining three multi-founders spin-outs the six entrepreneurs share a common experience in the same industry (Table 3).

Eight of the 14 spin-out entrepreneurs in the internet-based industry kept working in the spin-out company once an incumbent acquired their venture. Although entrepreneurs can leave the company at any time, e.g. usually a few years after the acquisition, in six cases the spin-out entrepreneur left the company at the moment of the purchase to start a new business venture. Both of the two single founders kept working for the spin-out once it was acquired. In the case of multi-founder companies, the proportion of entrepreneurs who chose to either stay or leave are equal (Table 4).

Table 4 Entrepreneur behavior after spin-out is acquired

Behavior after acquisition	Stay with company	Leave company	Total
All internet spin-outs entrepreneurs	8	6	14
In Single founder	2	0	2
In Multi-founder	6	6	12

Authors' own elaboration

Table 5 Observation in bio-tech spin-outs

Entrepreneurs with research-intensive experience	7
Entrepreneurs with non research-intensive experience	2
Companies with different experiences	3
Companies with same experiences	1
Entrepreneurs with different experience	6
Entrepreneurs with same experiences	3
Entrepreneurs stay in position	0
Entrepreneurs left company	9

Authors' own elaboration

3.4 Observations in the Bio-Tech Industry

In the sample relative to the bio-tech industry, there is not even one example out of nine spin-out entrepreneurs of an employee who worked for a bio-tech company before starting her own venture. Most of the spin-out entrepreneurs came from universities or research institutions (7 out of 9), which are clearly research-intensive positions. Only one was previously an entrepreneur and one founder came from a venture-capital fund. They are the only two in the sample without a related research-intensive experience.

Every spin-out company in the bio-tech sector counts at least two founders. In one case, the founders share the same previous experience as researchers in a California university. The other cases are formed by couples of entrepreneurs, remarkably, in two cases, one entrepreneur comes with a research background and the other with business administration or finance experience. All the nine spin-out entrepreneurs in the bio-tech industry left their companies after acquisition by an incumbent (Table 5).

4 Discussion

The 23 case-studies provide evidence supporting both theoretical perspectives. The spin-out company is an innovative firm, hence the spin-out entrepreneur moves to a different market of the parent company. Despite the market chosen being strongly related to the parent's or in a downstream market, the spin-out entrepreneur in only a few cases positioned herself in the same market or industry (6 of 23 entrepreneurs, all in the internet-based sector). Only one spin-out company is in the same industry as the entrepreneurs' parents, but with a clearly different market application (YouTube as spin-out of PayPal). Curiously, PayPal itself is spin-out company, originally named Confinity.

In most of the cases, the spin-out companies are strongly related to their parents' market, such as a downstream market position (e.g. Skype: VOIP as a downstream market of the telecommunication industry) or in a downstream industry (from hardware to software). Even research in academia might be considered a related (upstream) market for science-based industries. Such evidence confirms the organizational theory view, presumably because of organizational opportunities. Spin-out entrepreneurs start a new venture in a different industry or market. An innovation, e.g. a different application, pushes the employees to venture into a different market.

The entrepreneur's previous experience in a research-intensive position within the parent company explains most of the innovative spin-outs. In the internet-based industry, 11 spin-out entrepreneurs out of 14 had research experience, while just three did not have a previous position particularly able to create knowledge to be exploited in the internet-based industry (e.g. trader). No companies in the internet-based sector were founded by all entrepreneurs with no research experience in a related or upstream industry. Similarly, in the bio-tech industry only two entrepreneurs out of seven had no previous research-intensive experience in a related field. However, the two entrepreneurs with no research experience brought capabilities in entrepreneurship or business venturing to the spin-out companies that are both helpful for the establishment of a new company.

Nevertheless, all the four spin-out companies selected were founded by at least one entrepreneur coming from a research department. In this case there is strong evidence in support of the learning view of the spin-out. Entrepreneurs turn their company experience, usually a research-intensive one, into a new business venture. However, while learning theory predicts that spin-outs will be in the same industry of the parent, we must bridge this theoretical perspective with the organizational limitations view of the firm. Indeed, the learning activity usually took place in research intensive settings, which opened opportunities for the exploitation of the innovation in a different market, although they may relate to their parents' industry.

Exploring the composition of the spin-outs' founder team shows very different results between the two industries. In the internet-based industry there are four multi-founder spin-outs, involving 12 entrepreneurs, and two single founder spin-outs. The existence of single founder companies in an internet-based industry reveals no particular occurrence of multi-founders and hence it contradicts the theory (Cooper, 1985; Cooper & Bruno, 1977; Roberts, 1991). On the other hand, in the bio-tech industry, there is no occurrence of single founder spin-outs, providing preliminary evidence in support of the multi-founder hypothesis. Multi-founders seem to be a facilitating, but not necessary, condition to spin-outs.

The combination of different previous experiences does not explain the occurrence of a spin-out company (Table A3 in Appendix). In the internet-based sample, four multi-founder companies were formed by a total of 12 entrepreneurs equally sharing different or same experiences in the founding team. In contrast, a founding team composed of entrepreneurs with identical experience appears just once in the

Table 6 Age and type of experience

		Age	
		Old (+15y)	Young (−15y)
Experience	Research intensive only	3	4
	Business-related in the founding team	3	0

bio-tech sector. Particularly in this sector, the combination of research intensive and business-related experience, i.e. finance, may result in an advantage in the venturing process. This is, however, particularly dependent on the age of the companies. Spin-outs older than 15 years in the sample have occurrences of founding teams that include one entrepreneur with a business-related background in half of the cases, while that is absent in the spin-outs younger than 15 years (Table 6).

All the 10 spin-out companies in the sample were eventually acquired by an incumbent firm in the industry. This allowed testing of the entrepreneurial behavior of a former employee that starts a new business, whether the spin-out entrepreneur chooses to leave the company or to stay after the acquisition.

