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Doctoral Dissertation

Sources of innovation in firms from an emerging
economy: The case of Mexico

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Abstract

Historically, the research on innovation has evolved in the context of advanced economies and high-tech environments. This work represents an investigative exercise following the works of those scholars who have put their attention to this rather young research field, looking to throw some light into the innovation phenomenon in emerging economies. The dissertation has the objective to unravelling some of the nuances in the innovation management field in emerging economies. Accordingly, this work is structured in three interconnected analysis that start from a general study of innovation strategies at firm-level and narrows down to specific aspects of these strategies in a sample of Mexican firms.

The first part of this work explores the literature on the modes of innovation to determine the types of strategies utilised by firms in order to attain innovation and, subsequently analysing which is more effective. The analysis covers 9 628 Mexican firms with 10 or more employees. The results of the logit regressions suggest that a combined STI and DUI innovation approach yields better results in terms of product innovation. Also, these results point out that the weight of DUI mode of innovation is larger on product innovation than the STI mode. This is opposed to what was expected regarding the utilisation of the modes of innovation in emerging economies. Finally, the combination of STI and DUI modes are limited only to product innovation. The DUI mode has a greater impact on process innovation than STI mode as well as the combination of STI and DUI.

The second part of this dissertation empirically analyses the importance of external interactions over innovation results, first, in terms of the R&D content of the interactions (R&D-related and non-R&D-related), and second, in terms of the geographical scope (regional and global). The results aim to provide a more nuanced picture of the type of interactions pursued by the domestic SMEs in an emerging economy context. The analysis uses a sample of 2 834 domestic SMEs in Mexico with 10 or more employees during the period of 2010 to 2013. The results point out that domestic SMEs in Mexico seem to effectively innovate through non-R&D interactions, but not so using interactions based on R&D. On the other hand, the findings suggest that domestic SMEs find relevant knowledge that satisfy their requirements within regional boundaries, at least if this is compared with those accessing only global knowledge. However, firms that establish both global and regional interactions simultaneously have a greater innovation capacity than those who only rely on regional interactions.

Lastly, inspired by the previous two parts of this dissertation, the third part examines, in the context of an emerging economy, the role of Technology-based Knowledge Intensive Business Services as potential suppliers of crucial knowledge for innovation in manufacturing firms in low technology sectors and the impact on their innovation outputs. The analysis is based on sample of 2 735 manufacturing firms with 10 or more employees from the period of 2010 to 2013. The results show that product innovation in low-tech and medium-low-tech manufacturing firms is influenced positively by T-KIBS to different extents. However, this effect seems to decline after two years, suggesting that, although the potential for innovation in low-tech and medium-low-tech manufacturing firms can be enhanced by acquiring T-KIBS, this seems to be a rather short-term strategy.

Chapter 1. Introduction

Historically, the research on innovation has evolved in the context of advanced economies and high-tech environments. For the most part, it has been developed under the premise that science and advanced technology are the most important, and sometimes, the only underlying factors behind innovation dynamics. This research has contributed to the general notion that only through major increases of R&D, economic growth and prosperity are ensured. Consequently, innovation policy has, in large part, established strong science and technology instruments concerning mostly to highly technologically oriented environments. Over the years this has generated notorious criticism amongst scholars. The arguments reflect on the overemphasis in innovation studies of R&D and advanced technologies as drivers of innovation and determinants of the rates of economic growth (Godin, 2006; Kline & Rosenberg, 1986; Love & Roper, 1999; Lundvall, 1992), while at same time the field overlooks the reality in other less-advanced economies and low technology environments (Hirsch-Kreinsen, 2008, 2015). As a result, the innovation paradigm has been broadened towards the recognition and analysis of other types of innovation, moving from the pure technological profile and the generation of breakthrough knowledge to the more complex social components, learning processes, and slow-paced incremental changes that also foster innovation (OECD, 2005). This opened the door for researchers to analyse innovation phenomenon in other contexts rather unexplored in mainstream innovation studies.

In that line of thought, developing countries were quickly picked up to explore the fundamentals of innovation in places not particularly characterised for high innovation rates. The fact that most innovation models are R&D-centred with deterministic tendencies, showing the one best way to innovate (Hobday, 2005),

represented a challenge to portray innovation processes outside R&D structures, taking place through informal processes of trial-and-error experimentation, built around the adoption of technologies developed elsewhere in a variety of industrial sectors, and aiming not to introduce radically new products and processes, but to upgrade and build capabilities to catch-up with competition. This has encouraged a number of scholars to find answers to how innovation processes occur, their purpose, and their orientation in emerging economies utilising a variety of approaches such as innovation systems (Arocena & Sutz, 2000; Lundvall et al., 2009; Szogs et al., 2011), entrepreneurship (Szirmai et al., 2011b), global value chains (Morrison et al., 2008; Pietrobelli & Rabellotti, 2011), technological change (Kim, 1980; Kim & Nelson, 2000), knowledge spill-overs (Fu et al., 2011), and interactive learning (Chaminade & Vang, 2008), amongst others.

This work represents an investigative exercise following the works of those scholars who have put their attention to this rather young research field, looking to throw some light into the innovation phenomenon in emerging economies. This dissertation departs from the recent literature on the modes of innovation proposed by Jensen et al. (2007). which helps to outline the innovation management strategies in firms from an emerging economy, and later builds upon the findings towards an exploratory effort to provide more evidence about the intricacies of firm-level innovation strategy in emerging economies. For this purpose, the Mexican context is analysed because its economic reality and competitive trajectory are that of an economy based in traditional industries with little added-value; the predominance of more traditional ways to innovate such as the adoption of foreign technology; the lack of sophisticated market for radical innovations; and a low investment in higher education and R&D activities.

1.1. Innovation in emerging economies

Relatively recently the innovation process in developing economies has been subject of increasing interest (Kuhlmann & Ordóñez-Matamoros, 2017; Lundvall et al., 2009; Szirmai et al., 2011a). Traditionally, innovation strategies have been understood as processes that push forward the technological frontier, directly enhancing the competitiveness of firms and territories. But innovation in the context of emerging economies is fundamentally different. Innovation is envisioned as a mechanism to upgrade and build capabilities (Szogs et al., 2011); increasing productivity and efficiency in firms (Voeten, 2017); seeking economic growth and closing the gap between developed economies and developing ones.

Despite of the heterogeneity of emerging economies, they share some characteristics such as fast economic growth, recent implementation of economic liberalisation policies, a growing population, relatively strong internal consumption, on-going industrialisation, and commodity- and export-oriented industries (Hoskisson et al., 2000; Persaud, 2001; Sheth, 2011). In the last decade, the importance of the economic output of emerging economies has grown, this has been fuelled by market deregulation; therefore, allowing privatization of companies and entrance of foreign direct investment (FDI). Multinational corporations (MNCs) took advantage of the cheap labour and helped to build export-oriented manufacturing industries. However, several issues were unattended given the limited interest to develop complementary industries supporting the existing key sectors. For instance, this situation typically affects the diversity of the industrial base, contributes to the production of simple consumer goods, and promotes a strong dependence of imported manufacturing goods (Szogs et al., 2011).

