A Knowledge Spillover-based Approach to New Product Conceptualization

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***Abstract*—Entrepreneurship continues to be of the utmost importance in terms of national economic and industrial development. The formation of new companies (start-ups) encourages the creation of employment which in turn boosts economic activity. This growth, however, requires constant innovation within the start-ups. It is recognized that the process of innovation development is affected by a start-up's ability to capture knowledge spillovers which depends upon both external and internal factors. This paper proposes a conceptual model based on knowledge spillovers and their influence on the capture of new knowledge and its transformation into economic knowledge. We introduce and discuss various definitions, debating knowledge spillover theory, to provide a model based on classifications of cognitive and geographical proximity. Further discussion is provided against the product conceptualization process for start-ups.**

Keywords—knowledge spillovers; absorptive capacity; incubators; new product development; product conceptualization.

I. INTRODUCTION

The Knowledge Spillovers Theory of Entrepreneurship (KSTE) identifies how new knowledge is transformed into economic knowledge. It proposes that investment in Research and Development (R&D), performed by incumbent firms and universities, creates entrepreneurial opportunities for start-ups [1]. The theory has been extensively tested through the evaluation of economic growth rates proving that such investment enhances the creation of start-ups in different regions and countries around the world [2]. A key factor of KSTE is that knowledge is created endogenously. The KSTE exposes the geographical location of start-ups and their proximity to sources of knowledge, such as universities, Science and Technology Parks (STP) and incumbent firms [2]. The decision of start-ups to position themselves in certain geographical locations is primarily based on their desire to minimize costs when absorbing knowledge spillover, while taking into account the benefits on offer and whether these outweigh the operational costs of maintaining a presence in a specific location [3]. However, recent KSTE studies, using economic indicators, have not revealed the so-called 'boundary paradox', which suggests how companies working in alliance can collaborate to classify and share knowledge [2] and, instead, reveal that knowledge spillovers are uni-directional from incumbents to smaller organizations. Recent research has also explored what types of knowledge spillovers affect the development of start-ups created from spin-offs [4], and has considered differing approaches to assessing knowledge networks, start-up capabilities and knowledge transfer processes [5]. Research related to the mechanisms entrepreneurs use to transform commercialized knowledge, especially at the initial stages of start-up creation, still remains scarce [2]. The spatial boundary of the entrepreneur from the source of knowledge also needs further exploration [6].

A. *Defining Knowledge Spillovers*

The definition of 'Knowledge Spillovers' differs across disciplines. As knowledge is heterogeneous, it is not exclusive to one entity, with many researchers considering it an intangible commodity. In the case of organizations operating in high technology sectors, one method of tracing knowledge spillovers is through their Initial Public Offerings (IPO), based on the Knowledge Production Function (KPF) [7]. However, the so-called 'black box' of the KPF is aimed at uncovering the relationship between innovative outputs and the sources of knowledge, together with the value that academics and inventors give to commercialized knowledge [7]. The Organization for Economic Cooperation and Development (OECD) use the KSTE to explore economic indicators of R&D investment in the agglomeration of small firms. There is a clear need to assess the effects of knowledge spillovers in reducing the U-shaped relationship between the creation of companies and economic development. It is also necessary to uncover the cause as to why 20-40% of start-ups do not survive past the first two years of creation [8]. Mechanisms and technological opportunities that start-ups could exploit through knowledge spillovers remain unclear [9, 10]. The process has to take into consideration the location of start-ups and how this can enable the absorption of knowledge from sources involved in the innovation of new products [8]. This paper extends this to the geographical proximity of start-ups to sources of knowledge.

B. *Aim*

This research aims to propose a conceptual Knowledge Spillovers Model tailored to the new product conceptualization process of high technology start-ups. Section 2 introduces the proposed model, based on the KSTE and highlights how entrepreneurs may transform new knowledge into economic knowledge while evaluating technological opportunities [10].

The model distinguishes endogenous and exogenous knowledge and their corresponding variables, as well as identifying sources from which knowledge is generated [7]. Next, we explore the transformation of knowledge and the space in which it is realized [11], identifying where and when knowledge spillovers occur and how they are used to create innovative new products [12]. Finally, the possible outcomes in using the proposed model are discussed. This can result in either (1) the survival of the start-up, (2) the displacement of incumbent firms and competition in the market that lead to a process of creative destruction, and/or (3) the creation of knowledge that can be implemented or used by third parties. The proposed model seeks to include these outcomes at its early stages [4] and involves the innovation of products and evaluating its value for incubation processes [12]. The model includes start-up decisions and events, caused by knowledge spillovers, and how these reduce costs. It also considers the background and experiences of the entrepreneurs involved in the start-up and the increase in capabilities of the start-up to absorb and implement newly acquired knowledge. The new product conceptualization process exploits the way in which knowledge is constantly switched between tacit and explicit [11]. This reverberation enables the capture of knowledge spillovers generated closer to start-ups [10, 12], and also information from virtual platforms from sources of knowledge distant to the company developing the product.