At the time of the purchase, six spin-out entrepreneurs out of 14 in the internet-based industry and all nine in the bio-tech industry left their venture as it became part of a bigger company. However, there are very few examples of spin-out entrepreneurs that immediately start a new business venture after the acquisition of their company. That may suggest there was no particular frustration in being an employee and that the entrepreneurial motivation lay mainly in the pursuit of the discovery made while working for the parent company.

Only in the internet-based sector are there occurrences of entrepreneurs who stay in the business after acquisition, occurring in more than half of the sample (8 out of 14). Many of them took a managerial position in the acquiring group and some eventually left the company after some years. Looking at the behavior after the acquisition makes visible the marked difference between the two industries. A more dynamic and younger industry such as the internet-based sector would have evidenced a more pervasive seriality in the entrepreneurship process, while a more capital-intensive and relatively mature industry such as bio-tech would imply greater stability in an entrepreneur's career development. However, in the particular case of the spin-out entrepreneur, it seems that selling the company is the real goal of the venturing effort according to the ages of the entrepreneurs and industries.

At the company level, acquisition allows the spin-out to sell their innovation at a high price to a bigger company in the same industry. Instead of being a competitive threat to the parent company, spin-outs could be seen as powerful innovators. First, spin-outs move technological innovation from mature industries to dynamic ones, and second, they provide incumbent companies with innovations coming from different entrepreneurial contexts. Such innovations can be easily acquired together with the spin-out company.

4.1 Insights and Findings from the Exploratory Study

- Innovative spin-out entrepreneurs start a new venture in a different, related, or downstream market of the parent company (as expected by organizational theory).
- Spin-out entrepreneurs are expected to have experience in research-intensive processes (as expected by learning theory).
- Spin-outs are expected to have multiple founders, usually but not exclusively sharing different industry experiences.
- An entrepreneur with business-related experience is often part of a founding team in old spin-outs, while such experience is not found in younger spin-outs.
- The spin-out entrepreneur is expected to leave the spin-out company after acquisition, which varies according to the age of the industry. This suggests the serial nature of this kind of entrepreneur.

5 Conclusion

This chapter contributes to an improved understanding of how the technological experience of employees leads to the creation of new companies. So far, theories have not evolved a comprehensive view of spin-outs. Learning and organizational theories clash in explaining their nature and consequences. However, we have observed some empirical patterns that are helpful in bridging such theories into a new, useful framework.

Some research suggests organizational limitations to explain entrepreneurial behavior in employees. Spin-outs move to a (slightly) different industry or market than the parent firm. A confirmation of learning theory links combinatorial knowledge in entrepreneurial teams to innovative ventures. The occurrence of entrepreneurial teams with a background of different experiences increases the likelihood of venturing in a different industry, as suggested by the organizational limitations view, but there is no evidence of a trend nor it is a necessary condition.

Moreover, not all experiences are equal. Previous experience in a research-intensive role in the parent company is strongly related to the spin-out entrepreneur. In the few cases the entrepreneur did not accumulate knowledge related to the spin-out, he or she gained experience in business administration or in finance. The contribution to the spin-out company of such entrepreneurs is clearly helpful for the company's start-up stage, and combines well with the experiences of the other entrepreneurs for the exploitation of the innovative discovery.

This case analysis proposes a novel set of variables for future research. In particular, we strongly push scholars to investigate the individual level of analysis to avoid confusion about the consequences for firms. It underlines the powerful role of entrepreneurs in the diffusion of innovation across industries. Using a perspective closer to the individual entrepreneur helps to distinguish the nature of the spin-out company from the spin-off. The latter is the result of a corporate strategy, while the spin-out is created by one or more individual entrepreneurs acting independently.

The outcome fills a theoretical gap in the literature concerning entrepreneurship, innovation, and the diffusion of novel technologies. This new knowledge of the role of entrepreneurs' mobility from existing companies to new ventures, and from new ventures to incumbents by acquisition, is necessary for understanding the creation of new sectors or industries. Further theoretical development may help to explain the shake-up of existing industries. When entrepreneurs leave the company to start a new business that may create a new market, this in turn may affect the traditional market as a byproduct of 'creative destruction' (Schumpeter, 1934). For example, founders of software house SAP left IBM to develop standardized enterprise software at a time when IBM was dedicated to custom-made solution. This case shows how the company and the founders reacted to the innovator's dilemma (Christensen, 1997) in two different ways. Both did not know at that time whether the technology would be disruptive in the future, which eventually it prove to be.

The study presented here is only a preliminary exploration of the data that were used to analyze the effect of entrepreneurs' experience in explaining the success of spin-outs. Some of our conclusions support the theory or help to explain the adjustment of trajectories followed by scholars of innovative firms. Our main contribution is the shift in perspective from the firm-level to a more individual-level of analysis. Nevertheless, the research has several weaknesses. Further studies should collect data from a broader range of companies.

The cases investigated here are all US-based, with only one exception, Sweden-Estonian Skype, that presents outlier features. Cultural and institutional differences can change the incentives to quit a job and start a new venture, even in the case of an innovative discovery. The two industries studied cover only a narrow set of the innovative firms available, and share different market structures and business organizations. The analysis of spin-outs has to be strongly correlated with the main industry they belong to, since different requirements and pathways of behavior are implied. The industry structure, age, and technology affect entrepreneurial dynamics.

This contribution is not able to provide a clear theory about how learning effects push employees within a firm to form a spin-out. However, it sheds light on a different approach closer to the individual entrepreneur. By observing different cases of successful technologically-based entrepreneurs, we are able to recognize factors and patterns in action. Previous research-intensive experience is definitely fundamental in the explanation of the rate of technological change and industry dynamics, while knowledge-recombination can help more mature industries to keep their innovation rate high.