Some determinants of innovation such as the size of a firm, market conditions, organisational culture, and levels of education of the labour force, could rather act as hurdles for firms seeking innovation. For example, poor levels of higher education in a large percentage of human capital can act, at least in part, as a deterrent for the establishment of knowledge-intensive industries; and consequently, hampering the efforts to develop conditions where innovations can thrive.

Most of the economic growth in developing countries tends to be factor-driven, or efficiency-driven in some cases, rather than innovation-driven (Voeten, 2017). Factor-driven economies are at the first stage of economic development. They compete mostly through factor endowments related to cheap labour and exploitation of natural resources. Thus, economic growth tend to be determined by commodity prices in international markets. This type of growth undermines the creation of economic value from domestic innovations because as these economies struggle to create knowledge, they also lack a sophisticated internal market ready to use technologically complex goods and services. It is estimated that innovation in factor-driven and efficiency-driven economies represent about 5% to 10% of the economic activity whereas in innovation-driven economies it contributes to 30% (Ács & Szerb, 2009).

It is said that the transition from factor-driven to innovation-driven growth is ‘the key challenge for middle-income countries’ (Paus, 2014, p. 9). However, many emerging economies get caught in a period of growth slowdown that can lead to stagnation. Scholars refer to this as the middle-income trap. According to Paus (2014), countries in this situation face two main issues. First, they are no longer able to compete in terms of low wages, especially in labour-intensive commodity markets. Second, they cannot compete with developed economies in producing technology-intensive products because they have not effectively developed the necessary technological capabilities.

This is recognised to be a result of the inability of countries to undertake structural changes that allow them to transition towards more knowledge-intensive economic activities.

In developing countries, companies normally stand far behind the technological frontier where barriers for the competition are less costly (Acemoglu et al., 2006); thus, undermining the development of competitive advantage based on R&D capabilities. They typically refrain from engaging R&D projects because creating new knowledge is an expensive and risky process. Hurdles such as high fixed costs, the required high minimum investment in R&D projects, and uncertainty and heterogeneity of the outcomes can jeopardise the financial stability of firms and compromise their survival, especially in the case of SMEs (Rammer et al., 2009). Instead, firms are inclined to adopt technologies developed somewhere else which, on the positive side, might lead to an incremental type of innovations (OECD, 2005) but, from a negative perspective, could produce innovations lacking relevant novelty (Chaminade & De Fuentes, 2015). Feria and Hidalgo (2011) argue that this strategy might not be good in the long run because the dependency on foreign technology without the proper support of domestic scientific capabilities might render organisations unable to develop technologies on their own. In addition, innovation systems are fragmented and weak. Universities, research centres, and other knowledge brokers do not have a crucial role in the innovation system, in part, because of the scarce interactions between organisations (Szogs et al., 2011). Finally, innovation is typically not institutionalised, meaning that regulatory mechanisms are inadequate and institutions in charge of organising public efforts that encourage firms to collaborate are often absent or poorly managed.

All in all, the competitive advantage of many emerging economies, built on low labour costs and the availability of natural resources, is rapidly losing strength as

markets shift towards the use of more advanced technologies (Souza, 2017). These economies must engage in creating mechanisms to ensure a successful transition to a knowledge-based competitiveness, fostering technological change and economic activities with high added-value; otherwise, they would be setting a trajectory to economic stagnation. However, the current trends reflect that emerging countries have a difficult time upgrading their technological and innovation capabilities, relegating them behind the rapidly changing technological frontier.

1.1.1. Mexico: An emerging economy context

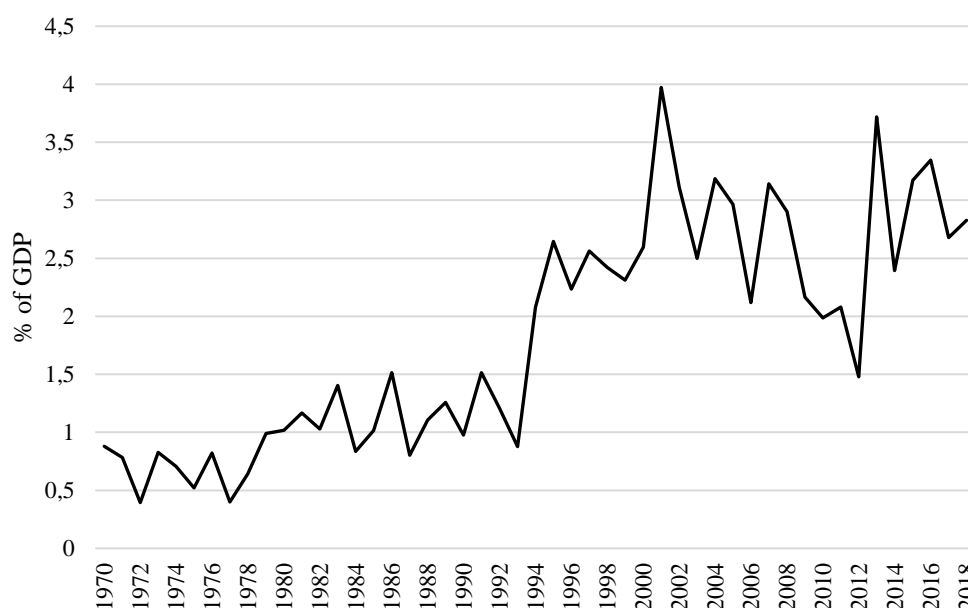
Over the last 20 years Mexico has built a solid macroeconomic structure with low inflation rates and an open economy for international trade. These conditions have attracted a stable inflow of foreign direct investment (FDI), which has gradually increased the aggregated value of the production in the country. Currently, the Mexican economy is the 15th largest in terms of GDP as for 2018¹. The fact that the Mexican economy is between the largest can be somewhat related to the economic impact of dominant traditional industries (e.g. oil and mining). As is the case of the Mexican economy, certain factors could bring sudden economic growth, for instance, an increase in commodity prices or an increment in the volume of foreign remittances. However, growth based on those drivers, runs the risk of stagnation if not reinforced through the development of technological capabilities allowing a holistic upgrading (Paus, 2012).

During the 1980s, Mexico started a process of economic restructuring. At that point, the import substitution industrialisation model was proving incapable to drive

¹ However, in terms of GDP per capita Mexico is in the 71st position out of 195 countries listed, well below the first 20 economies and reporting 9 807.44 USD in current prices (IMF, 2019).