II. KNOWLEDGE SPILLOVERS MODEL

The explanatory model illustrated in Figure 1 follows a linear process. First, knowledge spillovers are based on endogenous factors which focus on investment in R&D, causing growth in the economy at a national level for the innovation of ICT and e-commerce [13]. On the other hand, exogenous factors generate information that depend on technological advances and overcome geographical barriers between start-ups and the sources of knowledge [13]. Next, during product conceptualization, clusters of start-ups, STPs *inter alia* facilitate the further exposure to knowledge spillovers that can influence the innovation of products and processes [5, 12]. Finally, high tech start-ups can end up in a process of creative destruction or creative construction [14].

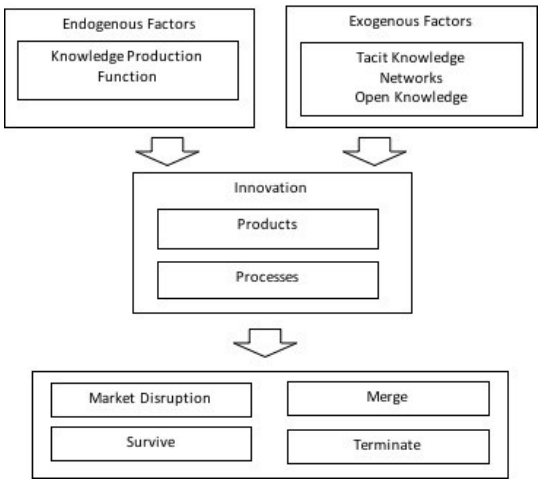

Fig. 1. Knowledge Spillovers Model at the Company Level

The KSTE focuses on the generation of new knowledge developed from R&D and patents spawned from universities and incumbent firms. These indicators are considered as a means to measure innovative output in the KPF [10]. Thus, 90% of investment on R&D improves the characteristics of products and the creation of new patents [15]. R&D can be used to evaluate the number of working hours dedicated to innovation, number of employees, income generated by the sales of products and knowledge that is generated endogenously [9]. The evaluation of knowledge spillovers, at a regional level, depends on a number of factors including (1) where the company is located e.g. near universities and/or incumbent firms, as well as (2) the local market and (3) geographical conditions, such as cultural diversity and unemployment rates [1]. Current research on start-ups in incubation programs focuses on assessing the number of patents produced through collaboration and investment. However, the allocation of monetary recourses on R&D would not be able to generate an economic value if a firm's absorptive capabilities are not effective [15]. To this end, recent literature on STPs have classified knowledge spillovers based on countries, firms and regions; and whether knowledge flows are horizontal or vertical [12]. As such, the evaluation of knowledge spillovers on R&D should take into account this unit of analysis and the potential relationships between Standard Industrial Classifications (SIC) [7].

Previous research on knowledge spillovers at the start-up level has been directed towards networking and the combination of technological knowledge, business models and competition. Mechanisms reported on in KSTE literature, aside from the mobility of workers, volunteers and entrepreneurs on clusters, remains unclear [2]. The effects of knowledge spillovers increases as start-ups become more involved in a common environment, such as STPs or incubators; when this occurs, they interact with other actors in the supply chain [12]. A study conducted in the USA highlighted how Silicon Valley start-ups attract a support network of law and high-tech firms, such as semiconductor companies, as well as venture capitalists, investment banks and consultancy groups [16]. Such close geographical interactions have been considered from both knowledge spillover and strategic entrepreneurship standpoints, where interactions between academia and industry has led to improvements in firm performance and capabilities. Such interactions in network spillovers depend on previous connections that the entrepreneur has established before starting the company and, therefore, has extended its geographical proximity [4]. These collaborations, established from previous professional and personal experiences, are enabled through the creation of clusters or organizations which collaborate and share knowledge towards a common project [17]. For example, a recent study of four clusters in Dubai and Australia highlighted how manufacturing companies boosted these interactions through conferences, meetings and events/ gatherings with incumbents [5].