Appendix

Table A1 Spin-out companies

N	Entrepreneur	Spin-out company	Spin-out industry	Parent company	Parent industry	Born	Occupation in parent company	Research experience	*	Year of venturing
1	Kevin Systrom	Instagram	Internet	Google	Internet	1983	Corporate Development team.	yes	sb	2010
2	Mike Krieger	Instagram	Internet	Meebo	Internet	1986	Designer & Engineer	yes	sb	2010
3	Sabeer Bhatia	Hotmail	Internet	Apple	Computer Hardware	1968	Designer	yes	sb	1996
4	Jack Smith	Hotmail	Internet	Apple	Computer Hardware	1968	Designer	yes	sb	1996
5	Max Levchin	Cofinity (PayPal)	Internet	NetMeridian	Software	1975	Entrepreneur	yes	sb	1998
6	Peter Thiel	Cofinity (PayPal)	Internet	CreditSuisse	Financial service	1967	Trader	no	ss	1998
7	Luke Nosek	Cofinity (PayPal)	Internet	Netscape	Software	1976	Computer technician	no	sb	1998
8	Ken Howery	Cofinity (PayPal)	Internet	Thiel Capital Mgmt	Financial service	1976	Trader	no	ss	1998
9	Elon Musk	Cofinity (PayPal)	Internet	X.com	Internet	1971	Entrepreneur	yes	sb	1998
10	Stev Chen	YouTube	Internet	PayPal	Internet	1978	Technologist	yes	ss	2005
11	Chad Hurely	YouTube	Internet	PayPal	Internet	1977	Designer	yes	ss	2005
12	Jawed Karlm	YouTube	Internet	PayPal	Internet	1979	Anti-Fraud system designer	yes	ss	2005
13	Dan Willis	Adscape	Internet	Nortel	Telecommunication		Engineer	yes	sd	2002
14	Colin Needham	IMDb	Internet	HP (UK)	Computer Hardware	1967	Engineer	yes	sb	1990

15	Herbert Boyer	Genentech	Biotech	UCSF	Education	1936	Researcher	yes	sb	1976
16	Bob Swanson	Genentech	Biotech	KpVenture	Finance	1947	Venture Capitalist	no	ss	1976
17	Sheridan Snyder	Genzyme ™	Biotech	Pitney-Bowes	Business Service	1936	Account manager	no	ss	1981
18	Henry Blair	Genzyme ™	Biotech	Tufts univ.	Education	1939	Researcher	yes	sb	1981
19	Edward Penhoet	Chiron	Biotech	UC Berckley	Education	1941	Professor	yes	sb	1981
20	William Rutter	Chiron	Biotech	UCSF	Education	1928	Professor	yes	sb	1981
21	Pablo Venezuela	Chiron	Biotech	UCSF	Education	1941	Researcher	yes	sb	1981
22	David Agus	Navigenics	Biotech	USC	Education	1965	Professor	yes	sb	2007
23	Dietrich Stephan	Navigenics	Biotech	N.H.G.R.I.	Research	1969	Researcher	yes	sb	2007

*Pavit (1984) taxonomy. Authors' own elaboration

Table A2 Acquisition

N	Entrepreneur	Age (2017)	Age at founding	Country	Spin-out	Acquiring company	Year of acquisition	Age at acquisition	Company age	Location	Status after
1	Kevin Systrom	34	27	USA	Instagram	Facebook	2012	29	2	US	Stay
2	Mike Krieger	31	24	Brazil	Instagram	Facebook	2012	26	2	US	Stay
3	Sabeer Bhatia	49	28	India	Hotmail	Microsoft	1997	29	1	US	Stay
4	Jack Smith	49	28	USA	Hotmail	Microsoft	1997	29	1	US	Stay
5	Max Levchin	42	23	Ukraine (USSR)	Cofinity (PayPal)	eBay	2002	27	4	US	Left
6	Peter Thiel	50	31	Germany	Cofinity (PayPal)	eBay	2002	35	4	US	Left
7	Luke Nosek	41	22	Poland	Cofinity (PayPal)	eBay	2002	26	4	US	Left
8	Ken Howery	41	22	USA	Cofinity (PayPal)	eBay	2002	26	4	US	Stay
9	Elon Musk	46	27	South Africa	Cofinity (PayPal)	eBay	2002	31	4	US	Left
10	Stev Chen	39	27	Taiwan	YouTube	Google	2006	28	1	US	Left
11	Chad Hurely	40	28	USA	YouTube	Google	2006	29	1	US	Stay
12	Jawed Karlm	38	26	Germany (Bangladeshi origin)	YouTube	Google	2006	27	1	US	Left
13	Dan Willis			Canada	Adscape	Google	2007		5	US	Stay
14	Colin Needham	50	23	UK	IMDb	Yahoo	1998	31	8	US	Stay
15	Herbert Boyer	81	40	USA	Genentech	Hoffmann-La Roche	2009	73	33	SWI	Left

16	Bob Swanson	70	29	USA		Genentech	Hoffmann-La Roche	2009	62	33	SWI	Left
17	Sheridan Snyder	81	45	USA		GENZYME™	Sanofi	2011	75	30	France	Left
18	Henry Blair	78	42	USA		GENZYME™	Sanofi	2011	72	30	France	Left before
19	Edward Penhoet	76	40	USA		Chiron	Novartis	2006	65	25	SWI	Left
20	William Rutter	89	53	USA		Chiron	Novartis	2006	78	25	SWI	Left
21	Pablo Venezuela	76	40	Chile		Chiron	Novartis	2006	65	25	SWI	Left
22	David Agus	52	42	USA		Navigenics	Life Technologies	2012	47	5	US	Left
23	Dietrich Stephan	48	38	USA		Navigenics	Life Technologies	2012	43	5	US	Left

Authors' own elaboration

Table A3 Spin-out composition

N	Spin-out company	Number of entrepreneurs	Single/ multi-founders	Experiences	In parent's industry	RI position	Business experience in founding team	Year of venturing	Age in 2017	Year of acquisition	Age at acquisition	Leave/ stay
1	Instagram	2	Multi	Same	Yes	All	None	2010	7	2012	2	All stay
2	Hotmail	2	Multi	Same	No	All	None	1996	21	1997	1	All stay
3	Cofinity (PayPal)	5	Multi	Different	No	2/5	Traders, Entrepreneur	1998	19	2002	4	4/5 left
4	YouTube	3	Multi	Same	Yes	All	None	2005	12	2006	1	2/3 left
5	Adscape	1	Single	n.a.	No	All	None	2002	15	2007	5	All stay
6	IMDb	1	Single	n.a.	No	All	None	1990	27	1998	8	All stay
7	Genentech	2	Multi	Different	No	1/2	Venture Capitalist	1976	41	2009	33	All left
8	Genzyme ™	2	Multi	Different	No	1/2	Account Manager	1981	36	2011	30	All left
9	Chiron	3	Multi	Same	No	All	None	1981	36	2006	25	All left
10	Navigenics	2	Multi	Different	No	All	None	2007	10	2012	5	All left

Authors' own elaboration

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Cooperating with Start-ups as a Strategy: Towards Corporate Entrepreneurship and Innovation

Stephan Jung

Abstract The economy of the twenty-first century is driven by digitalization of markets, industries and companies, accelerating innovation cycles and a worldwide rise of young ambitious talents that grow their own start-ups. Many established companies face major challenges in the area of innovation, organization or corporate culture.