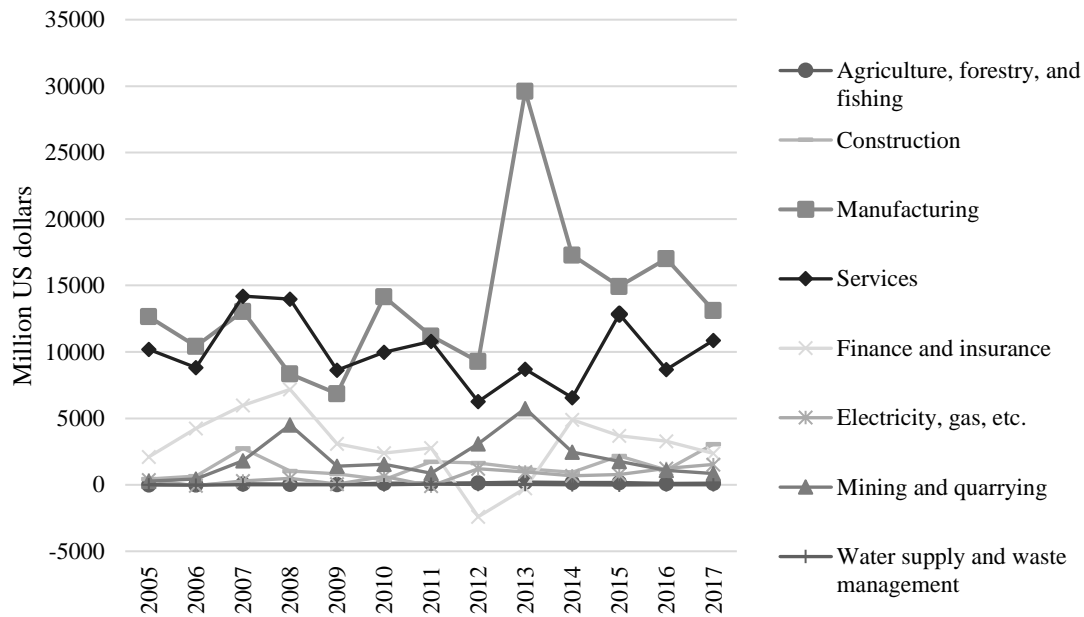
sustainable economic growth. The coddling of the internal market from external competition was causing several drawbacks such as a general underinvestment in technology, productivity stagnation, and overreliance on commodity prices (i.e. agricultural products and oil). In response, various mechanisms were set in place promoting the production of manufactured goods and services to diversify the economy. One of the most significant measures came in early 1994 when the country signed the North American Free Trade Agreement (NAFTA) with Canada and the United States. The NAFTA opened the market to international trade and foreign investors, which had an immediate impact in the Mexican economy. One year into the trade deal, in 1995, inward FDI flows increased significantly, leaping from 0.87% of the GDP to 2.64%, reaching a peak of 3.91% in 2001 (Figure 1). As shown in Figure 2, the manufacturing sector became the main recipient of the FDI inflow, followed by the service sector. This reflected the position of the country as an attractive destination to establish manufacturing facilities (i.e. maquiladoras).

Figure 1. Foreign direct investment as a percentage of the GDP in Mexico



Source: Own elaboration with data from the World Bank (2019).

Figure 2. Inward foreign direct investment flows by industry in Mexico



Source: Own elaboration with data from the OECD (2019).

As the national productive systems gradually integrated into the global value chains, it was expected that market forces would prompt a process of technological accumulation within domestic companies. In that way, the Mexican firm base would increase its technological capabilities and, consequently, their innovative capacity. This would also require the upgrading of educational programmes within technical schools and universities to supply the thriving new industrial economic activities with skilled labour force.

However, neither businesses nor policy frameworks were prepared for a fast process of technological catching up needed to effectively sustain economic growth. In the mid-1990s, the Mexican government defined strategies to foster innovation and knowledge as engines for economic performance. However, these policies failed to improve the conditions for the economy to take advantage of the technological spillovers generated by foreign firms entering the national market. According to Feria

and Hidalgo (2008), the policies did not provide incentives to strengthen cooperation between research institutions and firms; both public and private investment in R&D remained low; and the internal demand for technological developments was not sufficient to promote the establishment of advanced industries.

The attraction of FDI is essential in developing countries to establish flows of capital and intangible assets that stimulate technological spillovers to local firms (Vera-Cruz & Dutrénit, 2005). However, often spillovers are unintended as firms, mostly multinational corporations, are not likely to share their knowledge freely. Some authors remark (Arias & Wen, 2015) that foreign investors are more inclined towards short-term gains rather than a long-term industrial development of host countries. In that sense, science and technology policies are built around trade agreements with the objective to foster readiness amongst local firms to rapidly adopt new technologies and cope with the quality standards required by foreign markets. In that line, NAFTA's efforts to create flows of knowledge as well as to reinforce the process of technological change fell short. Scholars (Feria & Hidalgo, 2008; Lederman et al., 2005) agree that this was caused by the economic, cultural, and institutional asymmetries between Mexico and its northern neighbours. In large part, Mexican firms focused on adapting their production infrastructure to comply with the international trade standards that NAFTA required and, also, they needed to cope with the increasing demand of manufactured goods. However, they did not put much interest in advancing in the developing scientific and technological capabilities to support competition in foreign markets. As a result, firms specialised in low-skilled, labour-intensive, and assembly-based production (i.e. maquiladoras).

It is argued that Mexico has failed to climb the income ladder because of a combination of several issues (Arias & Wen, 2015): weak political and economic

institutions, a lack of strategic industrial policies supporting technological progress in key productive sectors, and an inadequate investment to promote higher education amongst the population. This is in line with the literature (Lee & Kim, 2009) suggesting that technological development and human capital are the main binding constraints to sustain economic growth in upper-middle-income countries.

Also, these factors directly affect the innovation performance in Mexico, which is characterised by a generalised underinvestment in R&D, limited interorganisational interactivity, especially, collaboration with knowledge agents (e.g. universities and research centres), and a lack of adequate competencies amongst the labour force. In terms of investment, most of the expenditure in R&D originates from public-funded initiatives (Rullán & Casanova, 2015). The latest data points out that the gross domestic expenditure on R&D (GERD) in 2018 was about 0.5% of the GDP (OECD, 2018a). From that figure, almost 70% comes from government funding, while business's share is around 20% (UNESCO, 2019). That distribution in the GERD is not ideal for the Mexican context. On the one hand, most of the public R&D effort fails to reach the market because of the missing links with the private sector and the lack of entrepreneurial orientation of research centres and universities (Corona et al., 2014). On the other hand, Mexican firms are averse to invest in R&D because of the prevalence of short-term vision, typically emphasising mass production and imported technologies; consequently, neglecting the development of local innovation capabilities (De Fuentes & Dutrénit, 2012; Santiago et al., 2017; Solleiro & Castañón, 2005). Similarly, Mexico's pool of talent is limited. The ratio of researchers in the workforce is 0.82 per thousand employees (OECD, 2018c). This is one of the lowest ratios amongst other OECD members. Also, only 22.6% of people between 25 and 34 years-old completed tertiary education, this is significantly below the 44.5% OECD's average (OECD,

2018b). In sum, the reduced interaction between organisations and knowledge actors, the weak research-oriented infrastructure and networks, the general risk-averse behaviour in firms, the lack of entrepreneurial skills, and the limited base of qualified human resources are constantly raising significant barriers to innovation in the Mexican innovation system.

1.2. Brief overview on the evolution of innovation models

In modern economies, innovation is a fundamental phenomenon that largely contributes to the long-term competitiveness of national economies, from a macrolevel perspective, and firms, from a microlevel viewpoint. Companies are, more than ever, required to engage in innovation activities if they expect to stay competitive in the current fast-changing markets. The innovation phenomenon is everywhere in the economy; it is possible to find it as different processes of learning, searching, and exploring (Lundvall, 2016). These processes can be performed under different rates depending on the type of economic activity and the particularities of a firm. In that sense, Lundvall (2016) argues that innovation does not embody single extraordinary events but it rather present itself as a gradual and cumulative process. This implies that, just as knowledge builds upon knowledge, innovation builds upon innovation. In other words, there is an interplay between prior knowledge and the new combinations and uses of this knowledge that results in new processes, new products, new ways of organisation, and even new markets (Schumpeter, 1934, 1939). In addition, innovation implies generating economic value from new developments, in other words, successfully introducing new products and services to the market. All in all, these characteristics emphasise the multistage nature of the innovation phenomenon, defining it as a process.

