

# A Taxonomy of Knowledge Spillovers for High-Tech Startups Development

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**Abstract**—Entrepreneurship is considered of utmost importance for national economic and industrial growth. A leading theory related to economic development is the Knowledge Spillover Theory of Entrepreneurship (KSTE), which aims to uncover the effects that economic agents have on the creation of new companies. By following the KSTE process, companies can commercialize and implement newly acquired knowledge in the market more quickly. Typically, economic growth evaluation is conducted at the country or regional level through global monitoring indexes, assessment on the generation of patents, and identification of the number of companies created. However, since knowledge is sometimes unattached to a physical document or item, it remains necessary to clarify a taxonomy and flow of knowledge spillovers at the individual level for startups in their first three to five years of development from the time that the company is funded. The purpose of this paper is to identify and discuss possible strategies for evaluating the effects of knowledge spillovers on startups in high-tech sections which, in-turn, will aid the decision-making process of Chief Executive Officers (CEOs).

**Keywords**—Absorptive Capacity, Startups, Entrepreneurship, High-Tech, Innovation, Knowledge Spillovers.

## I. INTRODUCTION

The Knowledge Spillover Theory of Entrepreneurship has been considered one of the main drivers for uncovering the creation of new companies. Its direction is often pointed towards the effects of investment in Research and Development (R&D) [1]. Research into the domain has extended to the country level, where the generation of new knowledge has a strong correlation with agglomeration theories and the creation of start-ups [2]. Through this development, countries and cities have established policies that solidify the development of Information and Communication Technologies (ICTs) and governmental regulations that support entrepreneurship [3, 4]. At the same time, research [5, 6] has shown that the proximity of companies to regions and cities with high generation of new knowledge boosts collaboration and increases the success of a startup.

The importance of proximity has been highlighted in much KSTE research, with researchers concluding that proximity closeness provides startups with the ability to access stocks of knowledge and implement them towards measured innovation [6]. For example, entrepreneurs that operate in supplier-dependent industries, such as manufacturing, rely on the transport of goods and on the mass production of products, which requires them to not only choose locations based on reduced costs of transportation, but also areas that facilitate

access to knowledge [7]. On the other hand, it can be disputed that there are forms of knowledge spillovers that are unbounded by geographical proximity through the development of potential networks, such as informal internet-based networks [8, 9].

To understand knowledge spillovers, researchers have traditionally assessed the creation of new companies based on investment in R&D and number of patents created. This process assumes that KSTE was initially based on the decision of entrepreneurial employees to create a start-up [10, 11, 12], however, the development of entrepreneurial mechanisms have extended to the development of networks that enable access to commercial and technical knowledge spillovers [13]. At present, the limitations of what defines intentional and unintentional knowledge sharing without agreement, and the understanding of entrepreneurs of what are knowledge spillovers remain unclear. Research is required to uncover how to successfully measure knowledge spillovers through the absorptive capacity of startups; most importantly, to assure that the collection of knowledge spillovers originates from incumbents and academia [2]. This research focuses on uncovering the perceptions of entrepreneurs involved in university and business incubators [14]. We focus on identifying a clear taxonomy and framework to define knowledge spillovers [4, 9].

## II. AIM

This research aims to identify the effects and definitions of knowledge spillovers at the individual level in the context of startups that have been through an accelerator or incubator program. The primary aim is to define the links that the KSTE has with the increase in performance and innovation of startups [15]. The focus is to uncover insights on the survival of startups during the first three years of operation, or so-called "valley of death" [16, 17]. The study firstly presents a literature review of theory, covering the most cited academic research on the KSTE, and entrepreneurship. Next, a deductive model is formed, based on hypotheses and variables that connect possible instances where knowledge spillovers would represent a gain of knowledge and an identification of a decision [18]. To that end, the expansion of the KSTE has to uncover the absorption and perception at the individual level of entrepreneurs. Subsequently we test the possible interaction of knowledge spillovers at the initial stages of startup creation, that can overcome geographical barriers and flows in virtual environments [14]. The three main points of discussion are discussed in the following sections.

