The innovation dynamo: Determining channels that generate and facilitate Knowledge Spillover (KS) in Regional Innovation Systems

Sergio Botelho Junior

PhD

2019

QQI

Waterford Institute *of* Technology

The innovation dynamo: Determining channels that generate and facilitate Knowledge Spillover (KS) in Regional Innovation Systems

---

Thesis

Sergio Botelho Junior
20065664

Submitted in fulfilment of the requirements of Waterford Institute of Technology for the degree of Doctor of Philosophy.

Waterford Institute of Technology

September 2019

Under the supervision of Prof. Bill O'Gorman and Dr. Valerie Brett

Dedication

This thesis is dedicated to my wife Thaiza and my daughter Victoria. Thaiza gave me all the support and encouragement I needed even before I started my PhD, as when I had to decide to leave my job and country in order to pursue my PhD in Ireland. During the course of my studies Thaiza also gave me the best present of my life, Victoria, who has been present since then and fills my days with joy and motivation to tackle challenges for better days.

Declaration

The author hereby declares that, except where duly acknowledged and referenced, this research is entirely his own work and has not been submitted for any degree or other qualification in Waterford Institute of technology or any other third level institution in Ireland or internationally.

_____

Sergio Botelho Junior

September 2019

Abstract

The innovation dynamo: Determining channels that generate and facilitate Knowledge Spillover (KS) in Regional Innovation Systems

Sergio Botelho Junior

This research investigates the process of Knowledge Spillover (KS), i.e. the unintended transmission of knowledge (Fallah and I5 8brahim, 2004) that has the capacity to benefit all kinds of firms, in a given region, including those that are non-innovative or lack resources to invest in R&D. Therefore, propagating KS should be a priority for policy-making because of its potential to improve regional innovation performance. However, policy makers may not understand KS in this way, as according to the OECD (2018), KS can be a drawback for innovative firms because these firms do not want to share their knowledge with competitors and lose competitive advantage to them. Moreover, an extensive literature review identified that the process by which KS happens at the regional level has not been fully explained. What was found in the literature review were studies that explain KS through a single, or a group of channels of KS, but they do not explore the process of KS by using a representative set of channels that can reflect KS propagation at the regional level. Thus, the current research, through a mixed methods approach, seeks to explain the process of KS at the regional level. Fifteen channels of KS were identified and tested through a survey administered to 7,292 firms (with a response rate of 6.02%) in four regions: South East Ireland, North East Brazil, Bucharest-Ilfov Romania, and Castilla-La Mancha Spain. Following the quantitative analysis, 24 interviews were conducted with two categories of key informants: regional stakeholders and experts on KS and innovation (KSIexperts), to determine how KS happens. The findings enabled this researcher to conceive two frameworks to explain, at the regional level, (i) the process of KS and (ii) the propagation of KS. Thus the major contributions of this research are that it provides new insights and methodology to existing KS literature as well as providing frameworks that can be used by policy makers and implementers to enhance the innovation capacity and capability of regions.

Key words: knowledge spillover, innovation, knowledge flows, regional innovation systems, geographical proximity, and innovation policy.

Acknowledgements

Above all, I am grateful to God for giving me the opportunity and strength to complete my PhD studies.

I would like to express my gratitude to my wife, Thaiza, and my daughter, Victoria, for all their support, in every great and not so great moment of my PhD studies. This thesis is dedicated to both of them.

To my parents, Sergio and Eliana, I am thankful for giving me education and constant motivation to go ahead with my studies. I also would like to thank my grandmother, Marlene, for her decisive encouragement and support; and my sisters, Fernanda and Carolina, for being present and giving me support.

I would like to show my appreciation to people who somehow were really helpful during my studies. From CEDRE, I thank Mandy Lalrindiki, Sandra Ewohime, Niall Crosbie, Eugene Crehan, Aisling O'Neill and the researchers that were there for a shorter time, such as Anna Rogowska and Barbara Marin Cambronero. From ArcLabs, I thank Ciarán Cullen, Mary Fearon and Clare McCormack. From WIT, I thank Don O'Neill, Joan McDonald, Brian Foley, Anne Sweeney, Catherine Lowry-O'Neill and Collette Kirwan. I thank Paulo Melo for telling me about doing research on innovation in WIT and for being very supportive with contacts and information. I also would like to thank the participants of my research, people who took the time to answer the questionnaires and interview questions that allowed me to conclude my research.

Last but never least, I would like to specially thank Prof. Bill O'Gorman, my academic supervisor and boss, for his academic support, guidance, patience and encouragement that helped me to grow both as a researcher and a professional. I would like to extend my thank to my co-supervisor Dr. Valerie Brett, for her academic support, advice and encouragement over the course of my PhD experience.

Table of Contents

List of Tables

List of Figures

Chapter 1
Introduction

Chapter 1 Introduction

Knowledge Spillover (KS), understood as an unintended transmission of knowledge (Fallah and Ibrahim, 2004), is a key component of Regional Innovation Systems (RIS) because it contributes to firms to acquire the necessary inputs to innovate (Stuetzer, Audretsch, Obschonka, Gosling, Rentfrow, and Potter, 2018; McCann, Ortega-Argilés, 2016; Romer, 1990). KS is geographically constrained, thus firms with little or no R&D that are concentrated in a region can obtain knowledge inputs from the region (Audretsch, 1998). An innovative organisation, even if unwillingly, transmits knowledge to surrounding firms due to constant interactions that occur because of close geographical proximity (Fallah and Ibrahim, 2004). One reason for this is because employees from innovative organisations, such as firms, universities or government agencies, interact with employees from other organisations located in their surrounding area, who eventually learn from their methods, practices and solutions, and use the knowledge to apply to their own organisations. As a result, they innovate and grow (Döring and Schnellenbach, 2006).

Moreover, as firms benefit from KS and become innovative, they are likely to spur KS to other firms, much like a domino effect that leads to regional development. Differently than innovation endogenously created (Grossman and Helpman, 1991), i.e. when firms lead the way to successfully develop and commercialise a novel idea, KS works as an exogenous source of innovation for firms and, together with endogenous innovation, plays a role in regional innovation. Thus, KS is about opportunity. Opportunity for a firm to gain knowledge without having to pay for that knowledge (Samuelson and Nordhaus, 1998), and, on a regional scale, opportunity for public policies to diffuse the knowledge concentrated in innovative firms to the entire region and, therefore, promote innovation and economic development. However, some innovative regions are eagerly willing to benefit from KS and others either lack the institutional framework to convert KS into innovation or just ignore it (Döring and Schnellenbach, 2006).

The causality effect between innovation and economic development is widely recognised in the literature (see for example Őnday, 2016; Freeman and Soete, 2009; Cooke, Uranga, Etxebarria, 1997; Schumpeter, 1934). Schumpeter (1934) understood innovation as new combinations of existing resources. Innovation can generate long waves of economic growth. The first wave is initiated by qualitative innovations, that is, the introduction of radical innovations that cause economic and social changes. The second wave occurs over time, when

less innovative firms learn the ways of innovative ones and, as a consequence, imitate and improve their products. Thus, the second wave is characterised by incremental innovations. Moreover, the second wave is quantitatively more important and has a deeper impact on the economy (Schumpeter, 1939).

From a microeconomic perspective, Nelson and Winter (1982), based on Schumpeter's definition of innovation, further developed the concept adding that innovation consists of a recombination of conceptual and physical materials or new combinations of existing routines that were previously in existence. There are two mechanisms for the spread of innovations, namely, greater use of an innovation by the firm that first introduces it, and imitation by other firms. Nelson and Winter (1982) stress that the condition for some novel product or activity to be considered as an innovation is based on the result of it, that is, it is represented by its value to the organisation that will apply it, which for firms consists of monetary profit. For non-market organisations, such as universities, research centres and government agencies, this value is more difficult to view, since these organisations vary to a great extent and do not operate for profit. However, there are mainly two elements that characterise innovation in non-market organisations. First, value for non-market organisations is not characterised in terms of monetary profits. Second, the behaviour of non-market organisations is constrained by voters and legislatures, which are respectively the equivalent of consumers and financers for firms (Nelson and Winter, 1982).

The theory that emphasises the importance of innovation for economic development has become widely acknowledged by the government of many countries as well as organisations that represent groups of countries (OECD, 2005). For example, the Organisation for Economic Co-operation and development (OECD) which promotes policies aiming at improving the economic and social well-being of countries around the world, developed studies that are references for member countries to better measure and understand data relating to science, technology and innovation, such as the Oslo Manual (OECD, 2005) and the Frascati Manual (OECD, 2015). These studies are of key importance for regional governments because they provide the necessary tools for collecting information on innovation in specific regions and, as observed by Park (2001), allow public policies to consider the particular conditions of region-specific RIS.

Another example of such organisations is the European Commission (EC), the executive of the European Union (EU), the core responsibilities of which include proposing EU laws, policies

and monitoring their implementation. The EC developed the Regional Innovation Scoreboard (EC, 2016), which consists of periodic analyses that measure innovation in all European regions and classify them according to their innovative performance, namely, innovation leaders, strong innovators, moderate innovators and modest innovators. The findings of the Regional Innovation Scoreboard indicate that there is a considerable gap in innovation performance among regions. As a reaction, the EC implemented a seven-year programme, the Horizon 2020 (EC, 2010), that coupled research and innovation and aimed at tackling regional differences so that lagging regions can catch up with the most advanced ones as regards knowledge and innovation (EC, 2016).

In the opinion of this researcher, what programmes such as the Horizon 2020 should have in common in order to be able to balance innovation performance between regions, are specific mechanisms to spur KS. As previously presented, the most important reason for this assertion is because KS supports regional innovation. The second most important reason is because it backs innovation in firms that do not have the conditions to perform Research and Development (R&D) themselves, which is especially the case of small and medium enterprises (SME), due to high risk exposure, high fixed costs, high minimum investment and several other financial constraints (Rammer, Czarnitzki, Spielkamp, 2009). Thus, public policies on innovation that aim at considering KS can focus on improving the quality of the interactions between firms and organisations within regions and expect innovative outcomes to result from KS over time. Nevertheless, in order to be successful as regards implementing such policies, the process of KS has to be properly understood by policy-makers. However, a review of relevant literature to date indicates that this process is not fully understood.

A vast quantity of research about KS already exists, but the majority of this research has been from a quantitative perspective, which is a research approach that by itself cannot provide explanations for a phenomenon (Creswell, 2013). These studies assume KS to be a source of positive returns to scale in the aggregate production function (see for example Cerver-Romero, Ferreira and Fernandes, 2018; Qiu, Liu and Gao, 2017; Agarwal, Audretsch and Sarkar, 2010; Audretsch and Lehman, 2005; Romer, 1990; Arrow, 1962; Griliches 1979). Thus, most of the existing research on KS focuses primarily on its outcomes. Moreover, different studies point out to the need for a better understanding on how KS happens (Paci and Usai, 2009; Ibrahim, Fallah and Reilly, 2008; Smeets and De Vaal, 2006; Fallah and Ibrahim, 2004; Audretsch and Feldman, 2004; Feldman, 2000). The literature reviewed to date for this research could not

identify a study that fully explains the process of KS. Therefore, the research question for this study searches for an explanation of the process of KS at the regional level. Both the research question and objectives are presented in Table 1.1.

Research question	How does the process of KS happen at the regional level?
Aim of the research	To explain the process of KS at the regional level
Research objectives	1 To determine the most and least important channels of KS 2 To determine the regional differences as regards channels and patterns of KS 3 To determine the differences between sectors with different technological intensity as regards channels and patterns of KS 4 To determine whether small firms attribute more importance to channels of KS than firms of larger sizes 5 To determine whether KS is region specific

Table 1.1 Research questions, aim and objectives (Source: Author)

In order to answer the research question, the current study assumes that the process of KS starts from its sources, that is, the channels of KS that can trigger KS within regions. Channels of KS are geographical mechanisms and structural conditions of knowledge diffusion (Döring and Schnellenbach, 2006) that can contribute to propagate KS within regions. One example of a channel of KS is Foreign Direct Investment (FDI). National and local governments are in constant pursuit of FDI because they tend to diffuse knowledge from multinational firms into their host regions (Görg and Greenaway, 2004). Another channel of KS is networking. Networking between employees from different firms and organisations leads to interactions that are important for KS to happen (Breschi and Lissoni, 2003; Hakansson and Snehota, 1995).

Some previous studies involved small groups of channels of KS. For example, Harabi (1997) investigated empirically the effectiveness of seven channels of KS within the Swiss industry and came up with three patterns of learning of competitive technology. Also, Görg and Greenaway (2004) reviewed five channels of KS from the literature to explain how host regions can benefit from Foreign Direct Investment (FDI) and concluded that, although literature points out that they lead to KS within host regions, it is difficult to find robust empirical evidence to support the theory. Thus, studies that consider specific contexts such as a single particular region or FDI, and much less those that focus on channels of KS, cannot emulate KS at the regional level because they miss a number of channels of KS that, together, play a prominent role in explaining how KS happens at the regional level and how it can be propagated.

The current research tackles the lack of understanding on how KS happens through a constructivist lens because it aims at understanding a particular phenomenon by relying on different perspectives from individuals. As a result, the research expects to build theory by generalising findings. In order to do so, the current research uses different techniques derived from quantitative and qualitative approaches that only combined can give the adequate response to the research question. The combination of quantitative and qualitative approaches is called mixed methods research (Creswell, 2013). However, during the planning phase of the research, it was initially considered that a qualitative approach would suffice to answer the research question, i.e. how does the process of KS happen at the regional level. This is because, according to Marshall (1996), how and why questions demand explanations that should be provided by qualitative approaches. However, the preference for a mixed methods research design is due to the complexity of the theme under investigation, Knowledge Spillover (KS), which is rather conceptual and abstract to approach: 'knowledge flows are invisible, they leave no paper trail by which they may be measured and tracked' (Krugman, 1991, p. 53). Thus, the quantitative approach concentrated efforts on identifying the relevant aspects for KS in firms from different backgrounds. Once these aspects were identified, the qualitative approach took place in order to interpret their importance to regional innovation. The overall research concept is represented in the research design (Figure 1.1).

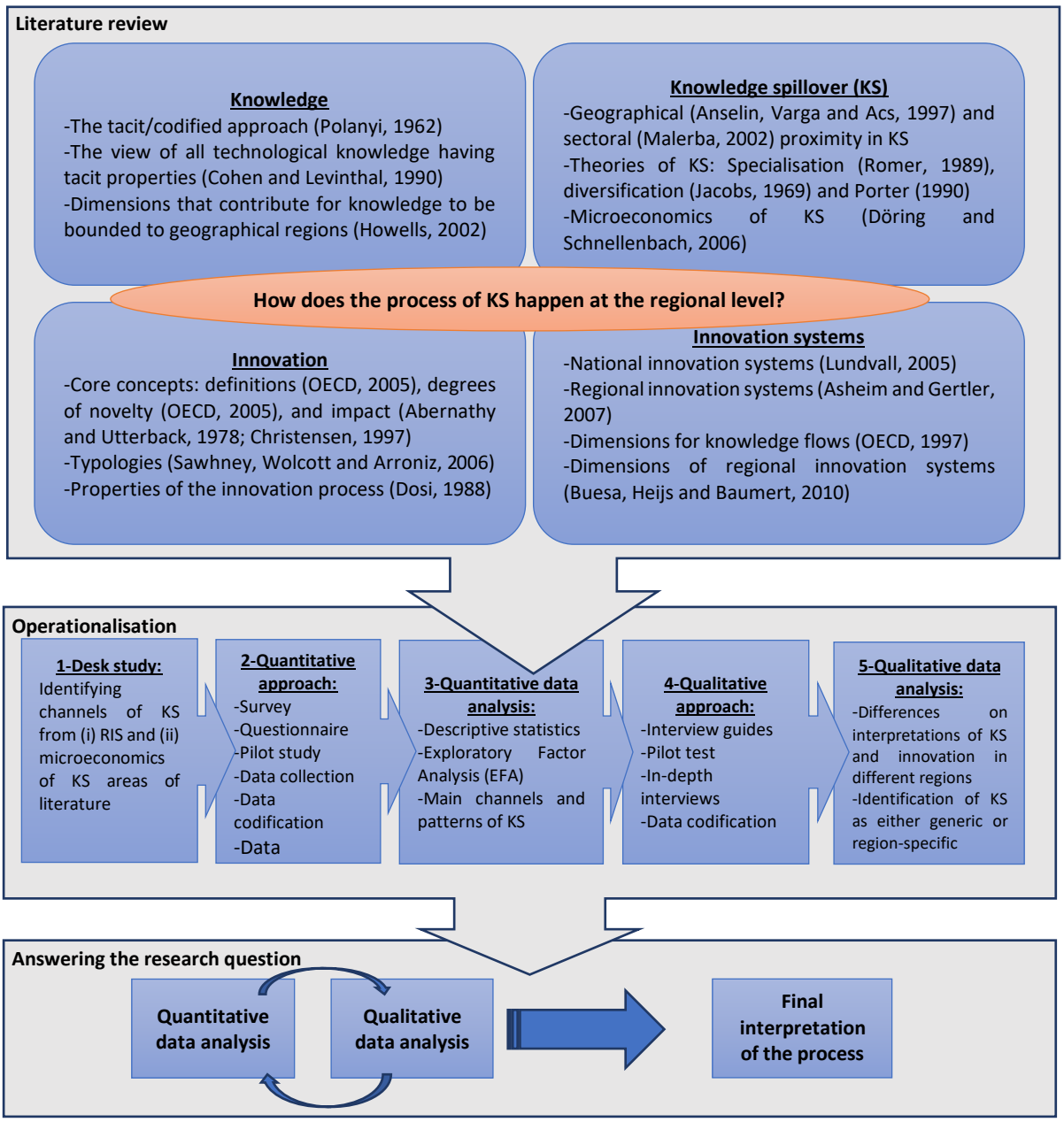

Figure 1.1 Research design (Source: Author)

This research is divided into five phases. Each phase was needed to be completed in order to move to the next. Thus, the type of design of the current research is explanatory sequential mixed methods because initially there is the collection and analysis of quantitative data and subsequently use of this data to plan the qualitative phase. The key idea of this type of research design is that the qualitative data collection builds directly on the quantitative results (Creswell, 2013).

The first phase consisted of a desk study aimed at identifying the channels of KS from the literature. Channels of KS can be found in two areas of literature, namely, Regional Innovation Systems (RIS) and microeconomics of KS. Thus, these two areas of literature consist of the

main domain in which the current research identifies channels of KS. The literature on RIS is important because it is concerned about the interaction of different organisations and institutions that affect the performance of innovation of the region (Acs, Audretsch, Lehmann and Licht, 2016). RIS is thus the ideal setting for KS to happen because it is generated by these interactions (Anselin, Varga and Acs, 1997; Audretsch and Mahmood, 1994) and involves all processes and elements that affect the implementation of innovation (Doloreux, 2003). These channels of KS are derived from three important dimensions of RIS, namely, market, spatial and stock of human capital. The microeconomics of KS, a term coined by Döring and Schnellenbach (2006) which refers to the literature that approaches the micro-level conditions for the dissemination of KS, is key for understanding how KS can be propagated and also for the design of the research as the channels of KS are obtained mostly from this particular area of the literature. These channels play a key role in the current research as they can propagate KS. Thus, the researcher assumes that they are the beginning of the process of KS.