Although innovation studies emerged in the 1950s, the embryonic idea existed since long before. Around a couple of centuries ago, in 1776, Adam Smith's *Wealth of*

Nations manuscript linked the inventiveness of the people working in production processes and the technological advances in machinery at the time; accordingly, innovation was a result of direct observation and experimentation (Soete, 2010). Later, in the 1840s, Friedrich List (1841) conveyed the notion of the intellectual or mental capital of a nation as the accumulation of discoveries, inventions, and improvements made by past generations. This idea established that the productive system of a country will be as good as its ability to use and further develop its repository of knowledge built along the years. But it was until the 1930s, when theorists such as Schumpeter (1934) pushed forward the idea of innovation as a source of economic growth, that the interest from public and private agents to better understand this relationship ignited (Fagerberg et al., 2013). During the post-war, researchers of the likes of Kenneth Arrow, Richard Nelson, Sidney Winter, and Christopher Freeman benefitted from this growing public attention and, supported by government initiatives, set to undertake a long and fruitful endeavour into the intricacies of the innovation phenomenon.

Many scholars have contributed to the literature aiming to explain the innovation process using models in order to reach a greater understanding of the phenomenon. Over the years these models have evolved giving way to new generations of thought, each working as the foundation of the next; nevertheless, this does not mean that models were substitutive of each other. They coexisted at various points, sometimes mixed, borrowing important elements from other models (Hobday, 2005). The next subsections present a brief overview on the most important developments in the innovation theory. Several conceptual models developed by scholars are described with the purpose to better understand the innovation phenomenon and to position this dissertation in the field of innovation management studies.

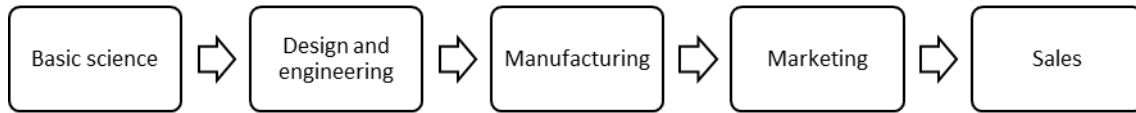
1.2.1. The linear models

One of the first approaches to understand the innovation phenomenon, the so-called ‘linear model’, was clearly influenced by a mechanistic 1950s post-war thinking of technological development in the US (Godin, 2006). The fierce scientific and technological competition between nations, caused by the need to gain warfare advantage over the others, left companies, especially those at the forefront, with a great deal of opportunities to shift the military purpose of their technologies towards the civilian use. As a result, new industries emerged (e.g., semiconductors, pharmaceuticals, and electronics) while old industries revitalised (e.g., textile, steel, and agriculture) with the incorporation of technological developments that augmented the productivity and quality of products (Rothwell, 1994).

At that point, science and technology were perceived as the solution to many of the problems faced by society (Godin, 2006; Rothwell, 1994). Consequently, innovation was mostly seen as new scientific discoveries, patents, and completely new technologies. This led to an increase in government’s financial aid to fund scientific research activities in universities and public research laboratories. At the firm level, companies started to invest in R&D in order to introduce new products in a market eager to consume them. In this point of view, innovation was a supply-side industrial effort, a result of applied scientific knowledge in the form of in-house R&D. As shown in Figure 3, innovation was conceived as a ‘technology-push’ linear process (Edquist, 2014; Kline, 1985; Rothwell, 1986). The scientific discoveries at laboratories were prompted into stages of prototyping, production trials, and marketing, to ultimately be introduced to the market as final products. This idea was particularly appealing for policymakers during this period because it is sound and simple, however, that same simplicity largely ignored the nuances in the innovation process itself. This perspective

also dismissed other determinant factors regarding the market needs and demands; the market acted only as a receptacle of innovation.

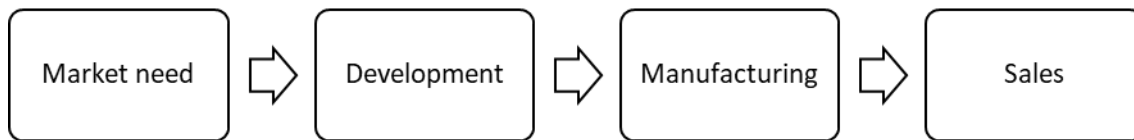
Figure 3. Technology-push model



Source: Rothwell (1986).

During the 1960s, it became evident that innovation was not purely an internal exercise of R&D muscle. Several relevant empirical studies pointed out that most successful innovations resulted as a response to a specific market demand or need (Utterback, 1974; Voss, 1984). Thus, the marketplace was increasingly becoming a source of inputs for innovation and, with that, another conception of the innovation process came along. In this demand-side perspective, also called the ‘market-pull’ model as shown in Figure 4, R&D efforts were repurposed as a response mechanism to clear and articulated market needs (Rothwell, 1986). The main drawback of this model was the over emphasis of the market as the only source for innovation ideas. If ideas are freely available in the marketplace, companies could diminish their R&D capabilities because these are considerably more expensive, but at the expense of losing radicalness and making innovations more incremental in nature (Haynes & Abernathy, 1980). Another point raised by Rothwell (1994) was that without well-developed R&D capabilities, firms would eventually fail to adapt to radical technological advances or significant changes in the market.

Figure 4. Market-pull model



Source: Rothwell (1986).

The linear models became widely adopted by firms and policymakers because it offered a simple and straightforward explanation of the innovation phenomenon. In this case, if there is an increase in the inputs (knowledge, financial aid, etc.) there will be an increase in the innovative outputs (Rodríguez-Pose & Crescenzi, 2008). Nevertheless, this vision was heavily criticised because it was short-sighted, placing emphasis only on inputs and outputs, either with a fully R&D-oriented strategy or a market-based one, and overlooking the innovation process itself. Some scholars (Kline, 1985; Kline & Rosenberg, 1986) argued that in these models there is no consideration for feedback loops, which are extremely important in every step of any process. Innovation does not happen successfully without feedbacks coming from inside (e.g., information from trials and failures), and outside the firm (e.g., from users).