#### *A. Importance of absorptive capacity on startup evolution*

To develop the proposed taxonomy of knowledge spillovers, we must first shed light on the changes that startups undertake. In this case, the changes in the process of absorptive capacity that enable possible collection of knowledge spillovers. Such drive develops through the motivation of entrepreneurs to engage in product innovation, and the identification of uncommercialized new knowledge [10]. The development process depends on the skillset and incentives that the human capital has in order to evaluate the value of knowledge [19]. The impulse to engage in this process is restricted to the type of industry and market that the entrepreneur decides to engage in for the creation of the startup. The exposure of startups to sources of knowledge spillovers would be expected to be from the interactions within the chain of value involved with the creation of the product, and the local government. This approach connects the horizontal knowledge spillovers that could incorporate technological knowledge [20].

Changes in the absorptive capacity process require the implementation of different types of knowledge spillovers by entrepreneurs. The starting point is the initial generation of knowledge spillovers which develops from industry and academia. In this context, the economic agent working in the institution absorbs new knowledge that has not become economical knowledge [21, 22]. The decision to embark on the creation of the startup begins the process of the decisions taken. First, the entrepreneur, with a background from academia or industry, decides to identify a knowledge spillover, based on the evaluation of the estimated economic value [2, 23]. The development of this new idea leads the entrepreneur to be part of a startup, where protected knowledge is identified as a form of technological-explicit knowledge from a knowledge spillover [10]. The understanding that exposures to knowledge spillovers increases in cities, since there are higher opportunities for startups to access skilled human capital, and infrastructure on ICT, public services is evident [4, 24]. These factors translate to the interaction and exposure that entrepreneurs have to different sources that generate knowledge spillovers. The most common sources of information identified from initial research on the KSTE are from academic research and expertise from universities; and new knowledge that is generated by investment in R&D from incumbents [1]. Further research has expanded from the understanding of agglomeration theories, where clusters of companies and Science and Technology Parks (STPs) are formed to enhance inter-organizational collaboration to be more competitive, and link research conducted by universities [20, 25]. These city structures are encouraged for further analysis. First, the density of population in cities and the financial structure that support employment growth is important [26]. Second, the cultural and technical diversity is unique [1, 27, 28]. Finally, the entrepreneurial environment enabled by organizations and the government should be explored.

#### *B. The expansion of knowledge spillovers from geographical proximity*

The development to uncover how knowledge spillovers exist beyond the mobility of human capital remains unclear [14]. The idea is that indicators are used to track flows of knowledge caused by investment in R&D, which lead to the creation of new companies. However, knowledge spillovers are often difficult to identify, since their very nature does not

provide physical evidence until their effects have been realised [1, 29]. The ideal scenario is to identify if there is any investment in R&D from startups, which can be measured to provide an insight on knowledge spillovers absorption through absorptive capacity. For instance, R&D can be translated to the number of hours entrepreneurs spend on the innovation of products and services, or on the financial resources used to hire skilled employees [10]. In such a controlled environment, high tech startups can choose to expand their network to obtain spillovers from tacit knowledge through events run by accelerator or incubator programs, or from their connections to pre-established networks [9, 13]. This flow of knowledge remains at a low or free cost when the final interactions are established between the startup and other company or institution. However, its absorption depends on the skillset and motivations of entrepreneurial-minded employees who are engaged in explorative discovery of technological opportunities [9, 24].

Knowledge spillovers can also transcend to the interactions in virtual or cognitive spaces, where the interactions between individuals evolve to groups that continuously transform tacit and explicit knowledge through an ongoing Dynamic Knowledge Creation Process (DKCP) [30]. This constant transformation of knowledge can focus on uncovering the interactions that entrepreneurs have with the public domain, using tools such as Web 2.0 [3, 31]. This method for expansion of knowledge spillovers using technological tools can help uncover the boundaries of entrepreneurial ecosystems. Such interactions could expand possible startup interactions at different levels through the usage of the internet [32].

### III. PERCEPTIONS OF KNOWLEDGE SPILLOVERS AT AN INDIVIDUAL LEVEL

In order to formulate an applicable taxonomy and proposed flow of information [33], it is necessary to uncover the effects that knowledge spillovers have on startups. The structure of the proposed analysis considers the initial background of the entrepreneur, which can be considered an indicator of the initial capability to absorb knowledge. Such responses would uncover the interpretation of technical and non-technical understanding to increase the performance of the startup [34]. The initial insights of the entrepreneurs' perceptions include evaluating the initial decision to choose the location of the incubator and the startup. This approach leads to the identification of the main differences and opportunities of being located in the center or outside of a city [35]. In addition, we establish propositions on the possible types of knowledge spillovers that are used by entrepreneurs related to their different stages of development.