These types of absorption techniques for valuable tacit knowledge, which drive organizational innovation, are most often realized with little or no cost and are generated from investment in R&D which leads to knowledge spillovers. However, the absorption and transformation of captured tacit

knowledge, to the implementation of technical specifications for products or processes which requires explicit knowledge, depends on employees' education and training [6]. This process can be facilitated when a group of entrepreneurial-minded employees are dedicated to the identification of new sources of knowledge [4]. This transformation of knowledge has been identified as the Dynamic Knowledge Creation Process (DKCP). The transformation of knowledge is cyclical as tacit knowledge is transmitted through communication and socialization, while explicit knowledge is absorbed and implemented through the transformation of concepts to well-established processes. In fact, the transformation of these processes increases with every completed cycle of the knowledge transformation process [11]. Importantly, interactions can occur between individuals and groups in both virtual environments and via face to face interactions [11].

The constant sharing and transformation of this knowledge spillover leads to improved innovation. As companies enhance their business models, human resources and investment in R&D to identify market opportunities, they improve their operations [9]. However, the innovation level depends on the behavior of the company and its ability to absorb knowledge. It is unclear if these interactions are enhanced by knowledge spillovers [9]. A recent study using R&D as an indicator of innovation from the North American Industrial Classification System distinguished the importance of companies to boost incubation processes to increase breakthrough innovations [15]. The same trend has been measured in STPs, where companies are affected by knowledge spillovers depending on the type and source of knowledge; most importantly, the absorption of global innovation transcends from geographical proximity [12]. Knowledge spillovers have also been explored through the evaluation of patents in the high-tech sectors, such as biotechnology, electronics and communications. For example, companies with a longer time in the market create less new products and patents in comparison to new funded start-ups. In response, incumbents transform processes to create or transform products. This modification depends on the transition of employees between production lines, influenced by previous experiences or their exposure to other processes from a different industry, which has to cover the initial structural holes on the organizational processes.

The outcome of small firms can be directed towards a process that disrupts the market of an incumbent or generates knowledge that can be used by other companies. This can involve creative destruction as new companies replace incumbents as the market is limited and shows high levels of competition [10]. However, in industries such as the high-tech manufacturing, the performance level of incumbents and their access to networks and resources to technological innovation reduces the impact of disruptive innovations [18, 19] whereas creative destruction supports new firms with explicit knowledge extracted from R&D within universities and companies, leading to potential alliances and merger opportunities with the incumbents [2, 14].

III. PROPOSED CONCEPTUAL MODEL

The development of a new product by entrepreneurs can be enhanced through the acquisition of knowledge spillovers. We see the capture of information as a linear process, starting from the early development of the start-up and the conceptualization of a new product, as illustrated in Figure 2.

The exchange of knowledge spillover between an individual and company in the supply chain and from the same industry is shown horizontally in the figure, while vertical knowledge spillovers represent the exchange of knowledge from individuals and organizations from a different industry [12]. In the case of entrepreneurial-minded employees or start-up companies, this process can cross geographical barriers by gathering knowledge from open, freely available sources. Vertical knowledge spillovers can be developed through the unintended exchange of knowledge between companies and individuals through networking. On the other hand, product development cycles, in high-tech sectors, deal with codified knowledge from other sources external to the organization. This level of technical knowledge protects information from individuals that do not have the required background to use it. This cycle of product development has proven to include levels of innovation that must be tested as a knowledge spillover.

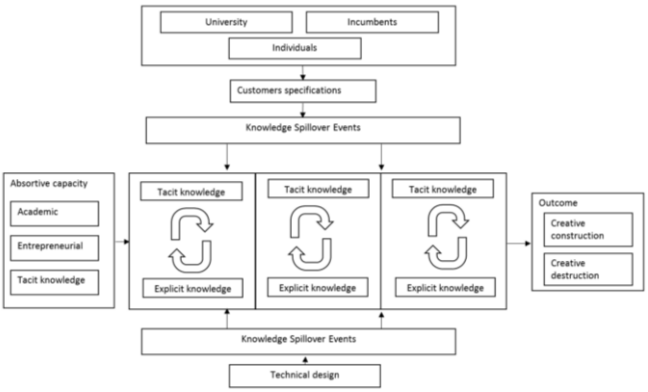

Fig. 2. Product Conceptualization Cycle

The initial stages of the creation and transformation of tacit and explicit knowledge can occur in a physical or virtual environment named as "Ba" [11]. The knowledge absorbed is directed towards product development by maintaining constant communication with end users. This interaction enables the improvement of quality and reduction of interactions [20]. For instance, the transformation from tacit to explicit knowledge can be enabled through Quality Function Development. One such example is the capture of the Voice of the Client by using the House of Quality [20]. The transformation of explicit knowledge is adapted to be absorbed by the technical members of the company and end users [20]. The process reduces the number of failures and negates the reengineering of products.