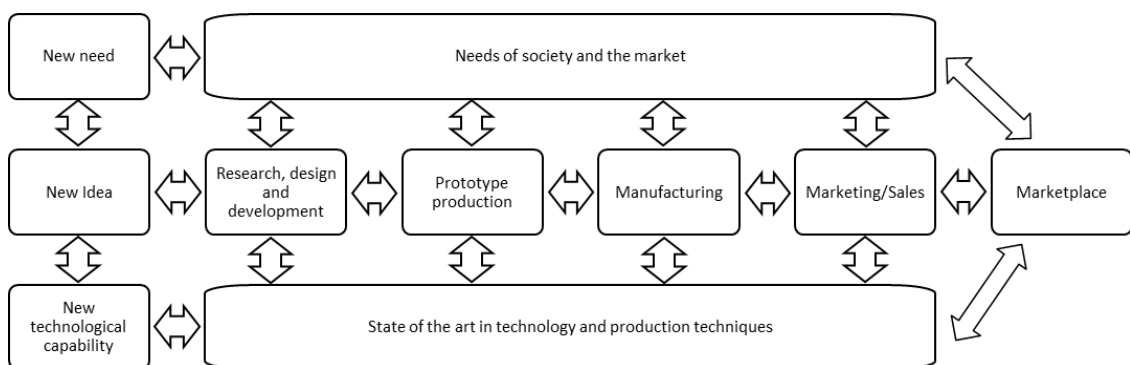
1.2.2. Interactive models

During the 1970s, global economic constraints provoked companies to exert more control on their costs of production, focusing on the efficiency of their processes. This period was important for innovation studies because there was a more critical view on the economic impact of failed projects (Rothwell, 1994). More research was carried trying to theorise and model more successful paths to attain innovation and, as a result, several new models emerged trying to incorporate new evidence of the importance of feedbacks, interactions, and learning processes both inside and outside the firm (Kline

& Rosenberg, 1986; Lundvall, 1985; Lundvall & Johnson, 1994; Rothwell & Zegveld, 1985), bringing a more systemic view of the innovation process (Chesbrough, 2003; Freeman, 1987; Lundvall, 1992).

First, the “coupling model” (Figure 5), proposed by Rothwell and Zegveld (1985), elaborated considerably in the complexities of innovation process. At this point it was clear that both pure R&D or market needs approach were not delivering effectively. Thus, the model presented a more balanced approach between technical capabilities and the marketplace as sources of innovation ideas. It was also emphasised that throughout the whole process of innovation, the firm should remain connected to these sources as they will provide essential feedbacks on the specific requirements for the final product. The innovation process was described as broadly interactive and interconnected, both intra- and inter-firm interactions and feedback networks were exalted. The process was still conceived as a series of sequential and well-defined steps, but it was no longer unidirectional; it acknowledged that there is a back and forth between different stages.

Figure 5. The coupling model



Source: Rothwell and Zegveld (1985).

On the other hand, Kline (1985) conceived the “chain-linked model”, which challenged the several conventionalities in the innovation process. The model, as shown

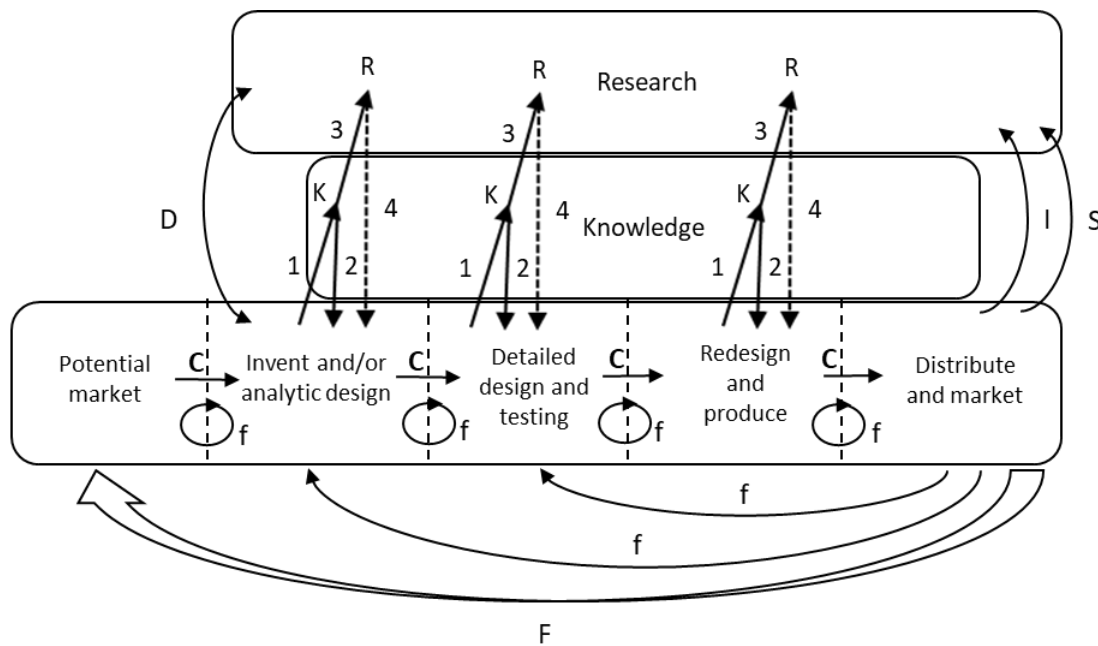
in Figure 6, presented five different paths to innovation, clearly against the rigid and unidirectional vision of the linear models. First, the central chain of innovation initiates at a design stage, often as a response to a market need, for instance, an improvement or a new use of a given product, then moves to the development (i.e. detailed design and test) and production stages, to finally arrive to the market. The second path builds on the feedback linkages (i.e., F and f) within the main chain. These represent knowledge circulating between each stage in the chain and the iterations of a given project. Also, the linkages shown beneath the central chain correspond to major feedbacks from the direct use of a given product, connecting to any prior step in the chain and generating improvements in design and performance.

Kline (1985) argues that research does not create a new product by itself, it rather serves as an stimulus of invention or analytic design. Also, many problems encountered during processes of design and redesign give rise to new research lines, for example, research on new materials for semiconductors and solar panels. Before a firm reaches out for research to solve technical problems, it would use the knowledge already available within the organisation. Both the accumulated knowledge (known science) and the research (new science) comprehend the scientific elements in the model, and these are not restricted to the initial steps of the process, but instead run alongside the other stages to be utilised whenever it comes handy. These feedbacks linking R&D with development processes and marketing are the third path.

The linkages described in the third path do not exclude the possibility of a direct connection between research and the chain of innovation. The fourth path explains that, although rare, direct connections can help in the creation of radical innovations if the new science can be embodied in a specific product by means of invention. In addition, market needs also provide opportunities for research, hence this is a mutually informing

link. Finally, the fifth path describes the connections between market factors, needs, and technology to research (i.e., I and S). Instruments, tools, and processes, many of which are the result of an innovation process, often enable new ways to do research. In that sense, science and technology assist each other, aided by the advances in science and sociotechnical systems established by such technologies (Kline, 1985).

Figure 6. The chain-linked model



Notes: i) C: central chain of innovation. ii) f: feedback loops. iii) F: particularly important feedback. iv) K – R: links through knowledge to research and return paths. If the problem is solved at node K, the link 3 to R is not activated. The return from research (link 4) is problematic, hence the dashed line. v) D: direct link to and from research from problems in invention and design. vi) I: support of scientific research by instruments, machines, tools, and procedures of technology. vii) S: support of research in sciences underlying product area to gain information directly and by monitoring outside work. The information obtained may apply anywhere along the chain. Source: Kline and Rosenberg (1986).

Notoriously, the chain-linked model took away the focus on research (R&D) and pushed the design processes as the initiating steps of technical innovations (Kline &

Rosenberg, 1986). Also, the model remarks that, contrary to the linear model, innovation can be produced even when there is no research involved. Many of the stages presented in the model are conducted with the knowledge already available within the organisation, or with knowledge that can be accessed relatively easily. This is not only science, but mostly knowledge about technologies, market structures, and organisational workings. In sum, the main contribution of the chain-linked model is that of a system in which research, technology, knowledge, production, and the marketplace interact at any moment, mutually reinforcing the innovation in firms (Kline & Rosenberg, 1986).