#### *A. The initial set of conditions*

The initial founders of a startup may decide to work or resign to secure job openings while undertaking the start of their new company. Hence, entrepreneurs initially take decisions based on the opportunity to build a reputation and maintain financial security [36, 37]. Academic entrepreneurs with a PhD degree would seek to undertake the development of the startup to progress to enhance academic research and publications [38]. The initial number of employees in high-tech startups is crucial, as the type of resources in a company relates to the likelihood of survival in the long term, and the capability to identify knowledge spillovers [15, 39]. This

process also allows for testing the value of the stock or new knowledge to be commercialized in the market through the network [40]. Finally, by identifying the number of years that a company has been in business helps give an initial categorization of the entrepreneur and to predict an expected outcome [41]. Therefore,

**P1.** The decision to start a new venture is dependent on the number of employees, and on evaluation of the business idea captured through knowledge spillovers.

### *B. Entrepreneurs background and perception of industry*

This section enables the evaluation of the base skillset and possible knowledge spillovers that entrepreneurs carry with them. First, the collection of previous industrial and academic experience. An initial pool of knowledge that acts as a source for making strategic decisions in the company are deemed the pre-established networks with industry and academia; these facilitate access to knowledge spillovers from companies and strategic partners [28]. Both resources link to the Absorptive Capacity Theory of Knowledge Spillover Entrepreneurship, where the collection of knowledge depends on the capability of the entrepreneur to understand technological and business knowledge. This skill enables economic agents to commercialize new products and services in the market [42]. Hence, the ability of an entrepreneur to obtain knowledge spillovers depends on their skillset. They must also transform knowledge spillovers into financial performance of the startup [34]. In addition, the cultural diversity of entrepreneurs from other countries improves the innovation process and enables the evaluation of business ideas from the perspective of international markets [43, 44]. Finally, the development of unexperienced entrepreneurs can be facilitated through attendance of incubators and accelerator programs that enable access to venture capital and engagement in initial explorative discovery of product conceptualization; this allows for the setting of foundations of the company [45]. However, the pivotal point to uncover from the KSTE is that the generation of the new business idea can be provided from tacit knowledge, which is the exchange and generation of ideas from the initial founders of the company [46]. Foremost, the sharing process of knowledge is embedded in the experiences and understanding of the main founders of the company, which does not have to be a form of new knowledge. Therefore,

**P2.** The identification of uncommercialized technological knowledge spillovers from entrepreneurs for the creation of a new start-up comes from the effects of R&D.

**P3.** The identification of business and product ideas are generated from tacit knowledge spillovers exchanged between the main founders of the company.

**P4.** The growth of startups with inexperienced founders can be enhanced through attendance of incubator or accelerator programs.

### *C. Incubator programmes and networking*

High-Tech startups are more able to identify knowledge spillovers from open workplaces, such as STPs and incubators [20, 47]. Such example can lead to boosts of absorption of horizontal knowledge spillovers in the chain of value [20]. On the other hand, the interactions that startups can have with other companies from different industries can lead to the exposure of vertical types of knowledge spillovers [20].

However, information that is provided through these programs that are linked to a monetary exchange is a process of knowledge management. In this case, the process of knowledge spillover would consider if the startup is a recipient of technical or managerial knowledge spillovers from networking events, where interactions remain informal and enable access to free knowledge [9]. Hence, start-ups would develop new forms of mechanisms and strategies to identify and capture knowledge and resources [9, 48]; this allows entrepreneurs to seek to be involved in an incubator program to gain more in-depth knowledge of the types of tacit and explicit knowledge that can be absorbed from the cohort of companies that are involved in the process [30, 49]. The question is how the flow of knowledge spillovers can start from an individual environment that can expand between face-to-face and virtual environments [30].