The second phase of the research consisted of a survey. In order to test the importance of the channels of KS, a questionnaire with five-point scale questions was designed and a survey was administered to manufacturing and ICT firms from four regions: namely, South East Ireland, Bucharest-Ilfov Romania, Castilla-La Mancha Spain and North East Brazil. These regions were chosen because their results on innovation performance categories range from strong to modest innovators (Hollanders and Es-Sadki, 2017; IBGE, 2016) (see Table 1.2).

Region	*2017* - score relative to EU 2011 (RIS 2017)	Performance group (RIS 2017)	Land area in the country (RIM+)	Population of the region in relation to the country (RIM+)	GDP percentage of the region in relation to the country (RIM+)	EU regional competitiveness index 16/7
South East Ireland	115.6	Strong +	53%	74%	80%	109
Castilla-La Mancha Spain	59.8	Moderate	15.70%	4.43%	3.50%	216
Bucharest -Ilfov Romania	47.2	Modest +	86.90%	11.62%	28%	161

Table 1.2 Fast facts on innovation and development of European regions investigated (Source: Author)

North East Brazil, is not included in Table 1.2 because the indicators of regional innovation and economic performance from the Brazilian Central Statistics Offices are not compiled in the same way as the EC. However, North East Brazil was considered in this research in order to include the perspective of firms from a lagging region on innovation performance in a developing country. The entire region of North East Brazil, which occupies 18.25% of Brazil's land area and 27.48% of the population (SUDENE, 2016), has 12.13% of the total number of innovative companies in the country (IBGE, 2016).

Firms were also analysed according to their technology intensity (OECD, 2011), that is, high-tech, medium-high-tech, medium-low-tech, and low-tech firms. As Exploratory Factor Analysis (EFA) is key to analyse the interrelationship of the channels of KS, the required number of responses per region and category of technology intensity was 75 because of the

number of variables researched (see section on Phase 2: Quantitative approach in Chapter 4, Conceptual and methodological frameworks for more details). Thus, once 75 responses were obtained, the focus of the survey moved on to another region. The number of firms surveyed is displayed in Table 1.3.

	INVITATIONS	VALID RESPONSES	RESPONSE RATE (%)	Required number of responses in the region to run EFA
Castilla-La Mancha Spain	2146	146	6.8	75
Bucharest-Ilfov Romania	2592	97	3.74	75
South East Ireland	554	105	18.95	75
North East Brazil	2000	91	4.55	75
Total	7292	439	6.02	75

Table 1.3 Response rate (Source: Author)**Table 1.3 Response rate (Source: Author)**

The overall number of firms surveyed was 7292. However, the number of valid responses was 439, corresponding to a response rate of 6.02%. The majority of valid responses were from Castilla-la Mancha, with 146, equivalent to 33.26% of the total responses. Conversely, the minority of valid responses were from North East Brazil, with 91 responses (20.71% of the total responses).

The third phase of the research was concerned with the analysis of the quantitative data derived from the survey (Phase 2) in order to identify the most important channels and patterns of KS (named as critical channels of KS and core patterns of KS respectively) by applying descriptive statistics and exploratory factor analysis. This information directly supported the next phase of the research, of qualitative nature, because it defined the questions to be asked to regional stakeholders. Thus, descriptive statistics was used to reach scores of importance, i.e. the average importance of the channels of KS. This was necessary to determine the most important channels in propagating KS (*Research objective 1*) and also whether they coincide in different regions and technology intensity of industry sectors. Exploratory factor analysis was conducted in each region and at technology intensity of industry sectors in order to yield patterns of KS (*Research objectives 2 and 3*). Patterns of KS are mechanisms that show how a group of channels of KS behave, that is, how they increase or decrease in importance when firms change their perception about a particular channel within the same pattern. Once yielded, these patterns are subsequently compared in order to reveal groups of channels of KS that are repetitive, i.e. revealing patterns that are consistent in different regions and industry sectors. These groups are named as the core patterns of KS. In addition, One-way Analysis of Variance (ANOVA) was

performed in order to determine whether small firms attribute more importance to channels of KS than firms of larger sizes (*Research objective 4*).

The fourth phase of the research, the qualitative approach, was essential to answer the research question because it generated results that greatly contributed to explain how the process of KS happens at the regional level. It consisted of two sets of interviews. The first set focused on regional stakeholders and the second on experts on KS and innovation (KSIexperts). Regional stakeholders were industry, academia or government representatives randomly selected from the four regions surveyed. KSIexperts were academics, industry representatives or policy makers that are knowledgeable and experienced about KS and innovation. The findings and analyses obtained in the previous phases dictated the content of both sets of interviews. This is because regional actors were asked for their interpretation of the importance of the most important channels of KS, which were revealed in Research Phases 1 to 4. The interviews with KSIexperts explored views on (i) how KS happens; (ii) the importance of the channels of KS in their region; and (iii) whether KS and innovation are region specific or a generic phenomenon (*Research objective 5*).

The fifth phase of the research consisted of analysing the data collected during the interviews. It aimed at understanding the importance of critical channels of KS for regional innovation and also interpreting the patterns of KS. Participants' interpretations and analyses from both sets of interviews, regional stakeholders and KSIexperts, revealed the inherent mechanisms of the process of KS at the regional level that served as direct inputs for a framework for explaining the process of KS at the regional level (*Research Aim*).

This research challenges concurring theoretical perspectives on KS that posit KS and innovation as either caused by the concentration of firms from the same industry sector (Romer, 1989; Porter, 1990) or caused by the concentration of firms from different industry sectors (Jacobs, 1969). Findings demonstrate that there is no hard view on KS, and different theories can be complementary, rather than being mutually exclusive, in order to explain the process by which KS happens. Deconstructing knowledge spillover into discrete factors and having them analysed in the context of RIS helped to understand the essence of this process; in turn this understanding assisted in identifying a model for KS propagation. Therefore the pioneering approach to this research study is expected to contribute greatly to the existing body of knowledge spillover research, and enhance understanding of the knowledge spillover process.

By providing an understanding of KS happens, this research has implications for policy makers, researchers and senior civil servants and decision makers at local, regional, and national government levels. Since KS is a core element of RIS, understanding the process by which KS happens can support policy makers to improve the long-term sustainability of RIS. In addition, understanding how KS happens can facilitate business practitioners, such as managers and entrepreneurs, to follow strategies and take decisions based on the existing flows of knowledge within RIS that can positively reflect on their innovation activities.

This thesis is divided into nine chapters. The first, this introduction, explains the rationale for explaining KS at the regional level and details the planning and some findings of the research. The second chapter, Contextualising the importance of innovation and knowledge spillover, explains why it is important to conduct this research. The third chapter consists of the Theoretical frame. The fourth chapter, Methodology. The fifth and sixth chapters comprise of presentations of findings, namely quantitative and qualitative findings. The seventh chapter presents the discussion about the research findings within the context of existing literature. Finally, the eighth chapter, Research contribution, limitations and future studies, concluded the thesis (see Table 1.4).

Chapter	Title	Description
1	**Introduction**	This chapter introduces the reader to this research, providing details such as the research question, aim and objectives. The research aim, explaining the process of KS at the regional level, is posed as important not only to contribute to existing literature and provide more insights to the process of KS, but also to offer support to policy-making because KS can lead regions to enhance their innovation performance. This chapter also informs readers about the research design, overviewing each research phase, as well as providing details on the layout and structure of the thesis.
2	**Contextualising the importance of innovation and knowledge spillover**	Provides context to this research and explains why it is important to understand and explain knowledge spillover
3	**Theoretical frame**	Reviews relevant theories and literature that are key to explain how KS happens at the regional level, such as knowledge spillover, knowledge, innovation and innovation systems.
4	**Conceptual and methodological frameworks**	Explains the research philosophy, design and provides details of each phase of this mixed methods research
5	**An empirical analysis on channels and patterns of knowledge spillover**	Presents quantitative findings generated from descriptive, bivariate and multivariate statistical techniques that describe how firms, in regional, technology intensity and firms size contexts, attribute importance to channels of KS and also identify their interrelationship.
6	**Perspectives from regional stakeholders and experts on knowledge spillover and innovation (KSIexperts)**	Presents qualitative findings derived from interviews with two categories of key informants, namely regional stakeholders and KSIexperts.
7	**The Knowledge Spillover (KS) Process And The Propagation Of KS In Regions**	Discusses key research findings in relation to the literature and practical applications (e.g. policy-making) and presents a framework for explaining the process of KS that answers the research question
8	**Conclusion, Major Contributions, Limitations and Recommendations**	Concludes the research by identifying its major contribution, overviewing its objectives and key findings, providing limitations and recommending future studies.

Table 1.4 Thesis chapters (Source: Author)

Chapter 2
Contextualising The Importance Of Innovation And Knowledge Spillover

Chapter 2 Contextualising The Importance Of Innovation And Knowledge Spillover

2.1 Introduction

This chapter provides context for this research, which aims at explain the process of Knowledge Spillover (KS) at the regional level, by initially developing a critique on innovation policies and the need for more understanding about different aspects of the innovation process. This chapter also presents how two key drivers of innovation policy, i.e. the European Union (EU) and Organisation for Economic Co-operation and Development (OECD), approach innovation in order to propose effective policies and tackle regional imbalances of innovation outcomes.

2.2 A critique on innovation policies

A vast quantity of research about Knowledge Spillover (KS) already exists. However, the majority of this research has been from an econometrics perspective, which can identify the existence of KS and also measure KS outputs, but cannot explain how KS happens (Döring and Schnellenbach, 2006). In fact, based on an extensive review of as far of literature pertaining to KS, very little is published that provides a clear understanding of how the process of KS actually happens within regions and how it supports innovation. Knowledge Spillover (KS) is a core ingredient of successful regional innovation systems (Fallah and Ibrahim 2004; Acs, Anselin and Varga, 2002; Breschi and Lissoni, 2001), therefore understanding the process of how KS happens could support policy makers to diminish innovation performance disparities between different regions.

However, despite there being plenty of empirical evidence indicating that KS leads to innovation (for example Stuetzer, Audretsch, Obschonka, Gosling, Rentfrow, and Potter, 2018; McCann, Ortega-Argilés, 2016), some studies still consider KS as not being beneficial and something to be avoided because it leads innovative firms to stop conducting innovation activities as the knowledge that was obtained in the process can be transmitted to surrounding firms without their control (OECD, 2018). According to Fallah and Ibrahim, the rationale for this argument is that ‘if it were up to the firms, they would want to appropriate all knowledge generated as the result of their innovation efforts’ (Fallah and Ibrahim, 2004, p. 11). Another explanation for this argument is that, for costly R&D activities, the possibility of firms to obtain

knowledge generated by third parties implies a propensity to underinvest in knowledge-generating activities (Döring and Schnellenbach, 2006; Audretsch 2000). This view suggests that some researcher consider, "knowledge is modelled essentially as a private good that can be utilised by a clearly confined group of users, so that spatial spillovers are not of any interest (Döring and Schnellenbach, 2006). Thus, arguably as a result of the influence of such previous studies, policy makers attempt to avoid KS as it stops firms from innovating. One example is the Oslo Manual (OECD, 2018), which serves as guidelines for OECD countries to collect and analyse innovations data in order to inform innovation-related policy decisions. Even though OECD is continuously looking for different aspects that can support innovation within regions (as demonstrated by the four versions of the Oslo Manual, each progressing with a broader understanding on what innovation is and how it can happen), it still does not consider KS as a viable regional aspect that can help OECD regions to become more innovative. The Oslo Manual does not recommend KS as a solution to improve innovation performance because it considers that unintentional knowledge flows (comprised of KS at the regional level) 'can result in unwanted transmission of information to competitors. Some types of flows can be illegal, such as knowledge obtained through industrial espionage. Firms cannot prevent knowledge contained in patents from flowing to competitors, but they can obtain damages for the misuse of knowledge protected by IP rights' (OECD, 2018, p. 131).

2.3 The innovation paradox and the policy dilemma

Despite identifying that innovation brings many benefits to different economies and societies, including income per capita and well-being, many countries are not investing in innovation and therefore failing to reap its benefits, as demonstrated by European countries (Hollanders and Es-Sadki, 2017), different countries around the world (OECD, 2016) and statistics offices from developing countries, such as Brazil (IBGE, 2016). This situation, according to Cirera and Maloney (2017), is known as the innovation paradox because many of these countries have the capabilities to catch up with more developed countries by becoming more innovative but are failing to do so. Innovation in developing countries should enable firms, that are less innovative by nature, to innovate as a result of Knowledge Spillover (KS) because the costs involved with R&D and related activities are much lower (Döring and Schnellenbach, 2006; Fallah and Ibrahim, 2004; Audretsch 2000). This situation is influenced by the innovation policy dilemma, a term coined by Cirera and Maloney (2017) which conveys that the less an innovation system is capable of supporting innovation activities, the weaker is the capacity of the government to

deliver policies that can improve this scenario (Cirera and Maloney, 2017). Thus, countries that could benefit most from KS are the least likely to have policies on innovation to support KS.

There are other dilemmas associated with regional innovation policies, as indicated by Uyarra (2007). These dilemmas revolve around the understanding of knowledge and learning in policy making, and also the boundaries of knowledge production and sharing. In particular, the dilemma of regional innovation policies on the diversity of technological-spatial configurations, referred to by Uyarra (2007) as a common assumption in regional policy making by which a region is considered as coherently innovative, that is, innovation performance is the same throughout the region. On the other hand, supporting Storper (1997), Uyarra argued for a situation of heterogeneity, i.e. that regions produce knowledge in a few locations of economic dynamism and relative success, which are linked to networks at higher spatial levels. Another assumption related to this dilemma, based on Oinas (2000), is that firms in a region form a relatively homogeneous private sector within which interests are shared, suggesting some degree of homogeneity in firms' and agents' cognitive frameworks and strategies at the regional level. Uyarra claims that firms and other types of organisations learn differently and more attention should be paid as regards to how firms interact with their innovation systems. Firms are agents that react to changes in systems of innovation and innovation policy, but little is known about firm demands for innovation, which would contribute to a better understanding on how knowledge can be shared. KS, for example, happens through agglomeration of firms and networking and can significantly help in knowledge sharing, however, little is known about how it can contribute to firms demands for innovation (Uyarra, 2007). Therefore, based on the need for policy makers to better understand innovation-related phenomena, as suggested by Cirera and Maloney (2017) and Uyarra (2007), understanding how KS happens can be of much benefit for regional innovation performance.

2.4 The European Union and its views on innovation

The European Union (EU) is an economic and political union that represents most of the European countries. The EU is actively engaged in promoting innovation within member states and their regions. Even though EU member states are sovereign and independent states, they delegate some of their decision-making powers to the shared institutions created by the EU. Thus, decisions on specific matters of common interest can be made democratically at EU level, which involves a number of institutions, in particular: (a) the European Parliament,

representing the citizens through direct vote; (b) the European Council, comprising of the Heads of State or Government of the member states; (c) the Council, embodying the governments of the EU; and the (d) European Commission, which represents the interests of the EU as a whole (European Union, 2017).

The EU was conceived in 1957 through the Treaty of Rome, which integrated member states through a common market by eliminating trade barriers and establishing a common external trade policy (Gabel, 2014). However, the original conception of the EU paid minimal attention to innovation and regional policies (Manzella and Mendes, 2009). Regional policies, however, increased in importance in EU policy in 1972 during the Conference of Heads of State of Paris. On this occasion, member states declared their intention to focus on correcting the structural and regional imbalances in the EU area. It was agreed to prepare a report analysing regional problems in order to propose a European Regional Development Fund (ERDF) (Manzella and Mendes, 2009).

In the first version of the ERDF, the financial resources that were available for regional development were directly transferred to member states, which would decide by themselves how to allocate these funds. In 1984, the Council introduced important changes in regional policy, such as an increase in finance allocations to the ERDF and distribution of the fund on the basis of a new system of indicative ranges, instead of fixed quotas. Thus, there was a shift in regional policy because the Commission's role changed from a mechanism of financial resources transfer to decision-making based on EU objectives, priorities and experimentation (Manzella and Mendez, 2009).

Also significant during the 1980s was the signature of the Single European Act (1985), which was a treaty to provide the basis for the creation of the single market (European Union, 2017) and constitution of an economic and social cohesion policy. The policy objectives of the cohesion policy became (i) to promote the overall harmonious development of the EU and (ii) to reduce disparities between the various regions, especially the backwardness of the least-favoured ones (Manzella and Mendez, 2009).

Specific efforts to promote innovation in the EU area happened after the Heads of State and Government of the Union Meeting in Lisbon (2000), which introduced strategies on innovation to make Europe a more competitive knowledge-based economy (Barnier, 2003). Scientific research played an important role in these strategies through the creation of the European

Research Area (ERA), which since then has been providing research opportunities within Europe with a transnational angle. In 2007, the signing of the Treaty of Lisbon simplified and streamlined the institutions that govern the EU (Ray, 2009). In 2008, there was an international financial crisis that affected Europe as a whole. In 2010, as a response to the crisis, the European Commission (2010) put forward three mutually reinforcing priorities for the following ten years, (1) Smart growth: developing an economy based on knowledge and innovation; (2) Sustainable growth: promoting a more resource efficient, greener and more competitive economy; and (3) Inclusive growth: fostering a high-employment economy delivering social and territorial cohesion.

These priorities were intended to meet the following headline targets (Table 2.1).

#	Headline target
1	75% of the population aged 20-64 should be employed
2	3% of EU's GDP should be invested in R&D
3	The "20/20/20" climate/energy targets should be met (including an increase to 30% of emissions reduction)
4	The share of early school leavers should be under 10% and at least 40% of the younger generation should have a tertiary degree
5	20 million less people should be at risk of poverty

Table 2.1 Headline targets for priorities of the European Commission (Source: Based on EC, 2010)

In order to achieve these targets, the European Commission put forward seven flagship initiatives to catalyse progress under each priority theme. The flagship initiative for improving European performance on innovation is called "Innovation Union", which aims at improving framework conditions and access to finance for research and innovation in order to ensure that innovative ideas can become products and services that create growth and jobs (European Commission, 2010).

The ERA allows different organisations to submit their own proposals in order to make Europe a more innovative place. For example, through the 7th Framework Programme for Research and Technological Development (FP7), which had a considerable increase in budget from previous versions, grants became available for research actors all over Europe in order to co-finance collaborative research, technological development and demonstration projects. Grants became available from 2007 to 2013 on the basis of calls for proposals and a peer review process, which were highly competitive (EC, 2007). In 2014, the 8th Framework Programme for Research and Technological Development (FP8) (more famously referred to as Horizon 2020 or H2020) was established to attend the 2014-2020 period. There were improvements from the previous version as, for example, giving more attention and resources to themes

related to global challenges, while leaving other parts of the budget more thematically open. While FP7 had significant activities with other countries and regions of the world through international cooperation, H2020 reinforced a more strategic approach, emphasising less on open competition and more on strategic cooperation, collaboration and openness between key partners on selected areas (Research Council of Norway, 2010). In 2021, the 9th Framework Programme for Research and Technological Development (FP9), will run until 2029. Some relevant details have already been considered for this framework, such as an increased budget, a slight re-focus of the three priorities defined by the EU in 2010 and the inclusion of open innovation and open science in project proposals (University of Leeds, 2018).