Keywords Corporate entrepreneurship · Corporate startup collaboration · Corporate startup accelerator · Innovation strategy

1 Introduction: Challenges for Corporates of the Twenty-first Century

The economy of the twenty-first century is driven by digitalization of markets, industries and companies, accelerating innovation cycles and a worldwide rise of young ambitious talents that grow their own start-ups. Many established companies face major challenges in the area of innovation, organization or corporate culture.

79% of world-wide CEOs believe that the complexity of the system will grow in the next years, but only 49% of them have an idea how to manage it.[1] They name globalization the biggest challenge for established companies,[2] which already has led to significant changes of industries and its leading companies (Damanpour, 1991; Suomala, 2004). While in 1958 the average life span of companies listed within the S&P 500 index was 61 years, today it is only 18 years and it is expected that about 75% of todays' most valuable companies in world will be replaced by—mainly

[1]IBM Global CEO Study, 2010; Roland Berger Strategy Consultants. Mastering Product Complexity, 2012.

[2]"The Challenge of Globalization." Boundless Management, 2015.

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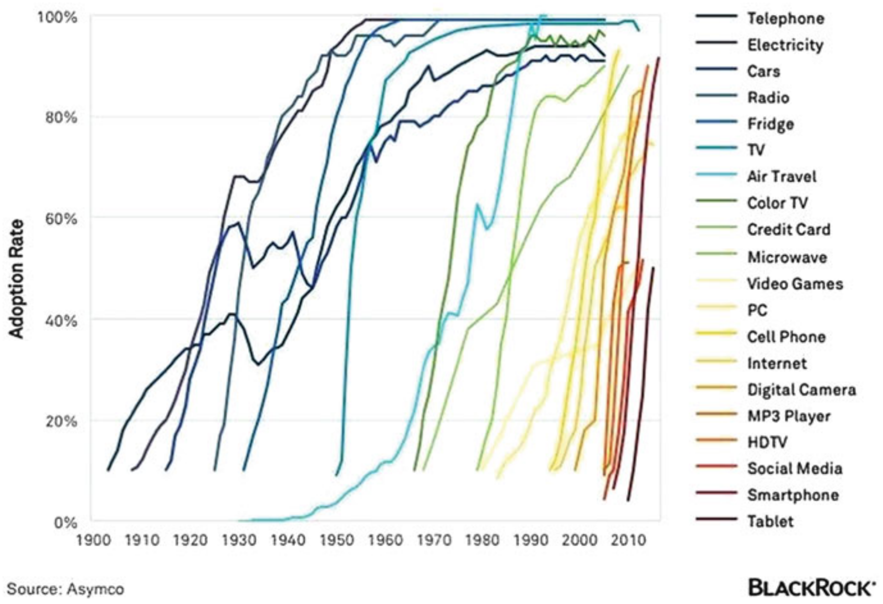

Fig. 1 Accelerating Adoption Rates of new technologies (source: www.asymco.com/2013/11/18/seeing-whats-next-2/)

younger—opponents. This is in line with growing technological opportunities and an accelerating adoption rate of those technologies as Fig. 1 shows.

Compared to the volume and speed on which industries—aka many different start-ups—innovate and experiment with new services, products and business models today, corporates—with a few exceptions—are not able to compete. On the one hand they have little processes and resources at hand to catch up regarding speed and volume of experiments. Corporates have hardly developed structures and processes to identify and develop many experiments/innovations in parallel (missing processes). They do not have the amounts of money left over or are not willing to spend this money in order to support a large volume of experiments (missing resources).

On the other hand, they have established company cultures and may be trapped in their past successes. Corporates are not prepared to handle failure, but most of these experiments will fail (company's innovation culture). Their investors (shareholders) become more conservative over time, leaders are CEOs or managers, which on average are less entrepreneurial oriented than founders. Their employees become less willing to stick their neck out with "out-of-the-box" ideas that may not work out and result in losing their jobs. Finally, companies get too "comfortable" with their past success, just before going out of business (e.g. Nokia, Neckermann, Kodak, Blockbuster, American Motors, Pan Am, . . .). Additionally, they are not always well-suited to develop these experimental ideas, as they are trained to exploitation excellence, but not exploration know-how. Research describes this fact as missing ambidexterity of a company, which has of course to do with company culture again

(O'Reilly & Tushman, 2004). Consequently, corporates have a hard job to utilize the given opportunities based on globalization and digitalization of the world, while start-up companies profit from this situation.[3] Therefore, these young start-ups can be seen as a consequence from, but also as a kind of catalyst of these developments based on globalization and digitalization. Start-ups are not just "smaller versions" of corporations or companies (Blank, 2010). They are structurally and culturally different organizations, which are geared towards other objectives than bigger companies or corporations (Blank, 2014). Following one of the most widespread definitions by Steve Blank, a start-up should be understood as "a temporary organization designed to search for a repeatable and scalable business model" (Blank, 2013). Eric Ries's definition emphasizes their search function, but also underlines the risk involved. For him a startup is a "human institution designed to create new products and services under conditions of extreme uncertainty". Highlighting these conditions of uncertainty is important, because this refers exactly to the differences in culture between start-ups and corporations. Start-ups are culturally used and designed to being able to deal with uncertainty and risk.