1.2.3. Systemic models

Aligned with the views previously discussed, scholars began to conceive innovation in a more systemic fashion (Freeman, 1987; Lundvall, 1992; Nelson, 1992). Also, the definition of what an innovation actually involves was enlarged, including those technological advances that were not necessarily new to the world but new to a domestic market, or at least new to the firm itself (Kline & Rosenberg, 1986; Nelson, 1992). The understanding that innovation required interactions, where different types of knowledge are exchanged both inside and outside the firm, suggested that it is not a process that happens in isolation, hermetically sealed within the walls of R&D departments. Innovation is a social phenomenon; it depends in large part on linkages with a different set of agents and is determined by institutions and social rules that allow learning, accumulation of knowledge, and technical progress. Naturally, those knowledge linkages extend in a delimited territory; thus, the concept of National Innovation Systems (NIS) emerged to broadly define these networks of interaction between organisations. Freeman (1987, p. 1) described the NIS as ‘the network of

institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies'. In the same line, Lundvall (1992, p. 2) characterise it as 'systems constituted by elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge'. Finally, Nelson (1992, p. 349) defined it as 'a set of institutions whose interactions determine the innovative performance... of national firms'. All in all, the different definitions share a common ground in terms of the presence of different elements (institutions and organisations) that interact to generate innovation.

Nowadays, the NIS has become a widely accepted framework to understand innovation and address the design of comprehensive innovation policy. Three pillars make up the foundations of this concept (OECD, 1997). Firstly, the economic value of knowledge and the establishment of knowledge flows. The advent of new economic paradigms such as the knowledge-based economy and the learning economy (Lundvall & Johnson, 1994), strengthened the importance of knowledge as a driver of economic growth and its central role in the NIS. In this line, the investments in the production of knowledge, including scientific knowledge (R&D) and technology, as well as investments in education and training, because knowledge is embedded in people, and the channels in which knowledge is exchanged between industries, government, and academia (Leydesdorff & Etzkowitz, 1998) become major factors to ensure the availability of knowledge in the NIS.

Nonaka (1994) provided a dynamic model to manage the knowledge creation process depending on the nature of knowledge, whether in tacit form (ingrained in the minds of people, mostly transferable by mouth to mouth communication and observation and, thus, dependent on idiosyncrasies) or explicit form (in written language, otherwise called codified, easily transferable but dependent on the

understanding of the final user regarding the language it is encrypted), and conveyed the main notion that the continuous interaction of both tacit and explicit knowledge is crucial for the conception of new ideas. Also, based on the degree in which knowledge is in tacit or explicit form, Lundvall and Johnson (1994) offered a taxonomy of four different types of knowledge, explaining the economic value of knowledge and how it is learned. Accordingly, i) know-what is knowledge regarding scientific principles and laws, the underlying reason to understand why things work the way they do (Aslesen et al., 2012); ii) know-why describes evidence and scientific facts; iii) know-who refers to the awareness of key agents that possess the know-what; and finally, iv) know-how is about skills, in other words, the knowledge needed in order to make things work. The first two types (i.e., know-what and know-why) are theoretical and easily codifiable into patents, scientific articles, and data bases allowing access and reproduction, in many cases after monetary transactions (e.g., property rights, licenses, etc.). In the same way learning is summarised in reading the written information but it is bounded by the understanding of the code, this is in both language and science domain. The other two are more practical and difficult to be translated into codes; most of it remain tacit. Although some parts are patentable and written in the form of manuals and handbooks, most of it comes through informal interactions. Learning these types of knowledge turns difficult as well, accessing them depends on the relationships and levels of trust established between people, which are not included in the monetary transactions (Arrow, 1970). Also, knowledge can be meaningless without awareness of the original settings in which it was produced, in other words, the social context.

Secondly, the systemic approach as opposite to the linear models. As discussed in the interactive models, innovation is not linear, but rather every stage is connected through feedback loops, reflecting that ideas come from multiple sources both internal

and external to the firm (OECD, 1997). Accordingly, external sources become extremely important to gain access to new knowledge that is not available within the organisation. For that purpose, firms might establish networks of cooperation (Chesbrough, 2003) with research centres, universities, suppliers, customers, and even competitors at local and global stages.

Thirdly, the institutional setup and the actors involved in the process of knowledge diffusion. The profile and knowledge orientation of a NIS is, in large part, determined by the institutional structure of a country (i.e., education system, market regulations, intellectual property rights, government funding) and the prominence of different actors (i.e., higher education institutions, business base, and government) involved in the production of knowledge (OECD, 1997). These factors will also affect the knowledge diffusion, encouraging different types of linkages, some more than others, such as intrafirm and firm-university collaboration, but also diffusion through technology adoption and human capital mobility. However, as the economic activities become more knowledge-intensive, these will require more sophisticated knowledge to maintain their competitiveness. This should encourage knowledge agents such as universities, public, and private research centres to gain importance within the NIS; however, other organisations providing specialised knowledge in specific areas might also turn relevant. In sum, the NIS stresses the presence of knowledge embedded in technology and in people, and the availability of knowledge flows between the actors involved in the production and use of knowledge in the system.

1.3. Research problem and conceptual framework

The academic interest to study rapid economic growth in certain regions in the world that took advantage of new opportunities brought by globalisation and other processes

related to technological accumulation and specialisation (i.e. South Korea, Hong Kong, Taiwan, amongst others), calls also for more studies in those regions that have not been able to upgrade their economies at the same rate, even if at some point they were in similar conditions. The undeniable role of innovation as one of the engines of sustainable growth also requires exploring the innovation capabilities in firms in these regions, often referred as emerging economies.

The present work has the objective to unravelling some of the nuances in the innovation management field in emerging economies. Accordingly, this work is structured in three interconnected analysis that start from a general study of innovation strategies at firm-level and narrows down to specific aspects of these strategies.

1.3.1. Part I²: The modes of innovation in an emerging economy

For a long time, managers and policymakers have favoured a kind of “one-size-fits-all” view of innovation, mostly based on the linear models, promoting the development of formal processes of R&D, technologies, and academic training, all aimed at creating codified knowledge, which reflected mostly the case of high tech industries (Fitjar & Rodríguez-Pose, 2013; Jensen et al., 2007). This led to a growing academic debate, with scholars (Cooke, 2001; Iammarino, 2005; Lundvall, 1992) arguing against this narrow vision that dismisses the importance of institutions, interactions, and networks of informal relationships, which are essential in the genesis of innovations. In that sense, several scholars sought the need for an approach that could bridge that divide and

² The subsections labelled ‘Part I’ in this manuscript are the base of the paper called ‘The modes of innovation in an emerging economy: A firm-level analysis from Mexico’ by Carrillo-Carrillo and Alcalde-Heras (2020).

provide a comprehensive innovation strategy. The work of Jensen et al. (2007), rooted in the ideas of Lundvall and Johnson (1994) on learning processes and in the notion that different types of knowledge bases lead to different types of innovation outcomes, proposed a taxonomy that acknowledges the importance of science and technology, while at the same time emphasises the relevance of the experience and interactions in the innovation process. The authors suggest two ideal modes of learning and innovation, the ‘Science, Technology, and Innovation’ (STI), building on explicit and codified knowledge sourced in science, and the learning based on ‘Doing, Using, and Interacting’ (DUI), relying on experienced-based tacit knowledge. These two modes of innovation are widely spread amongst firms; however, it is unlikely that they can be found in a ‘pure’ form (Herstad et al., 2015). Instead there might be a combination of both modes that drive firms to attain innovation. For instance, even in fully science-based industries such as laboratory experimentation in the pharmaceutical industry, people often uses knowledge collected from past experiences to perform their activities (Jensen et al., 2007).