One source of information that guides these public policies on innovation for the European Commission is the Regional Innovation Scoreboard (RISc). Since 2002, the RISc classifies European regions according to their innovation performance. There are four categories of regional performance group membership (Hollanders and Es-Sadki, 2017) (Table 2.2).

#	Regional classification of innovation performance	Explanation
1	Innovation Leaders	Regions with a relative performance more than 20% above EU average
2	Strong Innovators	Regions with a relative performance between 90% and 120% of the EU average
3	Moderate Innovators	Regions with a relative performance between 50% and 90% of the EU average
4	Modest Innovators	Regions with a relative performance below 50% of the EU average

Table 2.2 Regional classification of innovation performance (Source: Based on Hollanders and Es-Sadki, 2017)

By analysing different editions of the Regional Innovation Scoreboard (from 2002 to 2017), it becomes evident that cohesion policy is working to make Europe a more innovative place as the innovation performance of most regions are continuously increasing. However, innovation is not well-balanced throughout European regions and there is room for improvement, i.e. Moderate innovators correspond to 38.64% of the total number of regions whilst Modest innovators represent 10% of this total (Hollanders and Es-Sadki, 2017). Moreover, less innovative regions are not growing faster than more innovative regions in order to decrease the existing technological gap between them.

2.5 The Organisation for Economic Co-operation and Development and its views on innovation

The Organisation for Economic Co-operation and Development (OECD), initially called Organisation for European Economic Cooperation (OEEC), was established in order to promote co-operation and reconstruction between countries after World War II and also to run the US-financed Marshall Plan for the reconstruction of Europe. After 1960, other countries from different parts of the world joined the OEEC and the organisation adopted its current name, i.e. OECD. Since 2007, the OECD also works in cooperation with key partner countries who are not members. This cooperation works through "Enhanced Engagement" programmes and a central element is the promotion of direct and active participation of key partners in the work of substantive bodies of the organisation. The European Commission (EC) takes part in the work of the OECD since the Convention on the OECD in 1960. The EC participate alongside OECD members in discussions on the OECD's work programme and is involved in the work of the entire organisation, however, the EC does not have the right to vote and does not officially take part in the adoption of legal instruments submitted to the council for adoption (OECD, 2018).

The OECD's innovation strategy argues that policy-making can help to generate more innovative, productive and prosperous societies, increase well-being, and strengthen the global economy in the process. The OECD recommends public policies to concentrate on five areas of action (OECD, 2016). The first area that should be considered by public policies is *Effect skills strategies*, which focuses on people to have the skills to generate new ideas and technologies, bring them to the market, implement them in the workplace and that are able to adapt to structural changes across society. The second area is a *Stable, sound, open and competitive environment*, thus encouraging investment in technology and in knowledge-based capital. This enables innovative firms to experiment with new ideas, technologies and business models, and also help these firms to grow and reach scale. The OECD recommends that policy fosters open markets and sound competition and to avoid favouring incumbents over new firms as it reduces experimentation, delays the exit of the least productive firms and slows the reallocation of resources from less to more innovative firms.

The third area of action is *Sustainable public investment in an efficient system of knowledge creation and diffusion*. Public investment should focus on durable benefits for the society, rather than short-term outcomes. Support for business innovation should be well balanced and

not concentrate only on tax incentives, but also on competitive grants because they are better suited to the needs of new innovative firms, and on areas that have the highest returns to society. The fourth area of action is *Increased access and participation in the digital economy*. Digital technologies have a great potential for innovation, growth and greater well-being. Digitally enabled innovation demands investment in new infrastructure, such as broadband, but also on open internet preservation, address privacy and security concerns. Finally, the fifth area of action for innovation is *Sound governance and implementation*. Policies for innovation can have an impact if governance and implementation are based on (i) a well-developed institutional framework; (ii) strong capabilities for evaluation and monitoring; (iii) the application of good practices; and (iv) an efficient and innovative public sector.

At the national level, the OECD develops studies in order to establish standard practices for surveys on Research and Development (R&D) (OECD, 2002) and innovation (OECD, 2005). These studies become references for various large-scale surveys examining the nature and impacts of innovation in the business sector, such as the European Community Innovation Survey (CIS). One example is the OECD Science, Technology and Industry (STI) Scoreboard, a tool with 200 indicators that shows how digital transformation affects science, innovation, the economy, and the way people live. This tool aims to help governments design more effective science, innovation and industry policies in the fast-paced digital era. The STI Scoreboard is published every two years and the current 2017 version highlights important aspects of the digital revolution.

One of these aspects is that, led by China, Taipei, Korea, Japan and the United States, the digital revolution continues to grow, as reflected in the number of ICT-related inventions, patents and technologies. Another aspect relates to countries that most contribute with digital innovations, with US, China, UK and India showing leading roles in the ranking. In addition, R&D activities are highly concentrated in a few countries and a few firms. Furthermore, economies that use ICT technologies require broad skill sets for its workers (OECD, 2017). Other studies from OECD, such as previous version of the OECD STI Scoreboard and the Innovation Imperative, show that (i) between 1995 and 2014, based on GDP per hour, total productivity of the economy and annual percent change, productivity growth has generally fallen across the OECD; (ii) based on number of employees compared between start-up and old firms, (iii) firms in many countries, such as Japan, Italy and Turkey, do not scale after entry; and (iv) between

1998 and 2013, and based on firm entry rates, start-up rates have fallen in many countries (OECD, 2016).

Studies at the national level are not the only focus of the OECD (OECD, 2016), it also conducts analytical studies at sub-national level, such as the biannual OECD Regions at a Glance Report, which focuses on providing a comprehensive picture of the level of progress in OECD regions and metropolitan areas towards more inclusive and sustainable development regions and addresses two questions, as follows. (1) How OECD regions perform in a wide range of well-being outcomes and what progress they made towards more inclusive and sustainable development; and (2) Which factors drive the performance of the regions? The OECD regional classification answers these questions by taking into account the different geographies of the regions, i.e. a regional typology that classifies regions as (i) Predominantly Rural (PR), if more than 50% of the population lives in rural communities; (ii) Predominantly Urban (PU), if less than 15% of the population lives in rural communities; and (iii) Intermediate (IN), if the share of population living in rural communities is between 15% and 50%. This classification is important because it is more relevant to analyse regions that are geographically similar, enabling meaningful comparisons between regions that are from the same type (OECD, 2016).

The most recent version of OECD Regions at a Glance identified that regional and local governments control many policy levers for promoting prosperity and well-being. They were responsible for around 40% of total public expenditure and 60% of public investment in 2014 in the OECD area. In addition, regional and local governments were responsible for 85% of total public expenditure on education, health, general public services, economic and social affairs.

Relating to innovation during the 2000-2013 period, OECD Regions at a Glance (2016) identified that innovation-related activities, such as patenting which represents invention, are highly concentrated in a few regions. In addition, business enterprise R&D expenditure (BERD), representing the decisions by firms regarding the location and level of R&D investments to support innovation, is continuously increasing in the OECD area. However, the share of BERD in the top 20% regions has decreased over this period.

2.6 Regional policies on innovation and knowledge spillover

It is well known that Knowledge Spillover (KS) can benefit regions because knowledge is important in order for firms to become more competitive (Akram, Siddiqui, Nawaz, Ghauri

and Cheema, 2011; Smolny, 2000; Arrow, 1985) and also because KS can contribute for regions to yield innovation outcomes (Araújo, Silva and Teixeira, 2013; Yang, Phelps and Steensma, 2010; Fallah and Ibrahim, 2004; DiPietro, 2003). Thus, knowledge spillover, understood as an unintended transmission of knowledge (Fallah and Ibrahim, 2004), happens when innovative organisations indirectly transmit industrial knowledge that can be converted into innovation to firms that surround them due to constant interactions. However, even though KS plays an important role in regional innovation, the process by which it happens is unclear, as declared by different authors such as Paci and Usai, 2009; Ibrahim, Fallah and Reilly, 2008; Smeets and De Vaal, 2006; Fallah and Ibrahim, 2004; Audretsch and Feldman, 2004; and Feldman, 2000 (to mention but a few).

Therefore it is imperative that international organisations (for example the EU and the OECD) that are concerned with innovation outcomes of the countries that they represent need to look for viable alternatives to tackle the unbalanced level of innovation in their regions. As a consequence, the current research proposes that these organisations should consider KS in their policy strategies on innovation. KS has been widely recognised in previous published research literature as an important regional aspect that can lead firms to innovation (see for example Stuetzer, Audretsch, Obschonka, Gosling, Rentfrow, and Potter, 2018; McCann, Ortega-Argilés, 2016; Romer, 1990). However, the literature review to date for this current research indicates that KS has not been understood and a considerable number of studies could not find a thorough explanation of the phenomenon. It has also been identified that literature available on KS relies mostly on quantitative data, often derived from a knowledge production function (see for example Qiu, Liu and Gao, 2017; Romer, 1990; Griliches 1979; and Arrow, 1962). In these models, KS is assumed as a source of positive returns to scale in the aggregate production function (Döring and Schnellenbach, 2004).

A more interpretive approach is missing in previous studies in order to understand how KS happens within regions. Thus, qualitative techniques could be employed in order to interpret and build on quantitative findings. A better understanding on how KS happens could positively impact the planning of policies on innovation for organisations such as the EU and OECD, which are continuously searching for different aspects that can increase innovation performance. The reason for considering KS in policies on innovation is because KS facilitates the access of firms to the knowledge that is freely available in the region and can help them with innovation. As a result, the current research aims at explaining how KS happens at the

regional level. In order to investigate such phenomenon, the starting point is to identify in the literature on KS and innovation the channels that can propagate KS and that are present.

2.7 Chapter summary

This Chapter presented a critique on innovation policies and elaborated that both the EU and the OECD are continuously monitoring innovation performance in countries and regions in order to propose effective policies to foster innovation and decrease the differences that exist between regions/countries as regards innovation outcomes. KS is a relevant regional dimension that should be considered by policy-making because it supports firms to become more innovative. However, there are no previous studies that explain how policy making can benefit from KS in order to increase regional innovation performance; because most of the literature is concerned with KS outcomes as opposed the process itself. Thus, understanding how KS happens could support the generation of innovation policies to propagate KS within and across the regions.

In conclusion, because both the EU and OECD have identified that there are considerable differences in innovation performance between regions in their member states and, even though these organisations are continuously working for better policies to improve innovation outcomes, solving regional imbalances on innovation is still a challenge. Therefore, this researcher contends that clear knowledge and understanding of how KS happens can identify dimensions to propagate KS within regions; which, in turn, can support policy makers and implementers to decrease regional innovation imbalances; and thereby nurture the development of sustained innovation at national and super-national levels.

Chapter 3
Theoretical Frame

Chapter 3 Theoretical Frame

3.1 Introduction

The literature on knowledge and innovation recognises Knowledge Spillover (KS) as a key element for regional economic growth (Stuetzer, Audretsch, Obschonka, Gosling, Rentfrow, and Potter, 2018; McCann and Ortega-Argilés, 2016; Yang, Phelps and Steensma, 2010; Araújo, Silva and Teixeira, 2013; Romer, 1990). Innovative organisations build knowledge by conducting Research and Development (R&D) activities in order to create new products, processes and services and sell them in the market. Even though firms attempt to appropriate all of the knowledge they produce, some of it is always going to be indirectly transmitted to surrounding firms. This is because employees from different firms located next to each other have constant face-to-face interactions through formal and informal means and these interactions cause knowledge to be diffused (Fallah and Ibrahim, 2004). These are some of the important aspects of KS that are going to be addressed in this chapter, which covers the relevant theories for conducting research on KS at a regional level.

Thus, this Chapter investigates the micro-level conditions for KS to happen, a branch of literature on innovation referred to as the microeconomics of KS by Döring and Schnellenbach (2006). Reviewing the microeconomics of KS is important to be analysed in order to identify channels that are capable of spurring KS at the regional level. Channels of KS are the means and the sources by which KS happens and that can influence innovation outcomes. Such channels have been studied in previous research literature individually or in small groups that do not entirely reflect how KS can be propagated at the regional level. In fact, many studies in the literature reviewed to date argue that the process in which KS happens has not been fully explained (Caiazza, Belitski and Audretsch, 2019; Paci and Usai, 2009; Ibrahim, Fallah and Reilly, 2008; Smeets and De Vaal, 2006; Fallah and Ibrahim, 2004; Audretsch and Feldman, 2004; Feldman, 2000). These channels are used during the operationalisation of the current research (see Chapter 4, Conceptual and methodological frameworks).

This chapter reviews and analyses the theoretical approaches that are relevant for explaining how KS happens at the regional level, which is the research question this study seeks to answer. The first section presents the theoretical paradigms that influence the literature reviewed. The second section indicates and discusses the economic relevance of knowledge within regions. The third section presents definitions of KS and examines different aspects and channels that

can contribute to KS propagation. The fourth section explores concepts of innovation in a broad sense due to the fact that the kind of knowledge that spills over to a company may lead to technological and non-technological innovations. The fifth section focuses on regional innovation systems because firms that benefit from KS are not isolated, but part of a system in which the interaction of regional actors facilitate knowledge to be transmitted and converted into innovation.

3.2 Theoretical paradigms

Most of the literature review conducted for this research is based on two major theoretical paradigms, namely evolutionary and new growth theories. These two paradigms explain innovation as a key player in competitiveness and growth. The third paradigm, economics of knowledge theory, explains knowledge as an important part of the innovation process.

Evolutionary and new growth theories were developed during the 1980s after the economic slowdown of the 1970s (Saviotti and Metcalfe, 2018; Fagerberg, 2003) which contradict the neoclassical theory of economic growth in which knowledge is freely available and economic growth ceases in the long run (Sloman, 2006). Despite the differences between evolutionary and new growth theories identified in literature (Castellacci, 2007; Fagerberg, 2003; Hodgson, 1993), both of them are based on Schumpeter's seminal work on innovation and economic development (Saviotti and Metcalfe, 2018; Castellacci, 2007).

Joseph Schumpeter (1883-1950), considered as one of the most important economists in the 20th century (Fagerberg, 2003; Drucker, 1988), proposed an original theoretical approach that placed innovation, i.e. new combinations of existing resources (Schumpeter, 1939) as a key aspect of the economy capable of generating economic development, which is a complex process of transformation and qualitative change. From Schumpeter's standpoint, innovation is regarded in a broad sense, that is, his model considers technological and non-technological innovations (Schumpeter, 1934).

3.2.1 The evolutionary paradigm

The evolutionary paradigm supports the existence of long waves of economic growth created under direct influence of radical innovations (Schumpeter, 1939). The first wave is initiated by qualitative innovations, that is, the introduction of radical innovations that cause economic and social changes. The second wave occurs over time, when less innovative firms learn the ways

of innovative ones and, as a consequence, imitate and improve their products. Thus, the second wave is characterised by incremental innovations. Moreover, the second wave is quantitatively more important and has a deeper impact on the economy (Schumpeter, 1939). Scholars from the evolutionary doctrine supported the idea that innovations are interrelated and capable of generating growth in different prominent industry sectors. However, in the evolutionary theory, as innovation presents uncertain results, growth is non-deterministic and non-predictable (Saviotti and Metcalfe, 2018; Castellacci, 2007). These interrelated innovations form a technological paradigm (Dosi, 1982) and cause a strong technological push in the economic system.

The literature on evolutionary economics, according to Saviotti and Metcalfe (2018), Freeman (2007) and Castellacci (2007), interprets economic growth as triggered by dynamic interactions between heterogeneity, competition, selection and innovation processes. An economy is comprised of expanding knowledge, limited rational agents and uncertainty. In order to avoid uncertainty, heterogeneous firms follow routines in their processes. Their behaviour is derived from interactions over time with their environment and generates a pattern of economic activities and relationships. On the other hand, routines are always under the influence of dynamic forces, i.e. competition and selection.

The results of dynamic forces are competing firms. Some firms have more innovative capability and therefore become more competitive. Contrary to this, some other firms have less capacity for innovation, lose market share and are driven out of the market. Over time, there is a tendency that competition and selection will reduce the heterogeneity (Nelson and Winter, 2002; Nelson and Winter, 1982). This is because best practices get copied, encouraged by benchmarking. As a consequence, firms target their markets with similar offerings, using undifferentiated capabilities and processes (Sawhney, Wolcott and Arroniz, 2006). Through innovation, new and varied firms in the market will lead the economy again to heterogeneity and selection (Nelson and Winter, 2002; Nelson and Winter, 1982).

3.2.2 The new growth theory paradigm

The new growth theory paradigm criticises the neoclassical model of economic growth (Solow, 1956) in which rates of growth dwindle as diminishing returns to labour and capital cause low wages and decreasing rates of profit. For the new growth paradigm, the solution for growth in the equilibrium state is innovation. The new growth theory originated during the 1980s as a

reaction from studies on economic growth that emphasised primarily the accumulation of physical capital. New growth theory studies proposed that national and regional economic growth depends largely on the capacity that countries and regions have to accumulate knowledge, rather than physical capital, thus the focus of studies on economic growth should be on aspects that embody knowledge, such as technology and human capital (Grossman and Helpman, 2015). One of these studies, by Romer (1990), was particularly relevant for the new growth theory because it proposed a model in which technological knowledge is a partly appropriable good because the producer can obtain monopoly rents, such as patents, and become a monopolist in the production of goods (Romer, 1990), which contradicted the neoclassical model of economic growth in which innovation is exogenous and unexplained and innovation is assumed to be freely available to all firms in the economic system.

This partly available nature of technological knowledge introduced by new growth theory explains that firms have to invest in innovation and introduces the importance of KS in the economic system. Technological knowledge has also a non-rival feature (Romer, 1990), thus many firms can benefit at the same time and that drives economic growth. Therefore, unlike the Solon model, increases in inputs of production can have an impact on the rate of growth. Thus, in the new growth theory, innovation can drive increasing positive rates of growth (Grossman and Helpman, 2015; Castellacci, 2007).

Innovative activities are uncertain (Bedi, 2019; Verreynne, Williams, Ritchie, Gronum, and Betts, 2019; Jung and Kwak 2018), but it is possible to calculate an average arrival rate of innovation and growth of the economy once the pattern of productivity, something similar to the parameter of a stochastic process, is understood. Thus, new growth theory models relate innovation to stochastic innovative activity, creative destruction and aggregate increasing returns; and they predict economic growth in the long run by a function with three major factors, namely, (i) labour resources employed in the research sector, (ii) the degree of market power in the intermediate capital goods sector, and (iii) the productivity in the research sector (Castellacci, 2007).

The new growth theory approach stresses a key feature for conducting the current research, which is the acknowledgement of the existence of knowledge spillover (Grossman and Helpman, 2015). When firms invest in training, for example, firms in the same region benefit from the increase of human capital and the consequence is skilled labour available for hiring

by other firms and institutions. Another example occurs when firms invest in R&D and, as a consequence, the benefits are shared with other firms nearby (Sloman, 2006).