We must distinguish endogenous and exogenous factors in knowledge spillovers. These flows are shown in our model as horizontal knowledge spillovers travelling from the suppliers, employees and end users of the products and services. The endogenous factors that are bounded by geographical proximity and investment in R&D which involve the KPF and agglomeration theories. Exogenous factors deal with flaws of knowledge that transit on a virtual environment which is related to information generated outside of a company's boundaries and can be accessed regardless of location.

The proposed model considers that knowledge spillovers absorbed in the initial stages of a new company depend on the entrepreneur. That means that the knowledge spillovers go beyond the interaction between incumbents and academia. This flow of knowledge considers the entrepreneurial network of the entrepreneurs and their capacity to recognize knowledge through relevant sources, such as the internet or open innovation [4]. Such perception can be affected by the cultural diversity and interactions of the members of the start-up [1]. For example, the exposure to ideas in different countries and team interactions enables knowledge spillover absorption from those regions and fosters the flow of knowledge between the start-up and external entities or individuals.

After the initial spillover of knowledge, start-ups transform it as an innovation into products, processes and organizational models [12]. These interactions occur following the SECI process and adjust the transformation of knowledge in product specifications. The change of this process links tacit and explicit knowledge with customer expectations and the technical design of the products towards their functionality [20]. By connecting these product life cycles, it reduces the reengineering process and allows the emergence of new designs matching customer expectations [20]. With increasing cycles, the absorptive capacity of entrepreneurs increases following an S shaped learning curve [11]. During this interaction, the company is exposed to number of knowledge spillovers, established as events, which affect innovation and decision-making processes. These critical points in time, where disruptive ideas are generated, depends on the reliability of the entrepreneurial networks, the absorptive capacity capabilities of the company and its R&D skills.

The outputs and decisions of start-ups result in three possible outcomes. First, the company may fall during the process of creative construction. Thus, during the product development conceptualization process, knowledge spillovers generated from entrepreneurs enable incumbents to identify new technological knowledge. This event causes an opportunity, taken by incumbents, to absorb and collaborate with the start-up [2]. Secondly, the new firm falls due to creative destruction. Start-ups must face barriers set by companies. In other words, processes of innovation and prediction of the future by incumbents prevent new firms from entering established markets [18]. In the case of the high-tech sector, the survival of new companies is negatively affected by patents. If start-ups have more than three members, it has a higher chance of survival and may cause the displacement of incumbents. This process follows when the know-how and new technology developed differentiates entrepreneurs from the existing members of a long-established market. Finally, newly created companies may decide to merge with an incumbent, leading to selling all knowledge and intellectual property and ending the organization; this process forms part of creative destruction as the knowledge spillovers created from the organization leads to an arrangement where collaboration and capture of investment for the products is of importance.

IV. KNOWLEDGE SPILLOVER MECHANISMS

The initial conditions that set the absorptive capacity of a new hi-tech start-up depend on the location of the company and its members. The impact of location is determined by features such as the cultural diversity, industrial diversity, density on population, and immigration. At a national level, these variables positively impact the creation of new companies [1]. The exposure to a variety of cultures and industries enables early access to knowledge spillovers from other regions. Also, a high population density leads to the availability of skilled human capital. This movement of individuals from a diverse backgrounds and culture from different organizations acts as the key mechanism of knowledge spillovers. Hence, the fundamental knowledge brought to the start-up comes from academia, incumbents, and / or personal experiences had by the human capital. These type of information flows are vertical knowledge spillovers. The reason for this is that they come in the form of tacit knowledge bounded by spatial proximity from different industries [12]. Thus, knowledge spillovers generated by incumbents and universities are caused by their investment in R&D [1].

During the product development process, the mechanisms for absorbing knowledge spillover depend on the background of the entrepreneurs. A common source of valuable knowledge are Universities, as research-active academics use academic journals as a mechanism to capture explicit knowledge spillovers [3]. This type of content can be considered as an exogenous factor since it is information that can be accessed in many regions of the world. The second mechanism involves the movement of graduates and students from universities to start-ups [3, 6]. However, the effects that graduates create in companies depend on the institutional approach taken by the Higher Education Institution. In this case, universities have to enable systems, social values and a conducive environment that allows the flow of knowledge that boosts entrepreneurship [6]. More highly qualified academics as professionals holding a Ph.D. tend to try to collaborate with start-ups to build a reputation by conducting research and generating publications in academic journals [7].