Jensen et al. (2007) empirically demonstrates that when both modes of innovation are purposely combined together in a comprehensive innovation strategy, firms are more likely to innovate than others using either one separately. Different studies across Europe and Canada (Amara et al., 2008; Apanasovich et al., 2016; Aslesen et al., 2012; Fitjar & Rodríguez-Pose, 2013; González-Pernía et al., 2015; Isaksen & Karlsen, 2010; Nunes & Lopes, 2015; Parrilli & Alcalde, 2016; Tripl, 2011) support this result to different extents. However, as firstly remarked by Apanasovich et al. (2016), the implications of these results are contextually limited to advanced economies, were several of these studies were conducted. Consequently, it is not conclusive if these results are also true for firms in other contexts different from

advanced economies. This limitation brings the opportunity to contrast the findings of previous studies with the answers to relevant questions regarding the modes of innovation in emerging economies.

The first part of this work explores the literature on the modes of innovation (Jensen et al., 2007) to determine the types of strategies utilised by firms in order to attain innovation and, subsequently analysing which is more effective. The results on the seminal work of Jensen et al. (2007) and several other analysis demonstrate that combination of STI and DUI modes of innovation is the best strategy to improve firms' innovativeness than the use of either one separately. This analysis tries to answer two key questions:

- i) Which mode of innovation is more effective to foster firm's innovativeness in an emerging economy context?
- ii) What are the main differences observed in the configuration of the modes of innovation in an emerging economy context in contrast to those analysed in advanced economies in the extant literature?

This study examines the nuances of such joint innovation strategy in an emerging economy context. The differences and potential limitations in the existent literature on the modes of innovation are discussed as a result.

1.3.2. Part II: Patterns and scope of external interactions for innovation:

Domestic SMEs in an emerging economy context

Innovation is widely acknowledged as an interactive learning process, which benefits from both internal and external exchanges of knowledge generated by a diverse array of economic actors. External interactions become of utmost importance for innovation, these bring new knowledge to serve as input in innovation processes. Often, firms find difficult to produce knowledge by themselves especially if they have limited internal

capabilities to produce it. Thus, they tend to establish different forms of interactions with their environment to gain access to different kinds of knowledge. These interactions are put in place to get either scientific and highly technological knowledge, or commercial and technical knowledge, according to the knowledge bases in which firms build their innovation processes. Thus, the second part of this dissertation centres on the interactiveness of the innovation process by assessing the relationship between different types of interactions and firm-level innovation.

First, this work aims to contribute to the debate of the effectivity of R&D and non-R&D drivers of innovation (Arundel et al., 2008; Barge-Gil et al., 2011; Hervás-Oliver et al., 2011; Santamaría et al., 2009; Veugelers & Cassiman, 1999).

Traditionally, innovation has been measured using variables that reflect only the use of formal mechanisms of R&D, which are mostly present in high-tech industries and fully developed innovation systems. For many years, this view of the innovation process has limited the understanding of how innovation happens in contexts where science and technology are not well established as mechanisms supporting knowledge creation. Scholars have long argued that innovation comes from a wide variety of activities and not only from formal R&D mechanisms (Veugelers & Cassiman, 1999). In fact, as the literature remarks (Bender, 2008; Freeman, 1994) most innovations do not come directly from cutting edge scientific and technological advancements. Firms are more likely to tap on already available knowledge to produce innovative products and services. This means that other activities that extensively capture, utilise, and recombine existing knowledge, play a major role as sources of innovation. Activities such as design, training, and use of advanced machinery are not based on the intensive use of R&D knowledge, but are able to stimulate experimentation and learning with new

technologies, and adaptations that can lead to innovation in their markets (Barge-Gil et al., 2011; Santamaría et al., 2009).

Second, the geographical scope of the interactions have different implications for innovation. Following some influential studies on the geography of innovation (Fitjar & Rodríguez-Pose, 2013; Parrilli & Alcalde, 2016), this analysis also attempts to determine the context specificity of interactions and their impact on the innovation results in firms. A well-established body of literature sets a discussion about the effectiveness of regional and global interactions in the production of new knowledge and innovation (Bathelt et al., 2004; Gertler & Levitte, 2005; Maskell et al., 2007; Moodysson, 2008; Moodysson & Jonsson, 2007; Wolfe & Gertler, 2004). While some argue (Asheim et al., 2007; Boschma, 2005; Gertler, 2003) that close interactions are essential for the transmission of tacit knowledge, others foster more far reaching knowledge searching strategies to gain brand new knowledge and avoid lock-in effects (Alcalde, 2014; Bathelt et al., 2004; Chaminade & Plechero, 2015; Fitjar & Rodríguez-Pose, 2011; Grillitsch & Tripl, 2014; Maskell et al., 2007). Certainly, as stated by Parrilli and Alcalde (2016) this is a topic that requires further empirical analysis from different stand points in terms of geographic, but also economic contexts.

Drawing on the arguments presented above, it is interesting to know how the different types of interactions and their geographical scope are represented in a context where innovations are known to be low and firms lack important innovation capabilities related to science and technology as well as organisational and market skills. In that vein, this study uses a large sample of domestic SMEs from Mexico to empirically analyse the importance of external interactions over innovation results, first, in terms of the R&D content of the interactions (R&D-related and non-R&D-related), and second, in terms of the geographical scope (regional and global). The results aim to provide a

more nuanced picture of the type of interactions pursued by the domestic SMEs in an emerging economy context. Finally, this analysis is based in the following research questions:

- iii) How external interactions based on their R&D content influence the innovation outputs of domestic SMEs in an emerging economy?
- iv) How the geographical scope of the external interactions influence the innovation outputs of domestic SMEs in an emerging economy?

1.3.3. Part III: The role of Technology-based Knowledge Intensive Business Services on the innovation performance of low-tech manufacturing firms

Inspired by the previous two parts of this dissertation, the third part examines, in the context of an emerging economy, the role of Technology-based Knowledge Intensive Business Services (T-KIBS) as potential suppliers of crucial knowledge for innovation in manufacturing firms in low technology sectors and the impact on their innovation outputs.