Likewise as with evolutionary theory, innovations in new growth theory can be either incremental or radical (called drastic). Also, the existence of drastic innovations may lead to a technological paradigm (called general purpose technology). Drastic innovations drive general purpose technology when they are extensively used in a wide range of industry sectors in such a way that they change how problems are approached and solutions met (Helpman, 1998). The similarities between the evolutionary and the new growth theory approaches are identified in different studies and there are a number of scholars who point out a theoretical convergence of neo-Schumpeterian approaches (such as Sarkar, 1998; Ruttan, 1997; Romer, 1990). However, Castellacci (2007) analysed both approaches by focusing on their major theoretical foundations and discovered that they differ in all theoretical building blocks, thus not identifying any kind of theoretical convergence between both theoretical approaches. Nevertheless, regardless of differences, both evolutionary and new growth theories depart from the same idea, that they refute that the role of technology and innovation as exogenous (as proposed in the neoclassical model of economic growth) and that there is a causality effect between innovation and economic development. Moreover, both theories acknowledge the importance of incremental and radical innovations in this process of development. In addition, they seek to understand how innovation happens, how it impacts the economy and how it can be propagated. Thus, evolutionary and new growth theories have the same elements and objectives. What changes, though, is that the new growth theory is locked in quantitative methods on measuring impacts of innovation whilst the evolutionary theory considers a broader range of methods and solutions to understand the same phenomenon. Another relevant aspect is the recognition of knowledge as a precursor of innovation because how firms manage knowledge dictates how they succeed with innovation (Grillitsch, Schubert, and Srholec, 2019; Salunke, Weerawardena and McColl-Kennedy, 2019; Nonaka and Takeuchi, 1995).

3.2.3 Economics of knowledge paradigm

Another paradigm approached is the literature on the economics of knowledge, in which knowledge-based economies rely on production, distribution and use of knowledge and information (OECD, 1996). Innovation is viewed as the result of knowledge-based activities that leads to the practical application of new knowledge (OECD, 2018). The literature review reveals that this paradigm is not as exclusive and competing as the previous two paradigms. As

the next section indicates, economics of knowledge is a core aspect for understanding the phenomenon of innovation because the relationship between tacit and codified knowledge is essential for such understanding. Knowledge is understood as having a cumulative nature, that is, as new revelations are made, there is progressive learning about specific areas. Another aspect of knowledge in this doctrine is uncertainty. Production and distribution are subject to uncertainty and, for this reason, investment in knowledge is risky. Furthermore, knowledge production involves dealing with lags, for example, the length of time it takes from the start of a research until its conclusion with an applicable knowledge (Blakeley, Lewis and Mills, 2005). As for the characteristics of knowledge of non-rivalry and non-excludability, they are subsequently discussed in the next section.

3.3 Knowledge

Knowledge, clearly an essential part of the process of Knowledge Spillover (KS), is the basic understanding required to conduct the current research. Knowledge is identified as a key aspect of innovation and regional economic growth (Harrison and Turok, 2017; Őnday, 2016; Kamyab, 2014; Tappeiner, Hauser and Walde, 2008; Krugman, 1991; Romer, 1990). Knowledge helps firms to generate successful products and processes in the market as well as supporting regional competitiveness. Thus, this section presents concepts related to knowledge that are derived from the literature review on innovation, KS and regional economic development, and explains the types of knowledge and how knowledge can be created and transmitted.

3.3.1 Basic concepts of knowledge

The most accepted definition of knowledge, according to Bolisani and Bratianu (2018), is justified true beliefs (Nonaka and Takeuchi, 1995). It is important for firms to provide knowledge to employees because it consists of the cognitions and abilities that individuals use to solve problems, make decisions and understand incoming information (Döring and Schnellenbach, 2006). As knowledge provides firms with long-term capabilities and complements the success and well-being of individuals and communities (Howells, 2002), the importance of knowledge is widely recognised whether it is within a society or a business organisation (Akram, Siddiqui, Nawaz, Ghauri and Cheema, 2011). Knowledge is especially important for regional economies because when a region reaches the equilibrium state, growth

is mainly facilitated by an increase in the total amount of knowledge in that region (Smolny, 2000; Pratt and Zeckhauser, 1985).

Knowledge is identified among the most strategic resources for firms because it is crucial for their innovation process (OECD, 2018). However, knowledge depends on what the organisation does with that knowledge. Thus, knowledge management plays an important role in innovation through transforming knowledge, which is the cause for innovation, into knowledge assets for organisations (Akram, Siddiqui, Nawaz, Ghauri, and Cheema, 2011). Moreover, knowledge is crucial for the innovation process and this relationship is influenced by geographical proximity. As organisations learn from each other, the geographical proximity they share leads to greater levels of knowledge dissemination and innovation (Howells, 2002).

However, acquiring knowledge does not necessarily lead firms to innovation, even though knowledge is a key part of the process. It is what firms do with the knowledge they acquire, that is, how they apply it that helps their innovative capacity and capability. Thus, as stated above, knowledge management plays an important role in innovation through transforming knowledge, which is the cause for innovation, into knowledge assets in firms (Akram, Siddiqui, Nawaz, Ghauri, and Cheema, 2011). Innovation will happen only when firms succeed in converting knowledge into marketable goods and services that produce economic value (OECD, 2018; Fischer and Fröhlich, 2013). Thus, different authors explain the nature of knowledge and how it can be turned into innovation (Shujahat, Sousa, Hussain, Nawaz, Wang and Umer, 2019; Cowan, David and Foray, 2000; Nonaka and Takeuchi, 1995; Lundvall and Johnson, 1994; Polanyi, 1962). For example, Polanyi (1962) showed how knowledge can be transmitted between firms by considering essentially two different but complementary types of knowledge, namely tacit and codified. Nonaka and Takeuchi (1995) further elaborated tacit and codified knowledge by explaining that they are not separate elements, but part of a process that leads to firm innovation. However, Cowan, David and Foray (2000) believed that innovation is derived from technical knowledge as all technical knowledge is tacit because it cannot be articulated as it is highly specific and conditional on the capability of the receiver to decode the messages, which varies according to their expertise in the field.

Lundvall and Johnson (1994) identified four types of economically useful knowledge. Firstly, know-what is the concept of the facts, i.e. understanding that there is evidence of a particular incident. Secondly, know-why is the scientific knowledge that allows the development of technological innovations. Thirdly, know-who refers to knowing people who retain knowledge

on social relations. Finally, know-how is the knowledge that comprises of skills and abilities. Both know-who and know-how, however, are more difficult to codify and transfer (Lundvall and Johnson, 1994).

According to the OECD (2018), "information consists of organised data and can be reproduced and transferred across organisations at low cost. Knowledge refers to an understanding of information and the ability to use information for different purposes" (p. 46). Thus, knowledge is the result of an evolution of elements, namely data and information (Zins, 2007; Lambooy, 2002). These elements belong to a sequence that evolves according to the usefulness to the bearer. Data by itself does not have any meaning, as it consists of unstructured facts. When data becomes structured, it is information. Knowledge is derived from the competence of individuals to evaluate information and solve problems (Lambooy, 2002). Dunning (2002) identified the difference between knowledge and information by explaining that information can be easily codified whilst knowledge is difficult to codify and is serendipitously recognised.

Three interconnected characteristics are inherent to knowledge, namely, structure, process and function. The structural characteristic considers knowledge as formed by information (Albino, Garavelli, and Schiuma, 1998). The process characteristic explains that knowledge is a set of information associated to a meaning by an individual's or organisation's interpretation process (Huber, 1991). Finally, the functional characteristic shows that once knowledge is obtained, skills and competencies are defined and that allows activities to be conducted. Gained skills and competences relate to a certain task considered as a goal that can be achieved in a given condition (Leplat, 1990).

The seminal work of Polanyi (1962) that classifies knowledge as tacit or codified has been recognised by previous researchers because he has deepened the discussion on the types of knowledge as regards their role in scientific discovery (for further details on this subject see Ortiz, 2013; Fallah and Ibrahim, 2004; Howells, 2002; Feldman, 2000). Tacit knowledge is personal, difficult to communicate and dependent on the context. Polanyi (1962) explained that tacit knowledge involves direct experience that cannot be codifiable via artefacts. Thus, it requires individual articulation to be transmitted. Conversely, codified knowledge is explicit and can be easily transferred in formal language, procedures and standardised principles (Polanyi, 1966). Such explicit knowledge is thus a knowledge of rationality (Nonaka and Takeuchi, 1995). Both concepts, however, are not separated but part of a process (Ortiz, 2013; Nonaka, Byosiere, Borucki and Konno, 1994; Polanyi, 1962) as tacit knowledge is required to

understand codified knowledge (Polanyi, 1966). According to Nonaka, Byosiere, Borucki and Konno (1994), tacit knowledge can become codified (called externalisation) as codified knowledge can become tacit (called internalisation). Once knowledge becomes codified (or explicit) it can be transferable and available to anyone. Therefore, it is more difficult for the bearer of knowledge to control who receives it or how it can be used.

3.3.2 Knowledge transmission and its geography

OECD (2018) proposed a framework to explain the knowledge-based interactions that, based on knowledge flows, happen in a region and lead to knowledge transmission and diffusion of innovation to a regional scale. There are many types of knowledge-based interactions that can occur between the different actors in a region and propagate knowledge flows. These interactions create knowledge networks and knowledge flows that vary according to the type of knowledge and the actors that take part (see Table 3.1).

Determinants for the type of knowledge network	Types of regional actors
1. The extent to which the knowledge is tacit or codified 2. Excludability (mechanisms that impede other parties from using the knowledge) 3. Degree of novelty, i.e. whether the knowledge already exists or still needs to be developed	All organisations, agents or individuals in a region can be actors involved in knowledge flows. These regional actors are divided as follows: 1. Industry sector 2. Institutional affiliation (whether the organisation is part of a group) 3. Supplier or user of knowledge 4. Capability attributes 5. Relatedness or distance between entities

Table 3.1 Determinants for the type of knowledge network available in a region and type of actors involved (Source: Based on OECD, 2018)

As per Table 3.1, there are three determinants for the type of knowledge network available in a region. They are (i) the extent by which the knowledge available is tacit or codified determines the degree of rivalry in the use of the knowledge as tacit knowledge is more difficult to transmit than codified knowledge; (ii) excludability in the application of knowledge can be achieved by enforcing IP (intellectual property) rights, secrecy, agreements or social norms; and (iii) the degree of novelty determines how much, for example, firms that are involved in R&D cooperation are willing to join efforts in order to develop the innovation and launch it in the market. Moreover, regarding the type of actors that are involved with the knowledge flows in a region, it is important to consider five criteria. The first criterion, industry sector, is relevant because it indicates the type of knowledge being exchanged and suggests the degree of

excludability. The second criterion, institutional affiliation of the actors, needs to be addressed because a stand-alone firm may have more control over knowledge and less resources available to create knowledge than firms that are part of a group. The third criterion, whether the actor is a supplier or user of knowledge, defines whether actors use, supply, search for knowledge or both supply and use knowledge. The fourth criterion determines the absorptive capacity of individuals and organisations to apply knowledge obtained from other organisations in the region, that is, the ability of these individuals and organisations to recognise and assimilate new information in order to commercially apply it (Cohen and Levinthal, 1990). The fifth criterion refers to the existence of formal ties or similarities between regional actors, which are necessary for identifying a measure of distance in order to predict how likely knowledge flows are going to happen (OECD, 2018).

OECD (2018) also explains that knowledge flows that are present in a region can occur intentionally and non-intentionally. Intentional knowledge flows can happen through formal linkages between different parties involved as, for example, in R&D cooperation. This kind of knowledge flow can also happen when a firm uses reverse engineering in order to copy products from the competition or acquire knowledge by reading publications. Intentional knowledge flows can also happen informally through discussions in research or professional settings. Unintentional knowledge flows, also known as knowledge spillover (KS), are often unwelcome to and unwanted by the firms who create the knowledge because their competitors may end up knowing about their innovations. Unintentional knowledge flows can even be illegal, such as knowledge acquired through industrial espionage or misuse of knowledge protected by patents.

Previous empirical research investigating how flows of knowledge happen in regions is limited in number. One example, Pickernell, Senyard, Clifton, Kay and Keast (2007), is relevant for the current research because it explores KS and the flow of knowledge in regions by evaluating the capabilities of knowledge users and the effectiveness of knowledge transfer. As a result, Pickernell et all. (2007) developed a framework to examine these aspects at both local and non-local levels using the Australian biotechnology industry sector as a case study. Based on interviews with stakeholders (from industry, academia and government), Pickernell et al. found evidence of a number of different firms' governance modes at work simultaneously as well as KS from other firms and public organisations, such as universities.

The process of knowledge transfer was also explained by previous research. For example, the capacity to engage with knowledge transfer is a key factor for a firm to adapt to changes, innovate and become highly financially viable (Cohen and Levinthal, 1990). Comprising of a sequential process (see Table 3.2), knowledge transfer is important for both intra-firm and inter-firm perspectives. Inter-organisational knowledge transfer consists of collaboration agreements that can range from licensing agreements to research contracts to joint ventures (Albino, Garavelli, and Schiuma, 1998). Firms' success can rely on their capacity to transfer the knowledge incorporated in managerial practices from one organisation to another (Szulanski, 1996) as well as to enhance their competences by grasping new technologies (Gilbert and Cordey-Hayes, 1996). Technology is also different from knowledge due to its practical nature. Technology is the set of techniques used to develop products and services as well as the techniques developed with the employment of scientific knowledge and the scientific method (Cantisani, 2006). However, in order to learn a technology, it is necessary to have knowledge transfer. Knowledge transfer (see Table 3.2) is a learning process that comprises of five stages with increasing levels of information internalisation by the recipient organisation (Baranson and Roark, 1985).

1	**Acquisition**	Acquisition of information from an external organisation
2	**Communication**	Distribution of information within the organisation
3	**Application**	Utilisation of information within the organisation
4	**Acceptance**	Individual acceptance towards the applied information
5	**Assimilation**	Process of cumulative learning

Table 3.2 Five stages of Knowledge Transfer (Source: adapted from Baranson and Roark, 1985)

These five stages (see Table 3.2) form a process that can be used for managing the development of new knowledge within the organisation (Gilbert and Cordey-Hayes, 1996). The first stage of knowledge transfer is acquisition, which is the simple acquisition of information from an external organisation. The second is communication, i.e. distributing the information within the organisation. The third stage is application, which is applying the information within the organisation. The fourth is acceptance, which is the individual acceptance of applied information. The last stage is assimilation, which is related to the process of cumulative learning concerning changes in the abilities of individuals and in the routines of the organisation as an outcome of the knowledge.

Geographical regions and the location of firms matters considerably for knowledge transmission. Tacit knowledge is dependent on location as knowledge is bound to the specific backgrounds, interpretations, experiences and convictions of the individuals who are involved

with it (Ortiz, 2013). Thus, tacit knowledge encompasses technical and cognitive aspects (Nonaka and Takeuchi, 1995). Some authors defend that the effectiveness for the transmission of knowledge depends on the degree of codification, that is, the more codified (or explicit) knowledge is, the better it is transmitted. When knowledge cannot be easily codified, it can be due to the tacit nature of the knowledge which requires face-to-face interaction. The more opportunities for face-to-face interaction the better it is for absorbing tacit knowledge (Howells, 2002; Dunning, 2002; Feldman, 2000). Other authors have a view on flows of technological knowledge between firms and other institutions located in close geographical proximity and assume that any kind of technological knowledge is considered tacit because it is very specific and requires certain capacities from both the bearer and the recipient to decode the messages that vary according to their cognitive history and experience in the industry (see for example Cowan, David and Foray, 2000; Cohen and Levinthal, 1990).

Therefore, understanding knowledge derived from KS requires complementary knowledge that is obtainable in one's learning path (Döring and Schnellenbach, 2006; Cowan, David and Foray, 2000). This relates to the concept of path-dependency, in which understanding and adopting new technologies is subject to previous understanding and adoption of other technologies. Path-dependency filters firms and individuals that will absorb and apply new technological knowledge. As a consequence of distance making considerable difference in transmitting both tacit and technological knowledge, firms need to be close to each other in order to allow face-to-face interaction and knowledge transmission. Table 3.3 indicates the aspects that determine the importance of geographical proximity identified by Howells (2002) in a study aimed at critically reviewing literature that indicates knowledge as important to innovation and economic geography.

Aspect		Explanation
1	Geographical environment	the influence of cognitive, social, cultural and economic circumstances
2	Human interaction	forged by links to the region and bound by distance
3	External information	geographically constricted due to costs and acquisition barriers
4	Learning	knowledge depends on learning, which is influenced by specific locations
5	Individual interpretation	relies on experiences and is bound by location

Table 3.3 Aspects that support the correlation between knowledge transmission and close geographical proximity (Source: Author)

There are five different aspects that support the correlation between knowledge and close geographical proximity of organisations (Howells, 2002). First, knowledge relates to the geographical environment, thus individuals located in a particular region are affected by cognitive, social, cultural and economic circumstances. Second, knowledge depends on human interaction, which is also forged by links to the geographical environment and bound by distance. Third, knowledge of an individual requires information externally acquired, which is geographically constricted because of costs and acquisition barriers. Fourth, knowledge depends on learning, which is also influenced by a specific location. Finally, information has to be filtered and interpreted by individuals, which in turn rely on experience and are bound by location.

This section of the chapter explored the importance of knowledge transmission for innovation. It may not necessarily imply that a firm will innovate or be innovative once it acquires knowledge as it depends on what the firm does with the new knowledge. However, literature shows that, as regards regional knowledge transmission, knowledge plays a tacit role due to the necessary technical background for understanding its potential for innovation that is required from both the transmitter and the recipient. Moreover, knowledge is an important part of the innovation process. This section also explained how important it is to be close to other organisations in order to receive knowledge and convert it into innovation. Other points that are of implication to this research are the regional differences as regards knowledge. Due to their own trajectories, regions acquire and apply knowledge according to their location, level of human interaction, learning and capacity of individual interpretation.

By analysing previous studies on knowledge transmission and its geography, it is noted that there is a clear distinction between knowledge transfer and Knowledge Spillover (KS). The difference lies in the intention. If there is intention from the innovative organisation (firms, research centres, universities, government agencies) to transmit knowledge to firms, this is a case of knowledge transfer. However, if there is no intention for their knowledge to be transmitted, and this knowledge happens to be transmitted anyway, this is a case of KS. In practice, however, the distinction may not be that clear. There are many ways by which KS can happen; sometimes KS can occur even from knowledge transfer interactions. This is because a firm, by receiving intentional knowledge (knowledge transfer) from another organisation, may also learn something else from the interaction. This could be, for example, the identification of a successful management method that the 'receiving' firm can apply to become more

innovative or perhaps the identification of a production process that the firm may find complementary to its own processes; which in turn may lead these firms to further collaboration through joint R&D.

3.4 Knowledge Spillover

The previous section provided different aspects supporting that geographical proximity favours knowledge transmissions between firms and innovative organisations. This Section focuses on Knowledge Spillover (KS), which is a specific type of knowledge transmission. According to Fallah and Ibrahim (2004), knowledge transmissions can be intentional or unintentional. Intentional knowledge transmissions happen when firms seek to exploit their own technological assets, this process is called knowledge transfer. However, if the knowledge transmission is unintentional, the process is called KS.