The interactions in the industry can lead to a new form of knowledge filter, where entrepreneurs perceive an initial competitive advance from incumbents that have the necessary resources to create startups [50]. In this case, the newly founded companies rely on reducing costs to obtain knowledge and disrupt the filter to remain competitive and survive [29, 51]. On the other hand, startups can decide not to share knowledge with external individuals unless there has been previous collaboration set [28, 52]. Hence, companies would set measures of protection on Intellectual Property (IP) or on the creation of patents that focus on protection to prevent knowledge leakage [45, 53]. However, if companies decide to engage in alliances to a shared project with Equity Joint Ventures (EJVs), the exchange of knowledge spillovers between partners depends on the overvaluation on protected information [14]. This section aims to shed light on the possible increase in survival and innovation from the absorption and implementation of knowledge spillovers [39]. Hence, it can be stated that entrepreneurial knowledge spillovers that include all information that enables the support of the initial development of the startup, such as legal advice or documentation required to develop the company and gain funding [9, 47]. Therefore,

**P5.** Incubator and accelerator programs enable access to entrepreneurial knowledge spillovers.

**P6.** Knowledge spillovers are prevented through the development of patents and Intellectual Property agreements.

### *D. Individual perceptions towards knowledge spillovers and innovation*

From the perspective of the entrepreneur, it is necessary to highlight how knowledge spillovers, produced from R&D, can lead to two paths. First, if the startup decides to exploit the stock of knowledge that is expected to be around 90% of its outcome, it would focus on getting access to the valuation of captured knowledge spillovers [43]. The second path would lead to a process of exploratory discovery, where startups are directed to generate new patent knowledge [43]. This last method deals with the dependence of the absorptive capacity of startups to create new knowledge, as well as being dependent on the entrepreneurs in the long term at a regional level [23]. In this case, all the decisions taken by the company would determine the potential of the developed product or lead it to failure, which can be potentially identified by the number of patents created [43]. Hence, the exploitation of explicit knowledge spillovers. Therefore,

**P7:** Capture of explicit knowledge spillovers depends on the absorptive capacity of the founder of the company and members of the startup.

On the other hand, startups can be involved in the performance of the alliance or collaborations with companies that have been long established in the market, which is enabled through networking. Hence, mutual endeavors between companies can facilitate access to technological and international knowledge that is shared [9, 14]. Further development of the collaboration affects absorptive capacity by expanding the use of ICT and virtual platforms to obtain knowledge. Furthermore, it impacts on the development of new mechanisms and support to access public domains and interact with other organization. Further development of the startup depends on the support that entrepreneurial ecosystems provide on the Information and Technology (IT) infrastructure of the city and the international openness to the use of the internet [32]. Foremost, the use of IT and virtual platforms enable access to customer knowledge spillovers that can extend the source of horizontal knowledge spillovers [20, 28, 54]. In addition, interaction with suppliers can also lead to access of knowledge spillovers that can be obtained from the movement of goods throughout the supply chain. On the other hand, these tools can lead to the absorption of vertical knowledge spillovers, as companies that adapt knowledge from a different industry based on the Standard Industrial Classification, succeed [17, 55]. Therefore,

**P8:** Alliances and collaborations enable access to explicit knowledge spillovers on technology through use of virtual platforms towards product innovation.

**P9:** Virtual platforms facilitate access to explicit customer knowledge spillovers that enable product innovation that can be local and international.

**P10:** Movement of goods and materials is linked to access to supplier knowledge spillovers that support production.

#### IV. LOCATION AND PROXIMITY TO SOURCES OF KNOWLEDGE

The location of a startup can affect the exposure to knowledge spillovers from face-to-face interactions. This exchange of tacit knowledge is based first on the infrastructure and cities that deal with more than 250,000 residents, which have a large pool of human capital to access specific knowledge and higher interaction with the market [4]. Such locations enable communication that leads to the absorption of knowledge spillovers from universities and incumbents. Such development in cities from startups would lead to a U-shape relationship, which can decrease the level of entrepreneurship as the country improves its economy [3, 56]. These interactions, however, have to be clarified to distinguish the barrier from nascent entrepreneurs to already established firms [57]. It is necessary to evaluate the perception of startups on incubation programs, if the resources and access to knowledge can counter the level of employment and development in urban areas [3, 57]. R&D expenditure from universities and incumbents lead to knowledge spillovers. First, it is essential to consider that high-tech startups would evaluate their location so that they are close to organizations that provide information and support, such as law firms [47]. Next, it is necessary to assess how close interactions, enabled by networking, is set regarding distance from the location of the incubator and other entities [9]. These face-to-face interactions can also be intertwined with other sources of

knowledge, such as from STPs, universities, and incumbents [20, 28, 58]. Therefore, the discussions in previous sections lead to the identification of knowledge spillovers on the development of start-ups. To start, the flows and access to knowledge is depended on the stage of the product and business foundation, seed and growth [9, 59]. Therefore, the decisions taken from entrepreneurs on the type of knowledge spillovers absorbed influences this process. Hence, it can be further tested or assumed that factors that prevent the flow of knowledge would disrupt the development of a startup, causing failure or further development of the company, depending on the company's location [56, 60]. Hence, the type of knowledge spillovers involved in a startup's development is illustrated in the proposed knowledge spillover taxonomy in Figure 1.