As Start-ups seem to profit from the general economic development because of globalization and digitalization (Hirt & Willmott, 2014), established companies started to experiment with the integration of experiences, tools and know-how from the start-up ecosystem into their organizational design (Deakins & Freel, 1998; Gary, Akgün, & Keskin, 2003). Until today, multiple ways of doing this exist, but so far is not clear, what are motives those corporates have in mind when cooperating with start-ups. Literature focuses pretty much around "Access to Innovation" as the only motive for corporates to engage with startups (Birdsall, Jones, Lee, Somerset, & Takaki, 2013; Hallen, Bingham, & Cohen, 2014). Therefore, this chapter wants to shed light on the current development of corporates that start cooperating with start-ups with a special focus on the different motives corporates follow when engaging with startups. Within this chapter one major question is addressed:

1.1 What Are the Motives of Corporates to Cooperate with Startups?

First, a comprehensive literature review on corporate innovation illustrates the research gap this paper is addressing. Second, an overview is given on the main activities corporates offer towards start-ups, to understand the different existing opportunities. Third, the motives and goals of existing companies to cooperate with start-ups are elaborated and analyzed, followed by a short conclusion. The motives and goals are developed based on a qualitative research approach, including secondary data and 40 qualitative interviews with responsible managers of start-up activities of corporate companies.

[3] http://www.innosight.com/innovation-resources/strategy-innovation/creative-destruction-whips-through-corporate-america.cfm

2 Literature Review on Corporate Innovation

Noted by Drucker (2002) in 1986, the survival of a company is dependent on its ability to develop entrepreneurial capacities and competences (Drucker, 2002). But exactly this fact is difficult for corporations of a certain size and history of success (Dougherty & Hardy, 1996; Govindarajan, 2016; Van de Ven, 1986). Major reason is, that emerging disruptive technologies bring highly different value propositions to the market that have not existed before (Christensen, 1997).

Most companies of a certain life cycle (Wessel, 2012) face a similar challenge of balancing the contradiction of protecting current revenue streams and putting in place concepts that will be relevant for the future survival of the corporation (Kanter, 2006). It's the classical dilemma between exploration and exploitation (O'Reilly & Tushman, 2004), which demand different organizational forms in terms of culture, strategy and leadership (Dougherty & Hardy, 1996). Corporations are designed to efficiently execute an existing business model and are steared towards that objective driven by various KPIs, which essentially represent the "root cause" for their inability to innovate (Blank, 2014). The concentration on the existing operation prevents innovation in organizations geared towards exploitation (Drucker, 2002).

There have been uncountable attempts to address these limitations by building various innovation systems (Pisano, 2015), fostering corporate entrepreneurship (McFadzean, O'Loughlin, & Shaw, 2005) or formulating an innovation management strategy, as a comprehensive framework. But none of these attempts have brought about a single best practice model (Tidd, 2001). Many approaches suggest to separate the exploitative units from the explorative ones, conceptualized by O'Reilly and Tushman (2004) in the term "ambidextrous organization". Chesbrough (2000) remarks though that many have tried to separate entrepreneurial projects as separate business, or business units, but with little success (Chesbrough, 2000).

Consequently, many companies, embracing the environment as a source of innovation, have opened up their innovation processes (Kanter, 2006). "Open innovation", companies started to integrate external sources such as start-ups, universities, licensing agreements for innovation as well as using outside "pathways" to the market for internal innovations (Chesbrough, 2000; Chesbrough & Appleyard, 2007).

Following this open innovation approach, many corporations today build their innovation strategies around three combinable pillars: Fostering intrapreneurship, which is also known as corporate entrepreneurship; developing strategic partnerships; plus various models for working with start-ups (Euchner, 2016). Corporate entrepreneurship or intrapreneurship means that corporate employees launch independent businesses from within the company, leveraging "the parent's assets, market position, capabilities or other resources" (Wolcott & Lippitz, 2007). Some would also include the process of a company assigning employees to found companies outside of the parent's business, but with the aim of spinning them in at some later stage. This model essentially acknowledges employees as an important source of innovation. Interestingly, these intrapreneurial models are more and more designed based on start-up accelerators (Euchner, 2016). This leads to the second part of this chapter, zooming into and explaining various activities of corporates towards engaging with startups.

3 Activities of Corporates to Cooperate with Start-ups

The following section of this chapter will elaborate on the most common activities that corporates offer in order to cooperate with start-ups. The order of the activities described is based on the involvement regarding time and money a corporate typically invests with this specific activity, starting from very low levels of involvement. Typical activities are start-up event hosting, sponsoring of the start-up ecosystem, offering mentoring or workplaces, start-up competitions, corporate venture capital and incubation or acceleration programs.

3.1 Event Hosting and Sponsoring Start-up Events or Start-up Ecosystems

If well-established companies sponsor or host start-up events, they are automatically linked to new innovative niche markets (Rifon, Choi, Trimble, & Li, 2004). Therefore, sponsoring helps to position the own brand in a specific area, raising awareness of the company in the start-up ecosystem or getting access to the start-up community. Working together with well-known events (e.g. like the pioneers festival in Vienna, websummit in Dublin, Noah Conferences or TEDx) that are already established, enhance the sponsoring company's reputation by association or even leads to media visibility. This activity is seen as a very common first step for corporates to test their engagement towards start-ups.

3.2 Sharing of Resources and Corporate Co-working Spaces

Sharing resources with start-ups may be one of the cheapest ways to cooperate with start-ups and to build a more innovative brand. Corporates, such as Google or Microsoft provide start-ups with their tools and technologies for free to expand their digital business. Furthermore, the free offer of physical spaces as co-working opportunities is another frequently used way to support start-ups (Vázquez, 2014). Some corporates provide free access desks, meeting spaces, internet, access to machinery and so on for the young companies (Haley, Bielli, & Mocker, 2015). Corporate co-working is mainly understood to be a shared facility where employees from an established corporation work together with Startups. The creation of co-working spaces enables larger corporations to work together with entrepreneurs to create a new form of cooperation (Schuermann, 2014). Co-working spaces are often combined with the method of mentoring as Startups gain access to experienced entrepreneurs (Ed McLaughlin, Lydecker, & McLaughlin, 2014).