KS is an unexpected effect of a firm's innovation activities that were not planned but have impacts on other firms (OECD, 2018) through unintended transmissions of knowledge (Fallah and Ibrahim, 2004). Because KS enables firms to acquire knowledge from other firms without having to pay for the costs (Helpman, 1992), it is especially important for small and new firms, which usually do not have the resources to conduct their own R&D activities to create innovation (Van der Panne, 2004; Audretsch, 1998; Feldman, 1994).

Previous studies (for example Stuetzer, Audretsch, Obschonka, Gosling, Rentfrow and Potter, 2018; Qiu, Liu and Gao, 2017; Ramaciotti, Muscio and Rizzo, 2017; Őnday, 2016; Araújo, Silva and Teixeira, 2013; Audretsch, 1998; Jaffe, Trajtemberg, and Henderson, 1993; Glaeser, Kallal, Scheinkman and Shleifer, 1992; Griliches, 1990; and Arrow, 1962) identified that geographical proximity between firms and innovative organisations is important for KS to happen because it enables frequent face-to-face interactions that are key to generate these unexpected innovation effects. However, Marshall (1890) is credited with being the first author to suggest the existence of KS. Marshall said that 'when an industry has thus chosen a locality for itself, it is likely to stay there long: so great are the advantages which people following the same skilled trade get from near neighbourhood to one another. The mysteries of the trade become no mysteries; but are as it were in the air' (Marshall, 1890, p. 225). Thus, Marshall suggests that KS effects happen because of firms concentrated in the same region.

Even though literature on KS widely recognises the positive impacts of these unintended transmissions of knowledge on innovation performance, previous studies have not fully

explained how KS happens within regions. The reason, according to Krugman (1991), is that KS is invisible and complex, that 'knowledge flows……are invisible, they leave no paper trail by which they may be measured and tracked' (Krugman, 1991, p. 53). Krugman (1991) undermined the importance of KS as a reason for clustering firms because it cannot be modelled or explained scientifically, only through assumptions. Since Krugman (1991), literature on KS has progressed considerably as demonstrated by Cerver-Romero, Ferreira and Fernandes (2018) who explored quantitatively the content of 1,568 papers on KS published between 1991 and 2017. They identified that the theory on KS evolved into five areas, namely (i) location; (ii) agglomeration; (iii) institutional approach; (iv) demography; and (v) KS of entrepreneurship.

However, an extensive review of these five areas by the current research indicates that the literature on KS has not been able to explain the process of KS, which, nearly thirty years later, supports Krugman's (1991) assertions. Previous research that focused on explaining the process of KS is scarce and certainly does not focus on the regional context and how it influences regional innovation outcomes. For example, Ko and Liu (2015), by interviewing representatives of registered charities in the U.K., developed a framework by which proactive third sector organisations can benefit from KS. Ko and Liu recognised the lack of research on channels of KS and proposed that social enterprises' social and human capital are the two most relevant channels for third sector organisations to create organisational actions. However, there are no studies that identify what the channels are that support firms to benefit from KS at the regional level. Moreover, Fitjar and Rodríguez-Pose (2017), by identifying this same gap in the literature, surveyed 542 firms in Norway and found no empirical evidence of KS deriving from geographical proximity. But they suggested that '….it may also be the case that, by actually asking a large number of firm managers about how the relationships that are key to innovation within their firm emerged, we are finding that something that has been long assumed may require further scrutiny' (Fitjar and Rodríguez-Pose, 2017, p. 23), which implies that the process of KS still needs further research and investigation in order to be fully understood and explained. Thus, both Fitjar and Rodríguez-Pose (2017) and Ko and Liu (2015) identified the lack of research explaining KS and the channels by which KS happens.

3.4.1 Geographical and sectoral proximity in knowledge spillover

Geographical proximity is paramount for KS to happen at the regional level because firms and different organisations need to be close to each other in order to allow face-to-face interactions

(Anselin, Varga and Acs, 1997). KS is the result of such interactions due to its tacit nature, however, knowledge takes time to spill over and is often incomplete (Caniëls, 2000), only codified knowledge can be shared quickly and over distance (Döring and Schnellenbach, 2006). The kind of knowledge resulting from KS is essentially technical and scientific, thus it is tacit for being very specific and requiring certain capabilities from both the transmitter and the receiver (Döring and Schnellenbach, 2006; Cowan, David and Foray, 2000).

Previous research has already provided empirical evidence that geographical proximity is conducive to innovation due to KS effects (Oerlemans and Meeus, 2005). For example, Oerlemans and Meeus (2005), based on a survey administered to 5,500 manufacturing and service firms in the Netherlands, found that geographical proximity favours innovation performance. In addition, Ortiz (2013) explored the differences by which Regional Innovation Systems (RIS) can benefit from knowledge transfer that happens between firms and innovative organisations. Based on the context of innovation systems in Germany, Spain and the United Kingdom, Ortiz found that regional organisational configurations can influence knowledge transfer outcomes to firms in close geographical proximity. However, KS from geographical proximity cannot be verified in every analysis. For example, Araújo, Silva and Teixeira (2013) tested the importance of KS in small, peripheral and economically depressed areas through a survey administered to 259 firms in the municipalities of Vale do Ave, Portugal and found no KS effects from geographical proximity.

KS and geographical proximity are also discussed as regards the level of heterogeneity of industry sectors. As for this matter, there is a theoretical debate whether geographical proximity of firms from the same industry sector is more conducive to innovation than geographical proximity of firms from different industry sectors (see next sub-section 3.4.2, Theories of knowledge spillover).

A more disaggregated approach to KS (called sectoral KS) has focused on proximity between firms because they belong to particular industry sectors rather than geographic locations. Sectoral KS plays an important role in industries where new economic knowledge is a key asset. This particular knowledge is captured by firms, universities and skilled labour (Audretsch and Feldman, 1996) and then unintentionally transmitted to other organisations. Sectoral KS is also observed in industry sectors that are still new in the market (Döring and Schnellenbach, 2006).

Cooke and De Laurentis (2010) identified KS effects that are derived from sectoral proximity due to an investigation of networks of collaboration in high-tech clusters from three industry sectors. Their findings suggest that interactions between high-tech firms from the same industry sector evolve to networking and cooperation, and that the result of these interactions generate better innovation outcomes than the results of the interactions between high-tech firms from different industry sectors. As a result, a region that has a cluster of firms in sectoral proximity perform better on innovation than regions that have a cluster with firms from different industry sectors.

Malerba (2002) and Edquist and Chaminade (2006) found that when the capacity to protect innovation from other firms in an industry sector is low, KS effects are stronger. Moreover, previous research suggests that sectoral KS happens in industries that are more scientific in nature and not dependent on location (Howells, 2002). KS within industry sectors has been tested empirically in different contexts. For example, Anselin, Varga and Acs (2000), using sectoral disaggregated data from the US Small Business Administration Innovation explored KS from universities and found evidence of the importance of university KS in the electronic, machinery and instruments industry sectors. In addition, Cooke (2002) found evidence of KS within the biotechnology industry sector in both the US and the UK.

3.4.2 Theories of knowledge spillover

This sub-section presents the views of previous studies addressing KS through the perspective of the industrial setting of the region (Cerver-Romero, Ferreira and Fernandes, 2018; Beaudry and Schiffauerova, 2009; Van der Panne, 2004; Park, 2001; Glaeser *et al.*, 1992; Romer, 1990; Jacobs, 1969; Arrow, 1962; Marshall, 1890) and also through the perspective of firms from different sizes (Iammarino and McCann, 2010; McCann and Mudambi, 2005; Feldman, 1994). These studies are pertinent to the current research because they provide findings that refer to theories that explain how KS can happen at the regional level.

The studies that focus on the industrial setting of the region to explain KS are commonly divided by two competing theories. Firstly, the specialisation theory (Romer, 1990) explains that KS is intra-industry, i.e. the concentration of firms from the same industry sector facilitates KS and leads to innovation and growth. Secondly, the diversification theory (Jacobs, 1969) argues KS is inter-industry, that is, the geographic association of firms from different industry sectors is conducive to KS and innovation (Jacobs, 1969).

Thus, these theories can be interpreted as models that explain how KS can cause innovation. The first model, often referred to as specialisation model, was originated through the research of Marshall (1890) on agglomeration of industries and posits that the concentration of firms from the same industry sector is conducive to KS and innovation because of the interactions between high-skilled workers from different firms who live and work in the region. This view was later developed by Arrow (1962) and Romer (1990) and, due to their continuous work, Glaeser et al. (1992) created the acronym MAR to address the theory of these three authors (MAR (Marshall, Arrow and Romer) or specialisation spillover). Arrow (1962) developed the specialisation theory of KS by indicating the importance of scientific knowledge for the industry sector concentrated in the region and approaching uncertainty as a relevant aspect in KS. Arrow also introduced the characteristics of partial excludability and non-rivalry for KS. The specialisation theory of KS was further developed by Romer (1990) by proposing a growth model that explained economic growth as driven by innovation and KS effects.

The second model was created by Jacobs (1969) (Jacobs or diversification spillover) and posits that the concentration of firms from different industry sectors is conducive to KS and innovation. According to Jacobs (1969), the availability of a diverse composition of economic agents and firms from different industry sectors makes cities the ideal setting for KS and innovation. As cities become bigger and offer a wider variety of goods and services, inter-industry interaction grows into more sophisticated opportunities for KS and innovation. Such settings enable firms to interact, exchange ideas and solutions that can be applied in more than one industry sector (Jacobs, 1969). As regional production keeps growing, the region starts consuming more products from other regions. As a result, a multiplier effect takes place in the region. Local firms start producing the products that used to be produced somewhere else. At the same time, the region starts selling more products to other regions and consuming new products that are not produced in the region. Thus, over time, the interactions between firms and individuals from a diversified number of industry sectors transmit relevant knowledge to the region that can lead to an increase in the levels of both production and consumption (Glaeser et al., 1992; Jacobs, 1969). Moreover, Porter (1990) developed Jacobs' (1969) model by introducing competition as a key element that can stimulate imitation and continuous innovation.

There is a vast quantity of studies providing empirical evidence supporting either Specialisation or Diversification as conducive to KS and innovation. Notably, these studies address a

'*mutually exclusive'* debate by suggesting that either Specialisation or Diversification happens at the expense of the another. For example, the first study addressing this debate was conducted by Glaeser *et al.* (1992) and the findings, based on US manufacturing firms, suggest that KS and innovation happen because of Diversification rather than Specialisation. 'The evidence suggests that important knowledge spillovers might occur between rather than within industries [sectors]' (Glaeser *et al.*, 1992, p. 1126). The argument by which studies suggest that Specialisation is conducive to KS is also rather exclusivist. For example, Van der Panne (2004) investigated KS in Dutch regions and found that Specialisation, and not Diversification, favours relevant R&D outcomes. For example, 'a regional specialisation towards a particular industry tends to increase regional innovativeness in that industry. This suggests that intra- rather than inter-industry knowledge spillovers positively affect regional innovativeness' (Van der Panne, 2004, p. 595).

Other previous studies exist considering both Specialisation and Diversification as conducive to KS exist, but these studies are limited in number. One example is the work of Park (2001) which, based on innovation strategies adopted by policy makers in Korea, suggests that both Specialisation and Diversification can be considered by policy-makers in order to generate KS. Park (2001) favours a region specialised in mainly one industry sector for better innovation outcomes, but also comprised of firms from other industry sectors that contribute to its value-added chain. Park's findings suggest that, for generating KS effects, it is important for firms from one main industry sector to network with firms from other specific industry sectors that can help them with innovation. Thus, Park is in favour of Specialisation and a limited degree of Diversification for KS to happen. Another example is the work of Farhauer and Kröll (2012), based on German regions, who found that when cities specialise in a few industry sectors, i.e. diversified specialisation, the effects of KS are stronger if compared to regions that concentrate firms from many different industry sectors. Their findings show that both Specialisation and Diversification (to a certain extent), are important for KS, which is relevant because this study is among the few that acknowledges the importance of both channels of KS to regions.

Even though the Specialisation/Diversification debate has been ongoing for decades, it is still very relevant today. This was demonstrated by Cerver-Romero, Ferreira and Fernandes (2018) who, with the objective of identifying trends in KS research, found that the seminal paper on this debate, Glaeser *et al.* (1992), is the second most cited paper in the KS literature. However, it is necessary to consider other channels by which KS can happen, as alerted by Beaudry and

Schiffauerova (2009); these authors, by reviewing 67 papers addressing the Specialisation/Diversification debate, concluded that 'much more work is needed to go beyond the implicit interpretation of the underlying concept of specialization and diversification externalities in order to fully understand such an abstract phenomenon as knowledge spillovers' (p. 334).

Apart from trying to understand KS from the perspective of the industrial setting, i.e. specialisation and/or diversification, previous studies also addressed KS through the perspective of firms from different sizes. Based on the transaction costs theory, which explains that KS is beneficial to firms as long as there is an assessment of the relative importance of knowledge inflows and outflows, Iammarino and McCann (2010) and McCann and Mudambi (2005) proposed three industry-related theoretical models that explain the effects of KS on small and large firms that can be explained as follows.

1. The 'pure agglomeration' model describes the concentration of small companies with a broadly competitive market structure. In order to function, these companies need to acquire a kind of knowledge that is explicit and broadly available because it is originated in public institutions, such as universities and research centres. The resulting KS from the interactions between companies and institutions generally has positive impacts in the region.
2. The 'industrial complex' model considers a few innovative large companies with large market share in a region with a concentration of small companies. Small companies greatly benefit from regional knowledge inflows. Innovative large companies, however, realise that knowledge outflows are costly as they lose competitive advantage by benefitting their competitors with input for innovation. As a consequence, these large companies are unwilling for KS to happen as they do not benefit from regional knowledge flows as much as their competitors.
3. The third model, 'the social network', is based on trust. Thus, when the level of trust between firms in the same region is high, networking tends to lead to more R&D collaboration and KS. The social network model comprises of two distinct versions, (i) the old social network explains networks as rooted in historical experiences and based on social proximity, e.g. membership in a professional network. There is no focus on visible hierarchical structures, such as the differentiation between small and large companies; and (ii) the new social network

> is concerned with the innovative behaviour of small firms due to their inherent characteristics that allow flexibility and agility. In the latter aspect, technological opportunities are high although uncertain and with a low degree of cumulativeness. Knowledge is available from sources outside the company, such as universities and research centres. In addition, KS tends to be generic and non-systemic. Therefore, the occurrence and extent to which KS happens depends on the relationship between firms with their industry sector as well as backward or forward supplier-buyer relationships.

Thus, the pure agglomeration, industrial complex and new social network are theoretical models that propose that small firms benefit more from KS than large firms. Other research also provided empirical evidence suggesting that KS is more beneficial to small firms. Van der Panne (2004), for example, based on a survey administered to firms located in different regions in the Netherlands, found that small firms benefit more from KS than larger firms, especially from Specialisation effects. According to Van der Panne, this is relevant because small firms typically 'rely on firm-external knowledge more than do large firms, since the resources needed for maintaining the knowledge base are typically beyond the means of small firms' (p. 601). Feldman (1994), based on a census of innovation citations from over 100 scientific and trade journals, found that innovative small firms benefit more from KS from university research than large firms do. According to Feldman, 'the results…….suggest that small firms rely more on external sources of input to the innovation process. Small firms appear able to generate innovative outputs while undertaking negligible amounts of investment in R&D by capturing spill- overs from university research' (p. 370).

The fact that previous studies favoured small firms over large firms to benefit more from KS effects (Iammarino and McCann, 2010; McCann and Mudambi, 2005; Van der Panne, 2004; Audretsch, 1998; Feldman, 1994) is interesting because it sustains a general belief that small firms, because of their limited size and structure, are more flexible and agile than their larger counterparts, which enable them to comply faster with new and different opportunities.

As a final considerations for this section on the theories of KS, it is pertinent to assert that literature strongly suggests that specialisation and diversification are key means by which KS and innovation can happen, even though there is disagreement as to which is the more relevant. Moreover, based on a limited number of studies, it is seen that KS effects are generated from the interaction of firms not only from the same industry sector but also from a mix of industry

sectors the region (diversified specialisation). However, it is this researcher's opinion that diversified specialisation may be just a broader interpretation of the term specialisation. Since specialisation consists of firms from the same industry sector and region, it is not clear whether the scope of an 'industry sector' considered in previous research is limited to firms from the exact same activity or if it includes firms involved with related activities. For example, textiles may be an industry sector for some, while for others it may be an umbrella term that includes different industry sectors, such as clothing, fabric production and screen painting. It is important to consider this point because, for some authors, diversified specialisation, i.e. when a region specialises in a number of industry sectors which are interrelated, may be considered to be a region specialised in one particular industry sector. On the other hand, this same region could be considered as comprising of firms from different industry sector, which is therefore a case of diversification. Therefore, it is debatable as to whether one can label a region as specialised or diversified in relation to its industry sectors.

3.4.3 Channels of knowledge spillover

This section presents channels of KS that were found in previous research that can contribute to innovation in firms from different industry sectors and regional contexts. As the purpose of this study is to explain KS at the regional level, it is relevant to identify the channels of KS i.e. the means by and the sources through which KS happens and that can influence innovation outcomes. Each of these channels of KS corresponds to a specific instance that, according to previous research, triggers the process of KS and, consequently, explains, partially, how KS happens.

Some studies investigated channels of KS as a group (Halpern and Muraközy, 2007; Görg and Greenaway, 2004; Harabi, 1997; Levin, Klevorick, Nelson, Winter, Gilbert and Griliches, 1987), which could reveal the role of different channels as compared to others. However, most of the literature on KS focus on channels of KS individually, and explains that KS happens exclusively as a resultant of the channel of KS that was under investigation. This section considers both of these types of studies. The first subsection focuses on studies that considered channels of KS individually and the second focuses on studies that explained KS through groups of channel. The third and final subsection identifies which channels are relevant for KS at the regional level.

3.4.3.1 Previous studies considering channels of KS individually

Some previous research focusing on channels of KS indicates that KS happens through interactions between firms and organisations that are transmitting knowledge. The more innovative the organisation that creates KS, the better for the firms that interact with this organisation because they may obtain knowledge to create innovation themselves, depending on how the knowledge is used. Literature suggests different channels by which these interactions can be facilitated and KS created at the regional level. This subsection reviews key studies that focus on these channels individually.

Geographical proximity is a key channel for KS to happen at the regional level because it facilitates interactions between firms and other regional stakeholders (Carreira and Lopes, 2018; Hervás-Oliver, Sempere-Ripoll, Alvarado and Estelles-Miguel, 2018). Firms located in close geographical proximity to other firms and different organisations benefit from KS because they have more opportunities for face-to-face interactions (Tappeiner, Hauser and Walde, 2008; Krugman, Wells, and Graddy, 2008; Audretsch and Feldman, 2004; Anselin, Varga and Acs, 1997; Krugman, 1991). This happens because of the tacit nature of the knowledge that is facilitated through interacting with high-skilled workers (Döring and Schnellenbach, 2006). Even though close geographical proximity has a positive impact on KS and innovation, not all firms benefit equally. Based on a panel of Portuguese manufacturing firms, Carreira and Lopes (2018) identified that KS has non-linear effects and differences among industries. Moreover, by analysing a large dataset of Spanish firms from a survey on innovation, Hervás-Oliver et al. (2018) detected that co-location in an agglomeration has a positive influence on a firm's innovative performance and that firms benefit heterogeneously from agglomeration, with benefits being distributed asymmetrically. A previous section provides more details about how geographical proximity spurs KS (see Section 3.4.1 Geographical and sectoral proximity in knowledge spillover).