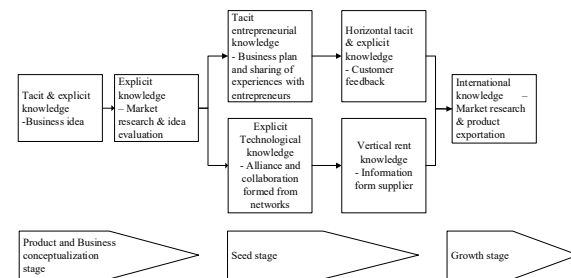


Fig. 1. Knowledge spillover taxonomy and flow of start-up development.

First, the identification of the business idea from entrepreneurs depends on the background. Entrepreneurs involved on academia and research institutions extract tacit and explicit knowledge spillovers from experience on Research Joint Ventures (RJV) and on the development academic papers [24]. On the other hand, entrepreneurs with industrial experience start-new ventures from the identification of the product to be developed from tacit knowledge spillovers [5, 9]. Hence, CEOs would decide to start the new company based on their experience and R&D that sets the evaluation of the company in the market [23]. Second, entrepreneurial knowledge on how to develop the company through business plans, planning, and access to funding is mainly obtained from the experiences of CEOs and entrepreneurs attending a common entrepreneurial ecosystem [9]. In that contexts, the support from incubators, accelerators, and Science and Technology Parks (STP) [13, 40, 20]. Moreover, the effect of these entrepreneurial environments leads further access to explicit technological knowledge spillovers fostered from the formation of alliances [14, 28]. Further exchange of knowledge spillovers through formal meetings and ICTs are critical to incremental product innovation. For that matter, critical sources of knowledge spillovers come from customers, suppliers, and competitors. Finally, startups that decide to engage in the growth process, and not on creative construction, would further decide to engage on exploratory and exploitative innovation on local and international markets, which triggers the escalation and growth of the business manifested on the number of full-time employees enrolled in the start-up, and on the sales and performance of products in new markets. Conclusions

This paper has discussed the importance of evaluating the effects of knowledge spillovers at an individual level. The aim of the research was to highlight the different perspectives that can affect the impact of knowledge spillovers. Firstly, it can

be seen that the level of absorptive capacity of entrepreneurs that go through an incubator or accelerator program increases and enables the identification of opportunities and technological knowledge. Second, the exposure or search for certain types of knowledge spillovers can affect the development and innovation of a product or process. Third, the transformation of knowledge, following the DKCP, has the potential to set the space of geographical proximity where face to-face-interactions are primordial to the collection of knowledge. Moreover, the expansion of knowledge spillovers is set to increase the use of virtual platforms and ICTs for knowledge capture.

By evaluating the initial propositions to establish an initial knowledge spillovers taxonomy that distinguishes the perception of entrepreneurs ongoing through the incubation process, we firstly identify that the evaluation of the background of the entrepreneurs on an incubator program would enable us to set the initial absorptive capacity of startups. These propositions would depend on the previous knowledge spillovers and experience on the sectors of entrepreneurship and the industry. Second, networking events facilitate access to alliances and collaborations that increase a startups absorptive capacity and capture of knowledge spillovers. Third, the exposure to knowledge spillovers at different stages of the startups development would influence the strategic aim of the startup and their further development in local and international markets. Finally, the proximity and location section seek to highlight the importance of the location of startups on survival, and exposure to technological opportunities.

Future research can extend on the evaluation of the knowledge spillover taxonomy proposed. The research required must be extended on the effects that horizontal and vertical knowledge spillovers has on the performance and growth of the company. Further evaluation must clarify the formal and informal interactions that enable the transformation knowledge spillovers into economic growth. For that matter, an initial common definition and establishment on the evaluation of informal flows of knowledge in mediated by the background of the founders of the company. In this case, previous working experience and acquired academic degrees affects the decision of CEOs to engage with universities or companies [61]. For that matter, the evaluation of knowledge spillovers requires to identify the start-ups process that capture knowledge spillovers from external sources of knowledge, and and its further implementation to incremental forms of product innovation.

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