3.3 Mentoring

Mentoring is a process that is understood to provide the ability to learn through experience and to offer assistance and help in overcoming problems. Mentors are known to have a significant impact on the development of start-ups and entrepreneurs by providing support that is concentrated on the individual needs of the one receiving the mentoring (Rigg & O'Dwyer, 2012). Mentoring, which is often given by experienced entrepreneurs who advice founders during the starting phase of their business establishment, has become an important means to address founders' learning need and is said to enhances venture's success, as it shortens the learning process of the mentee (Hill, 2015; St-Jean, 2012). Corporate mentors provide transferable knowledge as well as support to reflect that knowledge (Rigg & O'Dwyer, 2012) especially in the areas of marketing, sales, logistics, process- and project management (Macht & Robinson, 2009). Furthermore, a consistent contact between the mentor and the mentee is essential. Finding the right mentors is eventually the toughest challenge for organizations that are pursuing an organized mentoring program (Herholdt, 2012). Experience has shown that the ideal mentor has industry sector expertise, either work experience or sector knowledge to advise on the actual market entry and market positioning in the most optimal way. Most of the time, this sector expertise cannot be found, so that mentoring focuses on the personal development and the general business issues, and specialist mentors with sector expertise are asked to add the sector knowledge to the process (Hill, 2015).

3.4 Start-up Competitions or Hackathons

As a starting point to internal culture changes and to bring a company's employees closer to the mind-set of start-ups as well as to provide them with new business trends and technologies, some corporates compose various kinds of competitions between start-ups where the winner receives a special price (e.g. money, access to corporate network, exclusive partnership contracts) or so called Hackathons. Hackathons or hack days are events where coders and creatives people focus on the development around a specific goal, e.g. solving a technical problem or writing a particular piece of code. Many companies sponsor such events to receive new ideas for a specific problem their customers have (Haley et al., 2015).

3.5 Corporate Venture Capital

Acquiring start-ups is the logical extension of corporate venture capital investments, which serves as a quick way to buy new technologies, solutions for specific business problems or entering a new market (Harrison, Hitt, Hoskisson, & Ireland, 2001) "Acqi-hiring", a very famous practice to acquire a company to have access to its talent, is one of the most important objectives for buying start-ups (Haley et al., 2015).

The idea of corporate venture capital (CVC), is to give corporations an easy access to new ideas coming from start-ups by financing them. Chesbrough (2002) defines corporate venture capital as the "investment of corporate funds directly in external start-up companies". Further, this concept is used to complement research and development activities of corporations (Dauderstädt, 2013). In the second quarter of 2016 more than 8 billion USD of corporate venture capital money was spent within the US-software industry, followed by biotechnology with almost 1.7 billion USD.[4] Therefore, the impact of this concept is clearly visible. In terms of countries, the United States, Japan and Germany have the most CVC activities. He further describes two different ways of underlying dimensions of corporate venture capital. A firm either invests in external start-ups because of strategic or financial purposes. On the one hand, corporate venture capital aims at establishing strategic relationships between start-ups and corporations, while already investing at an early stage of the start-up phase—most frequently between early and mid-stage. On the other hand, some corporate venture capital activities aim at getting financial returns from the fulfilled investment (Reimsbach & Haushild, 2012; Waite, 2016).

3.6 Corporate Start-up Incubation Programs

Incubators are defined as programs that support businesses at an early stage (Zedtwitz, 2003). They "help ventures define and build their initial products, identify promising customer segments, and secure resources, including capital and employees" (Cohen & Hochberg, 2014; Clarysse & Yusubova, 2014; Hoffman & Radojevich-Kelley, 2012). According to Aernoudt (2004), different types of business incubators exist, starting from mixed incubators, which are offering services to companies of all branches to technology incubators with a focus within the industry or technology areas the corporate is currently active, to social incubators which mainly focus on overcoming social gaps and the raise of employment rates (social incubators are not familiar to be started by corporates) (Hackett & Dilts, 2004; Lalkaka, 2002). Becker and Gassmann (2006a, 2006b) see the enhancement of the corporation's technological development as major goal of corporate incubation.

[4] Statista (2016).

3.7 Acceleration Programs

The global supply of accelerator programs has rapidly grown over the last decade. These programs are often founded by a mix of investors, public bodies or large corporates and typically provide the young companies with space, money, mentoring and guidance to help the entrepreneurs developing and spreading their business idea. Accelerators provide an environment where start-ups can learn and test their business models with the help of mentors and peers. Several start-ups enter an accelerator together in groups called cohorts. These cohorts get the possibility to connect with each other as well as with a broader community of alumni, benefiting from their diverse skills and helping each other in difficult situations (Grimaldi & Grandi, 2005; Hansen, Nohria, & Berger, 2000). At the end of the program they often have the opportunity to present their company to possible investors. Specific models can differ from company to company, they do not necessarily include ownership of the start-up as a prerequisite (Weiblen & Chesbrough, 2015), others run the program with corporate partners and some are totally run externally. Nevertheless, many these programs usually receive an equity stake of 5–7% in return for a five-figure investment (Clarysse & Yusubova, 2014; Fehder & Hochberg, 2015).

The overall number of start-up accelerator programs are rather increasing. In 2012, around 7000 start-up incubators and accelerators could be identified worldwide.[5] According to the Global Accelerator Report,[6] accelerator programs are nowadays founded in all possible regions throughout the globe. However, it is found that its strongest foothold is in the U.S. and Canada. In the last years, for example in 2015, more than $90 million were invested in accelerator programs in the US and Canada by 111 accelerators into 2.968 start-ups. In 2014 there were already 76 accelerator programs existing, which launched 1.588 start-ups in Central Europe. The main centers of accelerator programs in Europe are the United Kingdom, Spain and Germany. Until 2015, the number of European accelerators still grew consistently. Both private and public interest and investments in the start-up industry animated the growth of accelerator programs in the European region.