There are different ways by which interactions leading to KS may happen. For example, any informal interaction between firms, and other regional stakeholders such as Higher Education Institutions (HEIs), government agencies and other firms, with employees of innovative organisations can contribute to firms benefiting from KS. Therefore, networking between employees from different firms and organisations is a channel of KS because it leads to

knowledge interactions leading to knowledge exchange. Networking, however, is more focused than a random interaction between regional stakeholders because it happens between individuals with the same kind of interest (such as industry sector, technological knowledge, regional infrastructure and so on) which can help with generating ideas or solutions for business problems and support innovation outcomes.

Previous studies have already identified a positive correlation between networking and KS (Forsman and Temel, 2016; Mahmood and Rufin, 2005; Breschi and Lissoni, 2003; Fischer, 1999). For example, based on a survey with 708 small Finnish firms, Forsman and Temel (2016) found that networking support non-innovative firms to become high-innovation performers. The primary benefits of networking for firms are increased access to knowledge and improved ability to meet challenges. Thus, networking leads to interactions that are important for KS to happen (Mahmood and Rufin, 2005, Breschi and Lissoni, 2003, Fischer, 1999). Thus, in order for a firm to innovate through networking and KS, it needs to observe three elements in its networks, namely, the actors that belong to that network, the activities they perform and the resources they utilise (Hakánsson and Snehota, 1995). Since the level of interaction grows more intense between nearby organisations, geographical proximity plays an important role in networking (Döring and Schnellenbach, 2006).

Networking allows strategic know-how and competences to be codeveloped and shared between members of the network. One example is research cooperation between firms' employees and academic experts, in which interactions create networks that share crucial knowledge for innovation (OECD, 1996). Another example of networking occurs through organisational interactions, seminars and social outings (Fallah and Ibrahim, 2004). In a theoretical paper, Fallah and Ibrahim (2004) argued that firms engage in such activities because they have in mind the exchange of knowledge between their employees, thus they intend their employees to benefit from KS. Firms' and customers' networks also constitute an example of KS through networking as they lead to innovations that can increase consumers' perception of value (Sawhney, Wolcott and Arroniz, 2006).

The most discussed channels of KS in research literature are specialisation and diversification. As explained in section 3.4.2, Theories of knowledge spillover, the idea of specialisation as a channel of KS was originated by Marshall (1890) who identified KS effects from firms in the same industry sector. Since Marshall the specialisation theory has grown considerably. The works of both Arrow (1962) and Romer (1990) were decisive to support newer research and,

consequently, recent literature still provides details on different aspects of specialisation supporting KS. One example is Hervás-Oliver, Albors-Carrigos, Estelles-Migel and Boronat-Moll (2018) who performed an exploratory longitudinal case study in two Marshallian industrial districts in Europe and provided empirical evidence that access to specific networks, such as leading incumbents' networks is a crucial aspect to generate radical innovation in such regions. In addition, Cainelli, Montresor and Marzetti (2014), based on a dataset of over 22,000 manufacturing firms from 22 industry sectors located in Italy, identified that specialisation significantly reduces the risk of firms to go out of business, especially low-tech firms.

The idea of diversification as channel of KS, already explained in section 3.4.2, Theories of knowledge spillover, was originated through the work of Jacobs (1969). Jacobs' research was supported by Glaeser et al (1992), and was further developed by other scholars such as Boschma, Coenen, Frenken and Truffer (2017) who identified that both related and unrelated diversification are conducive to KS and innovation. Related diversification derives from breakthroughs that emerge from recombining previously connected technologies into new configurations whilst unrelated diversification derives from recombining previously unconnected technologies into new configurations. Such new combinations may provide a long-term source of competitiveness as other regions that do not share the same specialised capabilities will find it hard to copy such a success (Boschma et al., 2017). Another example, Basile, Pittiglio and Reganati (2017), by considering over 160,000 Italian firms in a discrete-time proportional hazard model, identified that industry variety reduces the likelihood of firms to go out of business. Specifically, related variety was found to reduce firm closure in industry sectors and, unrelated variety, in service sectors (Basile et al., 2017).

Research and Development (R&D) is another channel of KS that is important for regional innovation. According to the Frascati Manual (OECD, 2015), R&D consists of creative and systematic work employed to increase the stock of knowledge, including knowledge of humankind, culture and society, and to devise new applications of available knowledge. Thus, if surrounding firms appropriate knowledge from the organisation conducting R&D activities, even without its consent, they can use this knowledge for their own innovation activities. The role of R&D activities in regional innovation is recognised by entities such as the European Union (EU), which uses R&D expenditure as one of the measures for innovation in their European Regional Innovation Scoreboard.

R&D expenditure is considered a prerequisite in order to progress to a knowledge-based economy, improve production technologies and provoke growth. However, many firms do not finance or conduct R&D activities, but still benefit from organisations that do conduct them. Private firms and universities make investments in R&D that will benefit other firms due to being in close geographical proximity to each other, which leads to multiple interactions capable of 'spilling over' knowledge derived from their R&D activities (Audretsch and Feldman, 1996; Acs, Audretsch and Feldman, 1994; Feldman, 1994). Geographical proximity is beneficial for R&D and innovation to happen in the region because effective learning requires face-to-face interactions, which is an easier and cheaper kind of interaction because agents are co-located (Boschma and Frenken, 2010).

The importance of R&D for KS was confirmed by Cozzi and Galli (2014), as the authors identified that if there is more legal protection for R&D activities not to 'spill over' to other firms, economic growth is hampered. However, Niwa (2016), by considering blocking patents (those that can prevent future innovations from a particular knowledge) into a mathematical R&D-based growth model, suggested that more legal protection on R&D activities may actually increase innovation rates and economic growth as it enables firms to focus on improving the quality of the goods and services that they produce.

Apart from conducting R&D by themselves, firms also rely on R&D cooperation with other firms. When KS effects from such cooperation are high enough, cooperating firms will spend more on R&D and become progressively more lucrative (Cassiman and Veugelers, 2002). This is an important reason for regional governments to support KS and R&D cooperation. Thus, R&D cooperation is a channel of KS apart from R&D by itself. This type of public policy on innovation can overcome the natural resistance for competing firms to cooperate technologically and, as a result, generate a virtuous cycle capable of spurring KS among participants (Watanabe, Kishioka and Nagamatsu, 2004).

Empirical studies demonstrate that firms which get involved with R&D cooperation benefit from KS, especially if it is cooperation within business groups and with customers, suppliers, universities (Iammarino, Piva, Vivarelli and Tunzelmann, 2012), other firms and public research institutions (Fritsch and Franke, 2004). Iammarino et al. (2012) based their findings on the Fourth UK Community Innovation survey administered to 28,000 manufacturing and service firms. Their findings indicate that R&D cooperation is significantly associated with firms' technological capabilities. On the other hand, Fritsch and Franke's findings, which relied

on their own survey administered to over 1,800 manufacturing enterprises in three German regions, suggest that R&D cooperation is of relatively minor importance as a medium for KS. Moreover, Marek, Titze, Fuhrmeister and Blum (2017), by using a spatial interaction model including eigenvector spatial filters with 402 German regions, identified that geographical proximity has a significant influence on the emergence of R&D cooperation and also that R&D cooperation activities tend to cluster in regions.

University research is also a channel of KS (see for example Haussen and Uebelmesser, 2018; Harrisson and Turok, 2017; Iammarino et al., 2012; Goddard and Kempton, 2011) and is recognised as a driver of prosperity, inclusion and regional development. University research contributes to wider forms of social enquiry, environmental innovation and critical reflection. Also geographical proximity and embeddedness are key advantages for universities to generate KS as they become agents for promotion of human interaction, transmitting know-how, and building trust and common purpose among diverse actors, including firms (Harrison and Turok, 2017). In fact, university research positively affects local economic growth and generates KS, as suggested by empirical evidence from Swedish data (Lundberg, 2017). According to Lundberg, who performed research using an econometric model based on the relationship between the number of academic publications and local tax, average income and migration to the municipality, he identified that university research does not merely affect the growth rate within the municipality hosting the university, but it also spills over to neighbouring municipalities.

Thus, the need for public policies to subsidise cooperation between university and industry is relevant and strategic for regional development. This includes subsidies for basic research cooperation as well as generating potential spillovers in the form of (i) innovations that could potentially be applicable to multiple industry sectors and (ii) benefits to subsequent applied research within the same industry of the firm that conducted the basic research. Moreover, the government should provide support to encourage universities to interact with their surroundings because many of these interactions consist of channels that can spur KS in a region (Leyden and Link, 2013, Anselin, Varga and Acs, 1997, and 2000). Some of these channels have been identified by Goddard and Kempton (2011) and justified as important to drive regional economic development, for example, consultancy services, employees' spin outs, workforce development, and both graduates' and employees' mobility to firms nearby.

R&D subsidies, according to Smith (2000), mitigate the knowledge appropriability problem of innovative firms to keep engaging in R&D activities. Innovative firms commonly generate outflows of KS to firms and organisations in their surroundings due to constant interactions that happen as a result of geographical proximity. In this process, R&D subsidies compensate for their loss of knowledge. However, the benefits of R&D subsidies go beyond the intended purpose of mitigating the loss of innovative firms and also acts as a channel of KS because the local surplus generated may be larger than the cost of the subsidy (Trajtenberg, 2009).

According to Ramaciotti, Muscio, and Rizzo (2017), there are two categories of regional innovation policy interventions. The first category, consists of hard measures, i.e. financial-type support such as loans and grants. The second category concerns soft measures, which are counselling and business advice services. Ramaciotti *et al.* (2017), based on new technology-based firms from the Emilia-Romagna region in Italy that were participating in an innovation programme, found that both soft and hard measures lead to an increase in regional growth rates. However, soft measures are more beneficial to technology-based firms, and they produce higher growth rates than the others.

Fischer and Nijkamp (2009) found that, when innovation policy interventions focus on R&D, KS and competition, they are prone to favour regional development. Competition between firms, according to Görg and Greenaway, (2004) and Halpern and Muraközy (2007), is a channel of KS because it puts firms under pressure to use technology more efficiently and also increases the speed of adoption of new technology. Local competition has two important effects in the region. First, intense competition affects profitability of firms and that leads them to search for innovation opportunities otherwise, they lose competitiveness in the market. Second, competition increases the rate of imitation of products and, consequently, the rate of incremental innovation (Porter, 1990).

Fons-Rosen, Kalemli-Özcan, Sørensen, Villegas-Sanchez, and Volosovych (2017), by trying to identify KS and competition effects from foreign investment and domestic productivity, found that when foreign firms produce in the same industry sector as domestic firms, domestic firms are negatively affected by increasing competition and positively affected by KS. Competition between these two categories of firms generates KS to domestic firms especially if they are operating in a technologically close industry sector. KS was also found to benefit firms in the region from different industry sectors if the firms are technologically close to the industry sector embedded by the foreign firms (Fons-Rosen et al., 2017).

Competitors imitate products from innovative firms through acquiring products and reverse engineering them and, as a result, the knowledge that was contained in these products is appropriated (Fallah and Ibrahim, 2004), thus reverse engineering is a channel of KS (Halpern and Muraközy, 2007; Görg and Greenaway, 2004; Harabi, 1997). Competitors can also imitate organisational innovation, also a channel of KS (Halpern and Muraközy, 2007, Görg and Greenaway, 2004) by reconsidering the extension of the activities of the firm that created the organisational innovation and reformulating the roles and incentives of different business units and individuals (Sawhney, Wolcott, Arroniz, 2006).

Other than secrecy, the most effective way to protect a technology from spilling over to competitors is to make use of patents. However, patents protect mostly codified knowledge from spilling over to competitors (Smeets and de Vaal, 2006) because tacit knowledge is more difficult to control (Döring and Schnellenbach, 2006; Romer, 1990). Patenting a technology, however, can avoid KS for a period of time only (Fallah and Ibrahim, 2004); after this point, patent disclosure becomes a channel of KS because third parties (other firms) can have access to the knowledge and the technology that was patented (Harabi, 1997).

Another channel that influences the spatial dimension is Foreign Direct Investment (FDI). FDI is defined as a category of international cross-border investment made by the direct investor in one economy that has the objective of establishing a lasting interest in an enterprise in another economy with at least 10% ownership (OECD, 2008). Previous studies recognise FDI as a channel of KS because it enables multinational firms to establish in regions from different countries and benefit the firms that interact with them by indirectly providing innovative knowledge (Delgado-Márquez, Hurtado-Torres, Pedauga and Cordón-Pozo, 2018; Roording and de Vaal, 2010; Halpern and Muraközy, 2007; Smeets and de Vaal, 2006; Branstetter, 2006). National and local governments attempt to attract FDI to their regions because multinational firms are assumed to transmit better practices in technology and management to firms in the host region (Görg and Greenaway, 2004). Delgado-Márquez et al. (2018) identified, based on the database from the Spanish Innovation Survey and a random-effects logistic model, that network relationships between multinational firms and firms located in a host region generate both incremental and radical innovation in the host region. According to Smeets and de Vaal (2006) in their study on modelling the relationship between knowledge spillovers and Foreign Direct Investment (FDI) ownership, when multinational firms decide to expand their business in another country through joint venture (union of two or more business

characterised by shared ownership), they consider the relationship between KS and the degree of ownership of the undertaking. In consideration of KS effects, multinational firms tend to choose extreme degrees of ownership in a joint venture with host firms, that is, they will either look for low degrees of ownership or they will look for a stronger representation. This is because multinationals, when partnering with firms that have similar technological development, tend to opt for a low degree of ownership, leading to high KS levels. However, when multinational firms consider KS as a threat, they increase their degree of ownership (Smeets and de Vaal, 2006).

Another relevant channel of KS is hiring skilled labour (Breschi, Lissoni and Montobbio, 2007; Döring and Schnellenbach, 2006; Dunning, 2002; Straubhaar, 2000) because knowledge accompanies skilled workers and, if they move away from the location where they originally created their inventions, knowledge is diffused to their new location (Breschi and Lissoni, 2003). The importance of skilled labour to a region as regards innovation and KS is recognised by policies on innovation, which is why governments try to attract high-tech manufacturing and skilled labour to their regions (Albalate and Fageda, 2016). Breschi and Lissoni (2003), by using data from Italian patents, found that hiring skilled workers allows firms to access both their knowledge and networks of knowledge exchange. However, spillover effects are stronger when new highly skilled employees help in creating a common pool of knowledge that existing employers can benefit from (Breschi and Lissoni, 2001). Therefore, hiring skilled employees will lead to constant interactions and learning with other employees that already work in the firm (Romer, 1990). Also hiring skilled employees is important for regions in the sense that these employees are likely to open their own enterprises at some time. Additionally, skilled mobility is particularly important for developing regions where skilled labour is scarce and local workers need training and experience (Görg and Strobl, 2005). Therefore, understanding the determinants of skilled labour employment is a key ingredient for regional policy-making.

According to Faggian and McCann (2009), another channel of KS is hiring university graduates because they are at the age where they are highly motivated to learn and consequently to exhibit productivity; and also, because their human capital is associated with the newest knowledge available. Also university graduates are relevant for KS because they usually change jobs multiple times especially in their early career and wherever they go they take the specialised knowledge acquired from university and also what they learned from the previous firm where they were working with them to their new employment organisation (Haussen and

Uebelmesser, 2018). Moreover, as identified by Audretsch and Lehmann (2005), geographical proximity between university and firms reduces the search costs for both the student and the firm and, if this proximity happens in regions that have high knowledge capacity, encourages the creation of new firms.

3.4.3.2 Previous studies considering groups of channels of KS

The literature review to date suggests that there is a lack of research focusing on the combination of more than one channel of KS. This subsection, therefore, presents examples of research with this approach (see for example Halpern and Muraközy, 2007; Görg and Greenaway, 2004; Harabi, 1997; Levin, Klevorick, Nelson, Winter, Gilbert and Griliches, 1987). By considering five channels of KS (FDI, imitation, acquisition of human capital, competition and vertical spillover), Halpern and Muraközy (2007) examined the impacts of KS through Foreign Direct Investment (FDI) in Hungary. Based on a sample of 24,000 firms, of which 25% comprised of foreign-owned firms and was heavily biased towards large firms, Halpern and Muraközy identified that FDI generates KS to domestic-owned firms located in the same region because of the influence of imitation, acquisition of human capital, competition and vertical spillover. Also examining the impact of KS through FDI, Görg and Greenaway (2003) reviewed the literature on KS in order to identify the channels that can influence FDI to generate KS and found that imitation, competition, human capital and exports are decisive in the process.

By administering a survey to Swiss manufacturing firms and performing both Exploratory Factor Analysis (EFA) and cluster analysis, Harabi (1997) explored the effectiveness of seven channels of KS (Licensing of the technology, Patent disclosures, Publications and open technical meetings, Informal conversations with employees of innovative firms, Hiring skilled labour, Reverse engineering, and R&D) and found that these channels can be divided into three groups representing patterns of learning of competitive technology. Additionally, Levin et al. (1987), by considering the same channels of KS later used by Harabi (1997), administered a survey to 650 US manufacturing firms in order to demonstrate alternative methods of learning based on their effectiveness for firms' products and processes. Based on cluster analysis, Levin et al.'s (1997) findings also demonstrate that these seven channels of KS can be divided into three patterns of learning.

3.4.3.3 Channels that are relevant for understanding KS at the regional level

Considering the relevance for policy making identified with KS effects, such as regional innovation and development, the literature considering the means and source that trigger this regional phenomenon is limited. Not only does the debate revolve around mainly two channels of KS, namely specialisation and diversification (as identified by Beaudry and Schiffauerova, 2009), it also does not focus on understanding how this regional phenomenon works (as identified by Beaudry and Schiffauerova), as most of the research techniques employed in these studies were of a quantitative nature aimed at measuring or identifying KS outputs. There is a clear lack of research approache in this sense, to the multi-channel of KS and how KS happens at a regional level. Some previous research, employing qualitative techniques, was dedicated to understanding regional flows of knowledge, where KS was somehow inserted in the process (OECD, 2018; Pickernell et all., 2007). Ko and Liu (2015) also reseaerhced how KS happens within third sector organisations (charities) in the UK. But apart from these, the literatue review to date suggests that the process of KS at the regional level has not been extensively studied nor explained.

Studies that were geared towards exploring channels of KS as groups are represented in Table 3.4.