Innovation systems in emerging economies are typically characterised by low levels of innovation, in large part, because of deficient knowledge linkages between the different spheres of the innovation system (i.e., business sector, science sector, and policy actors) and generalised poor levels of education. However, over the last decade, manufacturing firms in emerging economies have increased their exports of knowledge-intensive outputs (OECD, 2015). This suggests that firms in emerging economies are building up their capabilities to absorb more sophisticated knowledge, not only by purely adopting new technology, but also by an internal upgrading of technologies and innovating capabilities (Chaminade & De Fuentes, 2015). This has sparked a general interest of scholars (Arocena & Sutz, 2000; Chaminade & De Fuentes, 2015; De Fuentes et al., 2015; Fu et al., 2011; Lundvall et al., 2009; Rodríguez-Pose & Villarreal

Peralta, 2015; Wang & Kafouros, 2009) to study the drivers that lead firms in this context to deliver value propositions allowing them to compete at global markets.

In addition, the study of innovation in low-tech sectors have been for a long time neglected, arguing a lack of appeal given some features as ‘excess production capacity, price-based competition and even the off-shoring of many of the activities’ (Chamberlin & Doutriaux, 2010, p. 491). Quite often science-based activities, which are acknowledged as key to the development of radically new products, are not recurrent on the portfolio of strategies in traditional sectors (Heidenreich, 2009; Hervas-Oliver et al., 2011, 2012; Santarelli & Sterlacchini, 1990). However, low technology sectors are the base of any economy, they comprise a large part of the economic activities and a large share of employment is concentrated in these sectors. As discussed throughout this dissertation, innovation expands over the realms of the high technological environments and, therefore, is present as well in low-tech firms. As remark by Santamaría et al. (2009), low-tech firms are indeed generators of innovation, but also important users of technology. In that sense, the literature argues that KIBS fulfil a key role in manufacturing sectors as suppliers of crucial knowledge for innovation (Hipp, 1999).

This study is based on the idea that T-KIBS, especially those non-R&D-related business services, could aid low-tech manufacturing firms to manage technological change and cope with innovation-based competition. In addition, despite the extensive literature on KIBS, little is known about their functioning in other contexts rather than advanced economies (Javalgi et al., 2011). Thus, guiding this analysis, the main research question is formulated as follows,

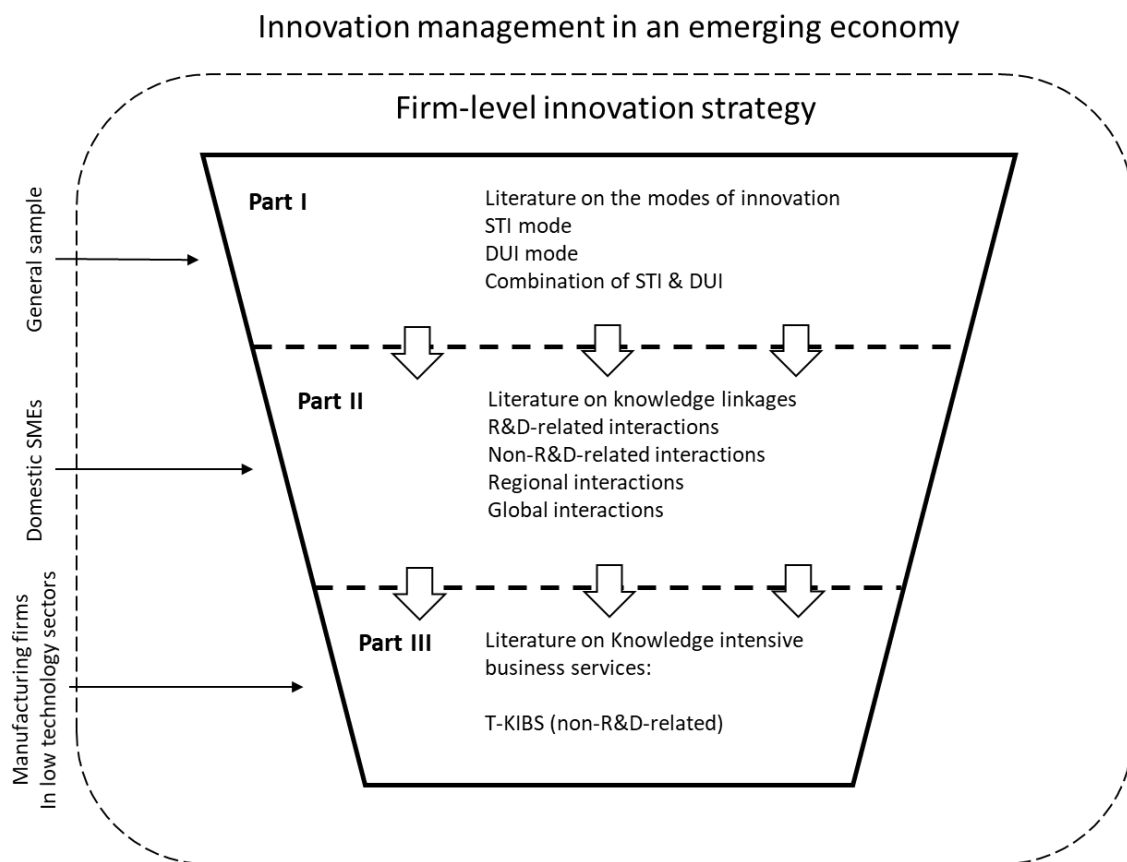
- v) How T-KIBS influence the innovation performance of low- and medium-low-tech manufacturing firms in an emerging economy context?

The main goal is to contribute to the growing literature on KIBS focusing on the traditionally overlooked innovation in low technology sectors.

1.3.4. Conceptual framework

The conceptual framework is presented in Figure 7, this is described in detail in the following sections and subsections.

Figure 7. Conceptual framework of the dissertation



Source: Own elaboration.

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Annex

Table A1. OECD technology classification for manufacturing firms in ISIC Rev. 3.1.

Code ESIDET	Code ISIC Rev. 3.1	Industry	OECD technology classification
05	15	Food products and beverages	Low
06	16	Tobacco products	Low
08	17	Textiles	Low
09	18	Wearing apparel and fur	Low
10	19	Leather and footwear	Low
12	20	Wood and cork	Low
13	21	Paper and paper products	Low
14	22	Printing and reproductions of recorded media	Low
32	32	Radio, television and communication equipment and apparatus	Low
40	361	Furniture	Low
16	23	Coke, refined petroleum products and nuclear fuel	Medium-low
20	25	Rubber and plastics products	Medium-low
21	26	Non-metallic mineral products	Medium-low
23	27	Manufacture of basics iron and steel	Medium-low
24	272/2732	Manufacture of basic precious and other non-ferrous metals	Medium-low
25	28	Fabricated metal products	Medium-low
41	369	Other manufacturing not elsewhere classified (n.e.c.)	Medium-low
18	24	Chemicals and chemical products	Medium-high
27	29	Machinery and equipment n.e.c.	Medium-high
29	31	Electrical equipment	Medium-high

34	34	Motor vehicles, trailers and semi-trailers	Medium-high
38	359	Transport equipment n.e.c.	Medium-high
19	2423	Pharmaceuticals	High
28	30	Office, accounting, and computing machinery	High
31	312	Electricity distribution and control apparatus (includes semiconductors)	High
33	33	Medical, precision, and optical instruments, watches and clocks (instruments)	High
37	353	Aircraft and spacecraft	High

Table A2. ESIDET size stratification

No. of employees	Value assigned in survey	Firm size
751 and more	1	Large
501 to 751	2	Large
251 to 500	3	Large
101 to 250	4	SMEs
51 to 100	5	SMEs
10 to 50	6	SMEs