Clear differences of accelerator to incubator programs are developed by Cohen (2013), who distinguishes accelerators and incubators based on their duration, cohorts, business model, selection and education, mentorship and network development as shown in Fig. 2. Although quite an academic discussion, this distinction might help corporates to clarify—based on their needs and strategic goals—which model fits better for them.

Worldwide, over 8000 programs exist today, which evidences the growing importance as a strategic tool not only for corporates, but also for universities, public institutions or states (Becker & Gassmann, 2006a, 2006b; Peters, Rice, & Sundararajan, 2004).

[5] The International Business Innovation Association (2016).

[6] Gust (2015). Global Accelerator Report 2015. http://gust.com/global-accelerator-report-2015/

	Incubators	Angel Investors	Accelerators
Duration	1 to 5 years	Ongoing	3 months
Cohorts	No	No	Yes
Business Model	Rent; non-profit	Investment	Investment, can also be non-profit
Selection	Non-Competitive	Competitive, ongoing	Competitive, cyclical
Venture Stage	Early, or late	Early	Early
Education	Ad hoc, human resources, legal etc.	None	Seminars
Mentorship	Minimal, tactical	As needed, by investor	Intense, by self and others
Venture location	On site	Off site	On site

Fig. 2 Key differences between Incubators, Investors and Accelerators (Cohen, 2013)

When corporations establish a start-up program, advice, mentoring and mediation is mostly included in the corporate incubation or acceleration offered. Data obtained even affirms that the success of incubation programs depends on the presence of advice and coaching (Peters et al., 2004).

4 Motives of Corporates to Work Together with Start-ups

Are they focusing on getting access to innovation? Do they want to learn from the start-up culture in order to become more attractive again for future talents? Do they want to invest in start-ups (corporate venture capital) in order to learn from the technology skills of start-ups? As shown in the previous section, corporate activities towards cooperating with start-ups is not purely focusing on the generation of financial return. Hence, a variety of different cooperation activities with focus on strategic benefits have developed. The emerging trend of establishing corporate incubators or accelerators additionally grounds the assumption that long-term, strategic considerations are the driving factors for corporates' involvement in start-up collaboration. Srinivasan, Barchas, Gorenberg, and Simoudis (2014) emphasizes that the specific type of activity should always be selected based on the targets a corporate desire to achieve. Thus, depending on the strategy in place, an established corporate might benefit from different forms of cooperation with start-ups.

I conducted a set of 38 interviews with managers responsible for start-up cooperation, to understand the goals and motives of corporates to engage with start-ups. They work for German-speaking corporates like IBM Germany, Swisscom,

Table 1 Descriptive statistics about the sample

Industry	Number of interviews	Percentage
Communication	1	2.6%
Consulting	1	2.6%
Engineering Industry	6	15.8%
FMCG	2	5.3%
Gambling	2	5.3%
ICT	9	23.7%
Logistic	3	7.9%
Media	3	7.9%
Mobility	2	5.3%
Telecommunication	9	23.7%

Frequentis, Deutsche Telekom, Kapsch, Austrian Post, SBB, Konica Minolta or Casinos Austria. The following industries where covered (Table 1):

Interestingly there exist a broad range of different job descriptions that are responsible for the startup engagement, including Head of IT, M&A Management, Head of Marketing, Innovation Manager, Brand Manager, Head of Business Development, Head of External Communications as well as several Business Unit Managers.

The Interviews followed a semi-structured approach that focus on understanding all the different activities a corporate is running towards startups. The second element of the interviews set around the identification of the different motives by asking lots of why questions about each activity that were mentioned before. This also helped to clarify the real range of activities per corporate. As a next step a category system was developed to identify different motives (Mayring, 2015).

First notable result was, that nearly 25% (9 persons) of the interviewees were not able to express clear strategic goals or motives, why they exactly foster the cooperation with start-ups by running a corporate accelerator or incubator program. The motives I detected are not equally important to the interviews, therefore I decided to follow a two-step approach. Firstly, based on a text analysis of the written transcripts of all interviews (average duration of one interview was 35 min) by grouping sentences and thoughts of each interviewee together to detect patterns within the answers. Secondly, to calculate the importance of the single motive, I used the written transcripts and codified them sentence by sentence into one of the nine areas and measured the length (number of words) of the text elements. With this approach nine different motives were identified. These motives are (Table 2):

Regarding the importance of the single motive, I identified the following order of the most relevant motive to the least relevant in the following order, as reported in Fig. 3: (1) Access to innovation, (2) Learning from the start-up culture, (3) Generating early investment opportunities, (4) Marketing effects, (5) corporate social responsibility, (6) broaden corporate network in the start-up ecosystem, (7) establish sales partnerships to resell products/services of the start-ups, (8) winning start-ups as future customers of the corporate and (9) access to talent.

Table 2 The table lists the nine motives for corporate start-up engagement

Motive 1	Access to innovation
Motive 2	Investment opportunity
Motive 3	Marketing and PR
Motive 4	Access to talent
Motive 5	Access to start-ups as future customers
Motive 6	Start-up culture
Motive 7	Distribution of products of start-ups
Motive 8	Enlargement of the founder network/entrepreneurial support
Motive 9	CSR

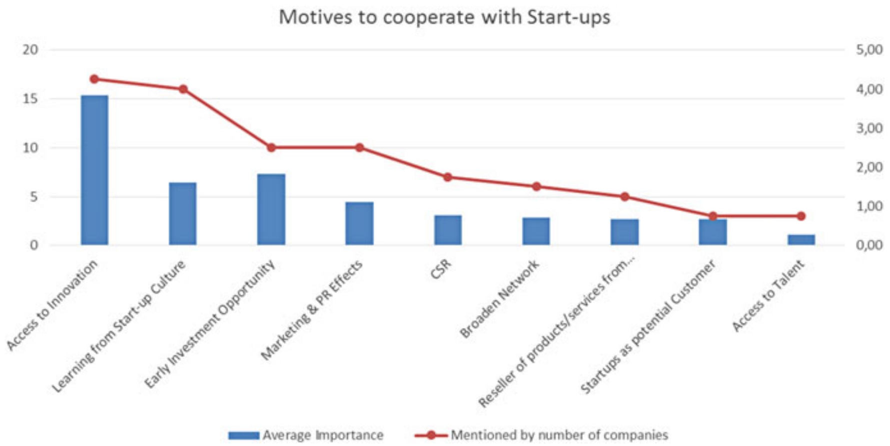

Fig. 3 Motive and Importance of Motives for Corporates to engage with Startups

Nearly all Corporates focus on "access to innovation" with their various cooperation models and approaches. More than 50% of all corporates want to "learn from the start-up culture", "generate early investment opportunities" or utilize "marketing effects" with their programs. About 40% mention that "corporate social responsibility" is a motive for them to offer cooperation models to start-ups, but regarding the importance this aspect is never a major driver of the program design, but more a welcomed side effect. Interestingly, only a few corporates focus on start-ups as their "future customers", but if they do this motive is the most important for them and they develop their program based on this goal.