Study	Channels of KS
Halpern and Muraközy (2007)	(i) FDI; (2) Imitation of organisational innovation; (3) Acquisition of human capital; (4) Competition between firms; and (5) Vertical spillover
Görg and Greenaway (2004)	(1) Imitation of organisational innovation; (2) Competition; (3) Human capital; and (4) Exports
Harabi (1997)	(1) Licensing of the technology; (2) Patent disclosures; (3) Publications and open technical meetings; (4) Informal conversations with employees of innovative firms; (5) Hiring skilled labour; (6) Reverse engineering; and (7) R&D
Levin, Klevorick, Nelson, Winter, Gilbert and Griliches (1987)	(1) Licensing of the technology; (2) Patent disclosures; (3) Publications and open technical meetings; (4) Informal conversations with employees of innovative firms; (5) Hiring skilled labour; (6) Reverse engineering; and (7) R&D

Table 3.4 Previous studies considering groups of channels of KS

However, as the current research seeks to explain the process of KS at the regional level and how it contributes to innovation, not all of these channels are relevant for this purpose. Firstly, Halpern and Muraközy (2007) identified five channels of KS (FDI; Imitation of organisational innovation; Acquisition of human capital; Competition between firms; and Vertical spillover). Out of these five channels, only vertical spillover is not considered relevant to explain KS within regions as it operates through different markets from different regions. Secondly, Görg and Greenaway (2004) identified four channels of KS (Imitation of organisational innovation; Competition between firms; Human capital; and Exports). The first three channels of KS are relevant for the regional approach. However, as for the fourth, exports, it was not considered relevant for this study. Thirdly, Harabi (1997), and fourthly, Levin et al., (1987), tested seven channels of KS (Licensing of the technology; Patent disclosures; Publications and open technical meetings; Informal conversations with employees of innovative firms; Hiring skilled labour; Reverse engineering; and R&D). Out of these seven channels, Licensing of technology; Publications and open technical meetings; and Informal conversations with employees of innovative firms were not chosen to be represented in the current research because they refer to examples of the interactions that happen between individuals in a region, interactions which are already embodied in all relevant channels of KS.

Moreover, by including previous studies that considered channels of KS that are relevant at the regional level (see previous section, 3.4.3.1, Previous studies considering channels of KS individually), there are fifteen channels of KS that fit this purpose for this research, see Table 3.5. In this table, Acquisition of Human capital (Halpern and Muraközy, 2007) and Human capital (Görg and Greenaway, 2004) are represented by Hiring skilled labour and Hiring university graduates in order to represent both of these different aspects of human capital.

	Channel of Knowledge Spillover	Reference
1	Interaction with employees from the same industry (specialisation)	Hervás-Oliver *et al.* (2018), Cainelli *et al.* (2014), Romer (1990)
2	Interaction with employees from different industries (diversification)	Boschma *et al.* (2017), Basile *et al*. (2017), Jacobs (1969)
3	Networking	Elvekrok *et al.* (2018), Forsman and Temel (2016), Miguélez and Moreno (2013)
4	Close geographical proximity	Carreira and Lopes (2018), Hervás-Oliver *et al.* (2018), Audretsch and Feldman (2004)
5	R&D	Niwa (2016), Cozzi and Galli (2014), Boschma and Frenken (2010), Audretsch and Feldman (1996)
6	University research	Lundberg, (2017), Harrisson and Turok (2017), Iammarino *et al.* (2012)
7	Hiring university graduates	Haussen and Uebelmesser (2018), Faggian and Mccann (2009), Anselin, Varga and Acs (1997)
8	Hiring skilled labour	Albalate and Fageda (2016), Breschi, Lissoni and Montobbio (2007), Audretsch and Feldman (1996)
9	Foreign Direct Investment (FDI)	Delgado-Márquez *et al.* (2018), Iammarino and McCann (2010)
10	R&D cooperation	Marek et al. (2017), Iammarino *et al.* (2012), Fritsch and Franke (2004)
11	Reverse engineering	Halpern and Muraközy (2007), Görg and Greenaway (2004), Harabi (1997), Levin *et al.* (1987)
12	Patent disclosures	Harabi (1997), Levin *et al.* (1987)
13	Imitation of organisational innovation	Halpern and Muraközy (2007), Görg and Greenaway (2004)
14	Competition between firms	Fons-Rosen *et al.* (2017), Fischer and Nijkamp (2009), Görg and Greenaway (2004)
15	R&D subsidies	Ramaciotti *et al.* (2017), Trajtenberg (2009)

Table 3.5 Channels of KS (Source: Author)

3.5 Innovation

Evolutionary economics is characterised by the processes of change that affect the economy, especially the process of innovation in firms' behaviour by which the economic system evolves. Thus, innovation is not a static process, but sensitive to variabilities over time and space. In this sense, innovations cluster in certain industry sectors, but also in regions and time periods. This is the reason why centres of innovation periodically shift from one region or industry sector to another (Fagerberg, 2007). The approach in evolutionary economics is

holistic and systemic. It is holistic because it views the economic system as a whole and understands that it cannot be explained by each part individually and it is systemic because an economic system is continuously under a process of qualitative change in which intrinsic elements affect its behaviour (Lundvall, Dosi and Freeman, 1988). The choice to investigate innovation through the lens of evolutionary economics in this research is because it considers innovation as part of a system, that is, firms do not often innovate by themselves, but are supported by other firms and organisations in their surroundings (Gogodze, 2016; Cooke, Asheim, Boschma, Martin, Schwartz and Tödtling, 2011; Edquist, 2010). For example, Gogodze's (2016) research, based on the Global Innovation Index measurement model and employing Structural Equation Modelling techniques, considered the innovation system as an underlying asset of a specific kind and identified seven fundamental components in order to provide management opportunities within innovation systems. Also, Cooke et al. (2011) analysed the concept of innovation and showed, by reviewing the development of theoretical and empirical studies, that innovation is much broader than something novel. Rather it is a multifaceted concept that revolves around many elements and mechanisms, such as proximity and learning processes that evolve along geographical and historical lines. Thus, the evolutionary economics approach reveals that the interrelationship of elements and mechanisms around innovation generate continuous interactions that lead to knowledge spillover (KS) (Soete, Verspagen and Weel, 2010).

The objective of this sub-section is to explain the concepts of innovation according to the approach adopted in this research, i.e. interpretations that consider innovation in the broad sense. It is relevant for the purpose of the present research to outline technological and non-technological concepts of innovation because KS is a regional phenomenon that contributes to innovation in both dimensions.

3.5.1 Understanding innovation

Schumpeter (1934), the first author to write about the innovation theory, defined innovation as new combinations of means of production. Innovation can generate long waves of economic growth. The first wave is initiated by qualitative innovations, that is, the introduction of radical innovations that cause economic and social changes. The second wave occurs over time, when less innovative firms learn the ways of innovative ones and, as a consequence, imitate and improve their products. Thus, the second wave is characterised by incremental innovations.

Moreover, the second wave is quantitatively more important and has a deeper impact on the economy (Schumpeter, 1939).

Scholars that followed Schumpeter's innovation theory, however, found that Schumpeter's interpretation of innovation is too generic and does not actually explain how it happens at the firm level (Fagerberg, 2003). Alternatively, these scholars conceptualised innovation and its variations based on originality and results. Thus, if the result of the industrial activity presents some degree of novelty and has positive economic impacts, it can be considered an innovation (Fagerberg, 2007; Sawhney, Wolcott and Arroniz, 2006; OECD, 2005; Fagerberg, 2003). This is the reason why an invention is not an innovation, the idea of invention implies that something is new, but not necessarily successful in terms of positive economic returns to the firm or the individual who created it. Schumpeter, for example, indicated that invention is more related to R&D, and is not essential for innovation. In fact, for an invention to become an innovation, there may be a considerable time lag between the invention and the innovation until the conditions for commercialisation are ready (Fagerberg, 2007; Schumpeter, 1934). Moreover, this shows Schumpeter's acknowledgement of innovation as comprising of technological and non-technological categories.

Other scholars that study innovation also recognised the non-technological aspects of innovation by stating it in their definitions. Dosi (1988), for example, understands that innovation is the search for, and the discovery, experimentation, development, imitation and adoption of new products, new production processes and new organisational set-ups. Dosi thus introduces a definition of innovation from the perspective of the firm and indicates mechanisms that facilitate both technological (product and process) and non-technological innovations (organisational). A similar and complementary definition to Dosi's is the one provided in the Oslo Manual (OECD, 2005) which states: "an innovation is the implementation of a new and significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations" (p. 46). This view considers two categories of non-technological innovation, namely, marketing and organisational innovations. Moreover, both Dosi and OECD's definitions of innovation mention implementation, that is, innovations must be implemented or adopted into the activities of the firm. New or improved marketing and organisational methods are only considered as innovation when implemented in the firm's operations. Likewise, new or improved products will be considered innovation only after being introduced to the market

(OECD, 2005). This concept is supported by Sawhney, Wolcott and Arroniz's (2006) broad view on innovation. Regardless of the means, i.e. technological or non-technological, innovation can be considered as such only if there are positive results to the firm that created it. For these authors, innovation is about new value, not new things. Regardless of how innovative a firm regards itself to be, what really defines an innovation is whether customers will pay for it (Sawhney, Wolcott and Arroniz, 2006). Moreover, even though the definition of innovation for organisations which are not firms (such as universities, research centres and government agencies) is also based on new value, it is often more difficult to identify or understand for mainly two reasons. First, value for non-market organisations is not characterised in terms of monetary profits. Second, the behaviour of non-market organisations is constrained by voters and legislatures, which are respectively the equivalent of consumers and financers for firms (Nelson and Winter, 1982).

3.5.2 The innovative process

It is relevant to consider the innovative process in the theoretical framework of this research because innovation is the expected result of KS at the regional level. Therefore, understanding different aspects of the innovative process that have been considered by previous research, such as its properties and differences between industry sectors, can lead to a better understanding of the aspects that can relate KS to innovation. Thus, firstly, this sub-section initially presents the properties of the innovative process which, according to previous studies (Dosi, 1988 and 1982; Pavitt, 1984; Nelson and Winter, 1982), are relevant because they reflect the behaviour of innovative firms. Secondly, this sub-section presents the differences by which the innovative process happens in different industry sectors which, according to Archibugi, (2001), can provide an understanding about the determinants of the innovative process.

Dosi (1988) introduced five fundamental properties associated with the innovative process, what he called stylised facts on innovation. They are: (i) uncertainty to predict technological and commercial problems that require unknown procedures; (ii) dependency of major new technological opportunities on advances in scientific knowledge; (iii) innovation tends to originate from formal organisations and within manufacturing firms. (iv) innovations are originated through tacitness and learning-by-doing, which involves informal activities that aim to solve problems identified by firms and customers; and (v) innovation is a cumulative activity. An important implication of these five fundamental properties, especially those related

to uncertainty, tacitness and cumulativeness, according to Dosi (1988), is the constant existence of asymmetries between firms in terms of their innovations.

Previous research has also found asymmetries in the innovative process between industry sectors. Pavittt (1984), by surveying 2,000 firms in the United Kingdom, found four categories of industry sectors by which the innovative process differs the most, namely supplier-dominated, scale-intensive, specialised suppliers and science-based (see Table 3.6).

Groups of sectors	Examples of industries	Characteristics
Supplier-dominated	Textile, clothing, leather, printing and publishing, wood products	- Permeated with process-innovations - Innovative opportunities embodied in new varieties of capital equipment and intermediate inputs - Innovation process is based on diffusion of best-practice, capital-goods and of intermediate inputs - Knowledge relates to (i) incremental improvements in the equipment producer elsewhere, (ii) to its efficient use and (iii) of organisational innovations - Appropriability of technological capabilities is low
Scale-intensive	Transport equipment, electric consumer durables, metal manufacturing, food products, parts of the chemical industry, glass and cement	- Innovation relates to both processes and products - Production activities involve mastering complex systems - Economies of scale are significant - various appropriability devices operate - Firms produce a high proportion of their own process technology - Firms employ a high proportion of their resources on innovation - Firms tend to integrate vertically
Specialised suppliers	Mechanical and instruments engineering	- Innovative activities relate primarily to product innovation - Firms operate in close contact with their users - Firms embody a specialised knowledge in design and equipment-building - Opportunities are generally high and are often exploited through informal activities - Appropriability is based on partly tacit and cumulative skills
Science-based	Electronic industries and most of the chemical industries	- Innovation is directly linked to new technological paradigms - Technological opportunity is very high - Appropriability mechanisms range from patents to lead times and learning curves - Innovative activities occur in R&D laboratories - Good part of product innovations enter a wide number of sectors as capital or intermediate inputs

Table 3.6 Pavitt's sectoral taxonomy of sectors of production and use of innovation (Source: Author)

Identifying that the innovative process is different between industry sectors suggests that KS is region specific because the number of industry sectors vary from region to region. In fact, Dosi (1988) explains that, because the degree of knowledge appropriability differs between

industry sector, KS is not only region specific, but also firm specific. Thus, each region has its own incentives and constraints for KS to happen.

3.6 Innovation systems

An innovation system is a set of interacting private and public interests, formal institutions and other organisations that function according to organisational and institutional arrangements and relationships conducive to the generation, use and dissemination of knowledge (Asheim and Gertler, 2007). An innovation system encompasses all parts and aspects of the economic structure and the institutional set-up affecting learning as well as searching and exploring (Lundvall 1992).

It is important to understand the innovative behaviour of firms through the perspective of innovation systems, and not individually, because it considers real world mechanisms that happen between firms and organisations, such as interactions that lead to collaboration and networking (Cooke and De Laurentis, 2010). These interactions are heterarchical, i.e. their conditions are based on trust, reputation, reciprocity, reliability, openness to learning and an inclusive and empowering disposition (Cooke, 2002). However, innovation systems have been considered mainly spatially at two different levels (Fagerberg, 2007), at (i) the National Innovation Systems level (Nelson, 1993) and (ii) the Regional Innovation Systems level (Cooke, Gomez, Uranga and Etxebarria, 1997; Howells, 1999). Innovation system studies can be employed in order to analyse two important and interrelated issues, the differences between countries in innovation capacity and also as a normative tool to suggest policy-makers' actions and strategies that support the innovation activity in a region or country (Őnday, 2016). Therefore, the ideal setting to investigate KS at the regional level is within regional innovation systems for four main reasons. First, the regional innovation system is a common theoretical approach used by policy makers to tackle regional imbalances of innovation (see for example OECD, 2018; Hollanders and Es-Sadki, 2017; Hollanders, Es-Sadki and Kanerva, 2016), which is aligned with the current research approach that focuses on KS based on the regional context and also on how it supports innovation. Second, innovation systems explain innovation as part of a system (Fagerberg and Verspagen, 2009; OECD, 1997) and they are derived from the interaction of multiple components that are responsible for the performance of the system (Acs, Audretsch, Lehmann and Licht, 2016). These are the same interactions discussed in the previous section (3.4.3 Channels of knowledge spillover) of this chapter. Third, the study of innovation systems focuses on flows of knowledge, including those stemming from

interactions between firms, and interactions between firms and universities and public research laboratories (Asheim and Gertler, 2007; OECD, 1997), which concurs with the objectives of the investigation selected for this research. Finally, an understanding of innovation systems supports policy-makers to identify leverage points to develop approaches for enhancing overall innovative performance and competitiveness of innovation systems (Doloreux and Parto, 2005; OECD, 1997). In the context of this research, the contribution for such understanding is translated by explaining KS at the regional level in order to propose a methodology to propagate KS within RIS (Regional Innovation Systems). However, even though KS is a core element of RIS (Breschi and Lissoni, 2001), the focus in this sub-section of the chapter is not on how KS relates to the aspects of regional systems, which have already been discussed previously in this chapter (3.4.3 Channels of knowledge spillover), but rather on the structures, interactions of elements and different characteristics that comprise regional and national innovation systems. Therefore innovation system theory is pertinent for the context of this research not only because KS is a core element of RIS but also due to the fact that this theory explains the mechanisms and conditions of how firms interact with other organisations in order to obtain knowledge to innovate.

The structure of this sub-section of the chapter is as follows: firstly, there is emphasis on the concept of National Innovation Systems (NIS) and the main dimensions for knowledge flows at the national level. Secondly, the interest of the study focuses on Regional Innovation Systems (RIS) by elucidating the concept, explaining how the RIS approach works for less favoured regions and showing RIS strategies for policy making in consideration of regional diversities. Thirdly, there are final remarks as regards implications for the current research.

3.6.1 National innovation systems (NIS)

National Innovation System (NIS) theory is the broadest approach that demarcates economic performance within the innovation literature (Acs, Audretsch, Lehmann and Licht, 2016, Lundvall, 2006). Such an approach is broadly recognised in both the literature on innovation and policy-making methods (Soete, Verspagen and ter Weel, 2010). However, there is no consensus on the definition of the concept. NIS can be understood as the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies (Freeman, 1995). They can also be seen as the national institutions, their incentive structures and their competencies, that determine the rate and direction of technological learning (Patel and Pavitt, 1994). In addition, NIS can be understood in a broader

sense that considers all important economic, social, political, organisational, institutional and other factors that influence the development, diffusion and use of innovations (Edquist and Johnson, 1997). However, what these concepts have in common is that they all regard the importance of institutions and interactions as key players and actions in innovation systems (Doloreux and Parto, 2005). Institution is also another broad concept in innovation system theory, consisting of not only organisations such as corporations, banks and universities, but also other social entities like money, language, laws (Hodgson 1993, p. 179), regulations, rules and habits (Fagerberg, 2007). Therefore, the concept of NIS comprises both of tangible and intangible aspects, also viewed as respectively hard and soft institutions (Tödtling and Trippl, 2005). Organisations such as firms, universities, development agencies, are established assets necessary to promote the intangible aspect of NIS, which is much influenced by institutions. Institutions, in turn, are based on the country's inherent attitude towards innovation. In fact, according to Acs, Audretsch, Lehmann and Licht (2016), systems are not created but inherited evolving structures in which research is required in order to provide solutions capable of improving their performance.

Learning is a central activity in NIS that contributes to their social and dynamic characteristics (Lundvall, 1992). NIS are social mainly because learning is a social activity (Őnday, 2016) that involves interactions and knowledge flows between different organisations (Asheim and Gertler, 2007), thus generating positive feedback and reproduction that leads to the resulting innovations within the system (Őnday, 2016). External knowledge is assessed by firms through direct interaction with the surrounding environment, such as those with customers, suppliers, partners, competitors, research institutions and universities, in a particular place and time (Fallah and Ibrahim, 2004). Thus, the smooth operation of NIS depends on the fluidity of knowledge flows among enterprises, universities and research institutions. In order to achieve this, four main dimensions must be observed (OECD, 1997) (see Table 3.7).

Dimension	Explanation
Joint industry activities	As the business sector is the main performer of R&D and innovation, joint industry activities can increase firm innovative performance.
Public/private interaction	Public organisations provide (i) generic research and new methods; (ii) instrumentation; (iii) valuable skills; and (iv) overall repository of scientific and technical knowledge in specific fields.
Technology diffusion	Technology diffusion can increase the innovative performance of firms by adopting and using innovations and products developed elsewhere.
Personnel mobility	Incoming new high-skilled workers can transfer knowledge both within industry and between the public and private sector.