Knowledge spillovers can also be transmitted from industry. Hi-tech companies can choose to be closer to suppliers and customers, which form a part of horizontal knowledge spillovers. This flow of knowledge can be tacit and explicit and may differ in terminology, as it has to be adapted from the supplier to the customers and the technical members of the team [20]. If the information obtained is related to goods, it is considered a form of rent-knowledge spillovers. These flows of knowledge differ from pure knowledge spillovers, as it is not received directly from human interaction. High-tech companies can follow a different strategy. The top-down approach focuses on the direct communication with the value chain and local government to enable quick paced clearance and tracking of goods [5]. Companies facilitate these processes through independent virtual environments. The mechanisms of knowledge spillovers used with industry are networks that allow access to different types of knowledge and connections through virtual environments powered by the internet.

First, pure knowledge spillovers are enabled through the proximity between organizations and can employ networking events to foster relationships. Agglomeration and proximity allow the exchange of managerial and technical knowledge for the improvement of products and access to additional recourses

such as human capital, locations and investment for product development [4]. The proximity between each one of the companies depends on the type of industry. For example, in the pharmaceutical sector, the process to patent and introduce a new product to market is more extended than electronics; for that matter, the proximity between industries depends on how fast the market changes [16]. Also, companies can decide to be closer to legal institutions to receive additional knowledge to protect and patent new technology. On the other hand, vertical and horizontal knowledge spillovers can be absorbed from organizations outside the value chain. However, to identify these opportunities, the company must invest or recruit human capital that can act as economic agents to identify technological opportunities. These variables combined with knowledge spillover enables businesses to continue innovation during the product conceptualization process [9]. Hence, investment in R&D improves the organizations chances to absorb public technological knowledge that businesses are not able to protect. This placement causes the company to move from direct face-to-face interaction to the use of virtual environments.

This process has been quick to use free knowledge from enterprise 2.0 applications allowing the creation of products at a low-cost with high quality [21]. Examples that can be used to absorb knowledge spillovers within the company and the web include microblogging, social media, file sharing and instant messaging. The focus of these tools is to integrate human capital from different organizations and backgrounds to interact and enable the product conceptualization cycle. In addition, knowledge spillovers obtained from the behavior of the market and the development of products and services from competitors can be used to take the decision on which characteristics can be used to incorporate on the development of products. Finally, the creation of knowledge spillovers from start-ups to the public domain can be exploited to expose information of the start-ups for the purpose to attract investment from incumbents or merge with organizations in the process [8].

V. CONCLUSIONS

This research has focused on adding understanding and applications of knowledge spillovers to the new product conceptualization process. The aim of this research was to distinguish the variables affected by endogenous and exogenous sources of knowledge spillovers. We proposed a conceptual model that identifies the flow of knowledge as a process, where innovation that focuses on product conceptualization is a cyclical process. The proposed interaction follows a SECI process, which is affected by events that are exposed to knowledge spillovers. This point of time triggers the decision making of start-ups to invest in R&D and take a decision on the functionality of the product. These interactions are continuous and affect the absorptive capacity of a firm, due to the background of the entrepreneurs employed in the organization. The potential outcomes of the initial year of the company lead to a process of creative construction or creative destruction. This research has visualized the effects of knowledge spillover and assessed how they may interact during new product conceptualization.

This paper has also identified the mechanisms and types of knowledge spillover that are available during the creation of a hi-tech start-up. Universities provide new companies with access to knowledge spillovers through human capital and academic research. Also, through the development of entrepreneurial networks, industry can absorb knowledge from customers and suppliers more easily. Start-ups can obtain information from competitors and the market from proximity and exploration of new products or by accessing knowledge through virtual environments, such as social media platforms. These events act as inputs to the process of product conceptualization. This approach enables the evaluation of the effects of knowledge spillovers on the characteristics of the products and processes of the start-up, and offers suggestions for the improvement of the absorptive capacity of the start-up during each transition between tacit and explicit knowledge.

This research has shed light on the different types of knowledge spillovers involved in the creation of new products and identified the possibility to expand the understanding of knowledge spillovers in virtual environments. Further research should explore survival, the actions of entrepreneurs during the incubation process and identify the types of knowledge spillovers that affect the process of product conceptualization. This model can be extended to consider the background and interactions that exist during the incubation process. Although this model started with a focus on hi-tech firms, it can be adapted towards the identification of knowledge spillovers in other industries. This can be extended to evaluate the constant effects of innovation of products and processes. Finally, research should be conducted to include entrepreneurs who maintain continuity of family businesses without relying on constant innovation.

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