The opportunity to have "access to talent" by running a start-up program is the least important motive and for those interviewees who mentioned this motive it is not more than a side-effect of their program. In times of a growing "war for talents" and many studies that elaborate on the ability to attract talent as a major driver of success, this is a surprising fact, as start-up founders are said to be creative, out-of-the box-thinkers, solution oriented as well as customer oriented, traits that many corporates are searching for within their recruitment process. Therefore, the recruitment of skilled entrepreneurs should also be taken into consideration.

In two surveys conducted by KPMG (KPMG, 2014, 2015) over 90% of the corporations interviewed, agreed that the main reason for working with start-ups is to increase their capacity to innovate. But, innovation is frequently used as a catch-all term, incorporating different and sometimes even contradictory things. In the context of corporate start-up engagement, innovation usually means using start-ups as a source of knowledge and ideas (Euchner, 2016; Kohler, 2016; Simoudis, 2014). These ideas often relate to emerging technologies and other trends (Ream & Schatsky, 2016). Many corporations use their start-up engagement also as a "scouting tool for technology" (Clarysse, Wright, & Van Hove, 2015).

The motive "Investment opportunity" covers the original objective of non-corporate accelerators, as seed-investment funds, which invest in start-ups and accelerate them to market as quickly as possible in exchange for equity (Hoffman & Radojevich-Kelley, 2012). Their business model is based on achieving capital gains through this investment at some later stage via an exit in form of an acquisition or IPO of that supported company (Dempwolf, Auer, & D'Ippolito, 2014). In relation to corporate start-up engagement this motive seems to be linked to whether the engagement involves to take equity from the start-ups. As corporate start-up engagement mostly involves early stage start-ups, capital requirements are between $35k to $50k (Kohler, 2016).

The motive "Marketing and PR" relates to the positive image effects start-up engagement can have on the corporation's brand and the attractiveness of the organization as whole (Kawohl, Rack, & Strniste, 2015). Corporations regularly use their start-up engagement to position themselves as innovative (Weisfeld, 2016). Being perceived as an innovative company is also becoming increasingly important to attract top talent as workforce, since more and more MBA graduates decide to work for start-ups as opposed to established corporations (Bonzom & Netessine, 2016). Therefore, this motive is closely linked to the motive "Access to talent". Interestingly, many organizations do not take HR and the motive "Access to Talent" into their considerations (Szal, 2017).

Many companies approach the motive "start-ups as future customers" by supporting start-ups by initially providing them with free access to the corporate's products or services. 57 corporations out of the Global 500 have provided start-ups with free access to their products and services in the last years (Bonzom & Netessine, 2016).

The motive "Start-up culture" is a very diffuse term, which entails a lot of different things. Broadly speaking this motive revolves around getting in contact with the start-ups' special way of working, with the hope of "rejuvenating corporate culture" (Mocker, Bielli, & Haley, 2015), as well as increase the speed of execution within the corporate organization, by adopting methods and tools startups frequently use to reduce time-to-prototype, time-to-market or even time-to-failure (Euchner, 2016).

The 7th motive of becoming a "distributors of the products of start-ups" is based on achieving synergies and mutual benefits from the corporation-start-up relationship (Kohler, 2016). Through these partnerships corporations can also effectively leverage their "existing scale, distribution, and relationships into additional value" (Dempwolf et al., 2014).

Many corporations also use their corporate start-up engagement initiative as an entry point to the entrepreneurial community. Running an accelerator does not only give them a good overview of the start-up landscape, but also brings them in contact with important (ex-)entrepreneurs, VC-institutions and business angels, which often serve as mentors or jury members in the accelerator (Weisfeld, 2016).

Some corporates present their corporate start-up engagement as part of their "Corporate Social Responsibility" initiatives (Motive 9). If one takes that claim seriously (and not only as a sort of "greenwashing"), it should be assumed that corporates view their start-ups engagement as part of their initiative to "contribute to economic development" and to improving and supporting their immediate communities and the societies they operate in (Watts & Holmes, 1999).

5 Conclusion

Large Corporations as well as SME companies (Kawohl et al., 2015) have significantly increased their engagement with start-ups in the past years. This engagement has expanded into many different forms, like various forms of accelerators and incubators, start-up challenges, hackathons and other events, or collaborations with private accelerators. Corporations have found various ways of getting in contact with start-ups and they have various motives for that engagement. The corporation's start-up engagement can be seen as a strategic approach to addressing certain corporate pains, mostly regarding corporations' problems with internal innovation and/or establishing a culture of innovation (Dougherty & Hardy, 1996; Kanter, 2006; Shieh, 2011). In that light corporate accelerators and incubators, which form by far the most prominent activity of corporates, are a continuation of the process of outsourcing or at least separating corporate innovation from the exploitative side of business (Drucker, 2002; O'Reilly & Tushman, 2004). While it can be said that "access to innovation" and getting in touch with "start-up culture" are clearly among the most prominent motives why corporations engage with start-ups, this study and others (Bonzom & Netessine, 2016; Kawohl et al., 2015; Kohler, 2016) show that there is a much greater scope of motives for corporation to get in contact with start-ups. Based on this research nine primary motives for corporate startup engagement have been identified.

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