Table 3.7Main dimensions for knowledge flows (Source: Author. Adapted from the OECD, 1997)

According to OECD (1997), the first dimension for knowledge flows consists of joint industry activities on innovation. As the business sector is the main performer of R&D and therefore innovation, joint industry activities are capable of increasing firms' innovative performances. The second dimension comprises of interactions between the private and public sector. Interactions with public organisations provide firms with a number of opportunities, namely, (i) generic research and new methods; (ii) instrumentation; (iii) valuable skills; and (iv) overall repository of scientific and technical knowledge in specific fields. The third dimension, technology diffusion, concerns the dissemination of technology through contact of newly acquired equipment and machinery; because technology diffusion can increase the innovative performance of firms by allowing them to adopt and use innovations and products developed elsewhere. It can also be understood that purchased inputs serve as carriers of technology across sectors. The knowledge regarding new technology is often acquired through interactions with customers, suppliers, competitors and public institutions. However, the process of diffusion of innovations is usually slow and may take years to complete. Finally, the fourth dimension, personnel mobility, is key to implementing and adapting new technologies. It implies that incoming new high-skilled workers can transfer knowledge both within industry and between the public and private sector. As a result of personnel mobility, it is not only a specific knowledge transfer that new workers provide that is important, but also their general approach to innovation and competence to solve problems.

It is well accepted that countries are different as regards their NIS. This is because they are shaped by the institutions as well as historical and path-dependence processes, thus these intrinsic aspects make systems endogenous and with great variation (Acs, Audretsch, Lehmann and Licht, 2016) that reverberate in systematic differences in terms of economic performance (Filippetti and Archibugi, 2011). As a result, Acs, Audretsch, Lehmann and Licht (2016) presented recent studies that apply the NIS approach and make these variations explicit. Some examples are as follows. Lehmann and Seitz (2016) referred to the importance of social norms, freedom and individuality as requirements for a sustainable, supportive and competitive innovation system. Lehmann and Seitz examined the relationship between freedom and innovation for a sample of 57 countries; their empirical findings support a positive relationship between the freedom-innovativeness slope. Santarelli and Tran (2016) investigated inputs of innovative activities in Vietnamese firms and questioned whether young innovative companies can impact economic development and, as a result, identified that they are micro-level institutions that contribute to technological innovation in NIS. Utilising a data set of 146 industries from 30 provincial-level regions in China, Li (2016) demonstrated that the pervasiveness of entrepreneurship in China's NIS varies according to both regions and industries and confirms the importance of interactions between industry structural variables and local conditions as causes of Chinese manufacturing entrepreneurship.

Therefore, NIS is a relevant approach for this study because it provides an understanding of the infrastructure of innovation at the country level that considers national organisations, institutions and different types of interactions that lead innovation to be disseminated through different mechanisms, such as the conducting of R&D activities, technology transfer and KS. The main institutions and organisations within NIS are those fostering and promoting learning and innovation. The role of the government at inducing innovations within the NIS is to stimulate, foster and shape the complementarity between institutions and organisations (Acs, Audretsch, Lehmann and Licht, 2016).

However, there is criticism as regards to the NIS approach. According to Őnday (2016), findings in many of his studies on NIS indicate the need for a regional approach in order to describe specific regions that have different dynamics and attitudes towards innovation. The NIS approach assumes homogeneity within countries even though many indicators such as economic performance, poverty and R&D investment show that regions vary considerably. Also, the concept of NIS is so broad that it covers almost everything and, as a consequence, it

does not mean anything; it gives the impression that all aspects of a nation are around firms' ability to innovate (Őnday, 2016).

3.6.2 Regional Innovation Systems (RIS)

Regional Innovation Systems (RIS), a term coined by Braczyc, Cooke, Heidenreich (1998), does not have a commonly accepted definition, but usually is understood as a set of interacting private and public interests, formal institutions and other organisations that function according to organisational and institutional arrangements and relationships conducive to the generation, use and dissemination of knowledge (Doloreux, 2003). According to Fagerberg (2007), the concept of RIS is wider than the concept of clusters because there may be several clusters within a RIS and institutions play a more prominent role in RIS. The RIS became popular not only to describe the distinctive and uneven geography in which firms innovate (Fagerberg, 2007), but also as a tool for policy-making, especially in Europe (Lundvall, 2007). The system of innovation approach understands innovation as an evolutionary, non-linear and interactive process that needs intensive contact and collaboration between regional actors, such as firms, universities, innovation centres, financing institutions, industry associations and government agencies (Tödtling and Trippl, 2005).

It is important to study RIS because it is in this perspective that some relevant knowledge for innovation activities is revealed. It is only within a regional analysis that important peculiarities become visible such as whether regions present the same rate of innovation as the rest of the country (e.g. Regional Innovation Scoreboard, 2016) and how knowledge circulates in regions. A relevant aspect of how knowledge circulates in regions concerns high-skilled workers who, when considering to move from one region to another, prefer going to places with both better infrastructure for research, employment opportunities and quality of life (Florida, 2002). Thus, understanding knowledge circulation at the regional level involves understanding not only the failures, but also the different prerogatives for successful regional innovation systems. For example, there is a 'buzz' between high-skilled-workers that, being analysed with more detail through a regional lens, is found to be characterised by common experience and understandings (Storper and Venables, 2004) that define location effects. Such location effects are stronger when the type of work is more knowledge intensive, thus increasing the importance of geographic concentration (Asheim and Gertler, 2007) and KS generation (Romer, 1990).

Knowledge circulation through high-skilled workers is important for public policies on innovation in order to retain the existing workforce as well as attracting new capacities and capabilities to the region. This is another point of importance for regional innovation policy on how to make regions benefit from the presence of high-skilled workers. High-skilled workers represent new sources of knowledge that can be obtained through constant and multiple interactions with existing workers from the same or complementary industries in a given region. These interactions can happen in everyday business activities, such as with suppliers and consumers, attendance at industry events and so on. Or they can happen through strategic collaboration such as industry joint-research projects or university research agreements. High-skilled workers carry knowledge that, if properly diffused within the region, can support innovation and growth (Lundquist and Trippl, 2013; Florida, 2002).

Regional policies on innovation, however, generally focus on best practice models derived from high-tech areas and well performing regions; these policies should focus on specific particularities of each region as regards preconditions for innovation, networking and innovation barriers (Tödtling and Trippl, 2005) and the existing singularity in each region with their own trajectories through combinations of political, cultural and economic forces (Cooke, Gomez, Uranga and Etxebarria, 1997). However, the RIS approach is becoming a more useful framework for policy making because it tackles these regional differences by drawing attention to (i) the firms, clusters and institutions, (ii) the interdependence within the region and (iii) its broader geographic areas (Tödtling and Trippl, 2005). An example of implementing the RIS approach is the policy making on innovation in the European Union through the development of NUTS[1] classification that divides countries according to territorial units. This is done in order to measure innovation performance, conduct studies, and implement public policies by facing regional realities and balance innovation outcomes in Europe as a whole (Regional Innovation Scoreboard, 2017).

Considering that the present research explores different regional patterns of KS, it is pertinent to present the different dimensions that form RIS (Buesa, Heijs and Baumert, 2010) because they represent the different types of organisations that, through constant interactions, propagate KS.

1 NUTS is the nomenclature of territorial units for statistics in the European Union. It provides a breakdown of the economic territory of the European Union into territorial units for the production of regional statistics and for targeting political interventions at a regional level (EC, 2015).

3.6.3 Dimensions of Regional Innovation Systems

RIS are comprised of many key characteristics that differ according to each region. When a group of these characteristics, or variables, are interrelated and behave in a similar way, they form a dimension that represents a different aspect of a RIS. The dimensions created in consideration of all the RIS characteristics represent the whole RIS (Buesa, Heijs and Baumert, 2010). In this sense and by considering twenty-one variables relating to the key characteristics of RIS, Buesa, Heijs and Baumert conducted a factor analysis and generated five underlying dimensions capable of representing the theoretical structure that represents firms and organisations within RIS, namely, innovatory firms, university, public administrations, regional environment and national environment. These dimensions are presented in Table 3.8.

Dimensions of RIS environment	Representing variables
Innovatory firms	- Firm's staff in Research and Development (R&D) (headcount) with regard to total number employed (%) - Firm's staff in R&D (full time equivalent) with regard to total number employed (%) - Firms' R&D expenditure with regard to Gross Domestic Product (GDP) (%)
University	- University staff in R&D (headcount) with regard to total number employed (%) - University staff in R&D (full time equivalent) with regard to total number employed (%) - University R&D expenditure with regard to GDP (%) - Percentage of 3rd level students with regard to the population
Public administrations	- Public administration staff in R&D (headcount) with regard to total number employed (%) - Public administration staff in R&D (full time equivalent) with regard to total number employed (%) - Public administration R&D expenditure with regard to GDP (%)
Regional environment	*Size of the region* - Gross fixed capital formation - Number of people employed - Gross Domestic Product - Gross Value Added - Wages *Human resources* - Human resources in high-technology (total) - Human resources Services sector - HR in tech intensive services)
National environment	- Investment capital (seed and startup) with regard to Gross Domestic Product (%) - Investment capital (development) with regard to GDP (%) - Penetration of Information and Communication technologies (ICT)

Table 3.8 Dimensions representing the RIS environment (Source: adapted from Buesa, Heijs and Baumert, 2010)

According to Buesa et al. (2010), the first dimension is innovatory firms showing R&D-related characteristics. The second and third dimensions, university and public administrations, also show only R&D-related characteristics. The fourth dimension, regional environment, is based

mostly on characteristics related to human resources and capital formation. Finally, the fifth dimension builds up a series of non-regionalised variables that affect the available sources of innovation funding and the depth to which new communication technologies are accessed. Buesa *et al.* (2010) indicated that their dimensions representing the RIS environment are the same as those identified in line with Asheim and Gertler (2007) by identifying the same regional dimensions. Also, "those factors reflect better the reality of an innovation system than each of the individual variables could do" (p.725). Thus, by conducting factor analysis, Buesa *et al.* (2010) were able to empirically represent all the RIS aspects that were proposed by Asheim and Gertler (2007). By using this same technique, the current research seeks to generate interpreting factors by conducting factor analysis (see details in Section 4.4, Research design, in Chapter 4, Conceptual and methodological frameworks).

3.6.4 Regional Innovation Systems approach in less favoured regions

Cooke, Boekholt, Schall and Schienstock (1996) identified three types of Regional Innovation Systems (RIS) according to innovation governance, namely: active regional state system, passive regional state system and immediate policy challenges. The RIS theory also approaches issues faced by less favoured regions. For example, Tödtling and Trippl (2005), based on the typology of weak innovation capabilities presented by Isaksen (2001) and Nauwelaers and Wintjes (2003), explained common deficiencies of regional innovation systems in different types of problem regions, namely, peripheral regions, old industrial regions and fragmented metropolitan regions. Tödtling and Trippl argued that public policies should focus on the deficiencies of each region, and not be based on best practice models from elsewhere that do not reflect the reality of less favoured regions. The reasons for public policies intervention in these settings are not only market failures, but also system failures such as organisational thinness, fragmentation, and lock-in[2]. Problem regions identified by Tödtling and Trippl (2005) are explained in Table 3.9.

2 Organisational thinness corresponds to low levels of clustering and a weak endowment with relevant institutions. Fragmentation refers to a lack of interaction and of networks. Lock-in is a regional effect caused by too strong ties between innovation relevant organisations that undermine the innovation capabilities of regional economies (Tödtling and Trippl, 2005).

Type of problem region	Explanation
Peripheral regions	The main problems faced by peripheral regions are the low outcomes of R&D and innovation from an unbalanced prevailing proportion of small firms in traditional industry sectors that are capable of realising only incremental innovation, weakly developed firm clusters that provide little business networks, few knowledge providers and weak collaboration with innovation support organisations. Not many services of knowledge transfer are available, and are not specialised.
Old industrial regions	Old industrial regions may have a satisfactory number of firms, important clusters and key organisations. Also, most of the large firms are specialised on mature technologies. However, old industrial regions are concerned with lock-in effects, such as to strong business and policy networks, cognitive barriers due to common world views, and a restricted orientation of knowledge providers on existing trajectories.
Fragmented metropolitan regions	Fragmented metropolitan regions comprise of many industry sectors and services. However, they normally lack prominent and knowledge based clusters. R&D is conducted within the headquarters of large firms and in high-tech firms. Knowledge diffusion is performed through collaboration with universities, through which opportunities are many and of high quality, but with weak industry links. Knowledge transfer services are vast and well provided through commercialisation. Networks are dominated by market links and involve a few clusters only. The main problem of fragmented metropolitan regions is that they are often in need of specialised industry sectors and innovation networks.

Table 3.9 Common deficiencies of regional innovation systems (Source: adapted from Tödtling and Trippl, 2005)

According to Cooke, Boekholt, Schall and Schienstock (1996), it is not all regions that have well established industrial clusters. Regions differ in the closeness of cooperation and, in some regions, either local authorities are weak or the region has no supportive institutional set-up. Thus, less favoured regions are addressed in this chapter because they reflect the reality of Regional Innovation Systems (RIS) in countries that are not in the mainstream of knowledge creation and diffusion, which is the case of some regions covered in the current research (see details in Section 4.5, Sampling, in Chapter 4, Conceptual and methodological frameworks).

3.6.5 Regional Innovation system strategies for policy making - tackling regional diversity

Regional innovation strategies that tackle the existing diversity and variations within regions, such as less favoured regions described previously, are identified in a basic framework of key

strategies that can develop the innovation potential for regional development. Previous research has focused on regional innovation strategies from the perspective of policy-making (for example Park, 2011). Park, in examining major regional strategies for regional development in the knowledge-based economy in Korea, identified a basic framework and key strategies for the improvement of innovation potential for regional development (see Table 3.10).

Objective	Explanation	Strategies
1 Promoting region-specific clustering	Establishing region-specific clusters is a precondition for the development of RIS.	a) Supporting the specialisation of existing industry by focusing on providing professional services and networking between firms along the value-added chain, between firms and universities, and in training systems
		b) Establishing techno parks in order to facilitate or attract high-tech firms, professional service providers, R&D institutions, innovation incubators, and so on. Techno parks emphasise inter-organisational interactions, collective learning processes, and innovative networks
		c) Restructuring traditional industrial parks in order to improve the innovation potential in these parks. New technologies need to be assimilated by existing industry sectors through more intense collaboration between firms and universities, technology transfer and labour specialisation
2 Building habitats for innovation and entrepreneurship	When continuous innovation and sustainable development are planned to be achieved at the regional level, the culture and business climate for innovation and entrepreneurship should be embedded in the region.	a) The role of universities as a source of knowledge, technology, and learning should be facilitated. Interactions between industry and universities can be done through employee exchange, internships, training, collaborative research and spin-offs from both universities and industry
		b) Incentives should be provided to attract high-skilled employees and specialised service providers
		c) Diversity of sources of business finance should be provided for businesses in different stages of growth
		d) Availability of a business and cultural environment with flexible labour markets and favourable business rules
3 Building collective learning and innovation networks	Firms rarely innovate in isolation. They rely on an existing collective learning process and also on	a) Promotion of inter-firm cooperation and alliances as well as elimination of regulatory impediments that inhibit the creation of cooperative networks
		b) Providing of incentives for collaborative research between firms and universities

	inter-firm networks in order to obtain knowledge, skills and networks that are critical for innovation	c) Providing of easy access to knowledge intensive professional services
		d) Promotion for formation of social networks among regional actors and high-skilled employees through workshops, conferences and informal meetings
4 Building a stock of social capital	The formation and definition of the characteristics of social organisation, such as networks, norms and trust that facilitate cooperation for mutual benefits, can enhance the cycles of knowledge conversion through collective learning	a) Encouraging the role of non-governmental and non-profit organisations (NGO and NPO respectively) in order to promote networking, diffusion of information and knowledge, and collective learning processes
		b) Establishment of social norms and fair rules in business with the help of an active civil society, including NGO and NPO
5 Promoting local and global networks	Local networks and embeddedness are central for knowledge creation and diffusion across collective learning processes. In addition, diversity is also interpreted as a potential advantage for innovation through local and global interactions.	a) Promotion of incentives that improve skills, regulatory frameworks, or financial systems and to encourage the formation and improvement of local networks
		b) Development of cross-border learning regions with inter-governmental cooperation
		c) Promotion of collaborative inter-regional technology networks in order to complement the cross-border learning regions
		d) Promotion of learning from best practices in order to acquire an improved mutual learning among regions as regards their successes and failures in addressing common objectives

Table 3.10 Key strategies for the improvement of innovation potential for regional development (Source: Author, based on Park, 2001

As demonstrated by Park (2001), the innovation system approach is important not only for considering regional diversity, but also for supporting the creation of strategies for policy makers that can develop the innovation potential for regional development. In the current research, different worldwide regions serve as samples, and each of them is different in its own paths and trajectories for developing innovations. Thus the relevance for acknowledging regional diversity and the major policy issues on innovation.

3.7 Chapter summary

This literature review sought to identify the pertinent theories around the concept of Knowledge Spillover (KS) that can be used as a foundation for performing research in this regard, namely, knowledge, knowledge spillover, innovation and innovation systems. Understanding the characteristics of knowledge, how it happens and how it can be disseminated is the base that helps to understand the essence of KS. KS theories were reviewed in order to identify the channels of KS, which are the means by and the sources through which KS happens and contributes to innovation, thus enabling the construction of the framework for the design of this research (see Chapter 4, Conceptual and methodological frameworks). Innovation was reviewed because it is associated as the expected outcome of KS processes and, as a consequence, it is important to consider a broad view of innovation, that is, its technological and non-technological aspects, in order to explain how KS can contribute to innovation. Identifying innovation only as a technological phenomenon would imply that only technological processes and mechanisms were unintendedly transmitted between firms and organisations, thus neglecting organisational and marketing possibilities. Innovation systems, particularly Regional Innovation Systems (RIS), were reviewed because they comprise of organisations and institutions that, combined, spawn the interactions that generate KS.

Some pertinent observations derived from the current literature review are as follows. Firstly, due to the increasing importance attributed to knowledge by both firms and regions as a result of markets becoming more competitive, some innovative firms are not willing to generate KS (knowledge outflows) to the region, because it means revealing their competitive advantage to other firms, whilst for smaller firms or firms without resources to conduct R&D, KS presents an opportunity to benefit from knowledge inflows that create innovation. Thus, both perspectives must be taken into consideration by regional policies on innovation that aim at propagating KS. Secondly, most empirical studies to date involving KS are found within the new growth theory, which is very quantitative in nature and concerned about measuring the effects of KS. These empirical studies prove that KS happens and can cause innovation; however, they do not explain how KS actually happens. Evolutionary economics theory does not provide as many studies on KS as the new growth theory, however, evolutionary economics theory provides a much more varied range of methods and analyses to understand innovation and the related phenomena by employing both quantitative and qualitative perspectives in order not only to measure, but also to explain how they happen. Thirdly, the literature review to date

did not identify a study that explains how KS happens at the regional level, that is, how knowledge evolves in order to be indirectly transmitted between firms and organisations. Therefore, explaining how KS happens at the regional level has become the research question of the current research.

Research question: How does the process of KS happen at the regional level?

The conceptual framework, which is explained in detail in Chapter 4, Conceptual and methodological frameworks, addresses the research questions as per Figure 3.1.

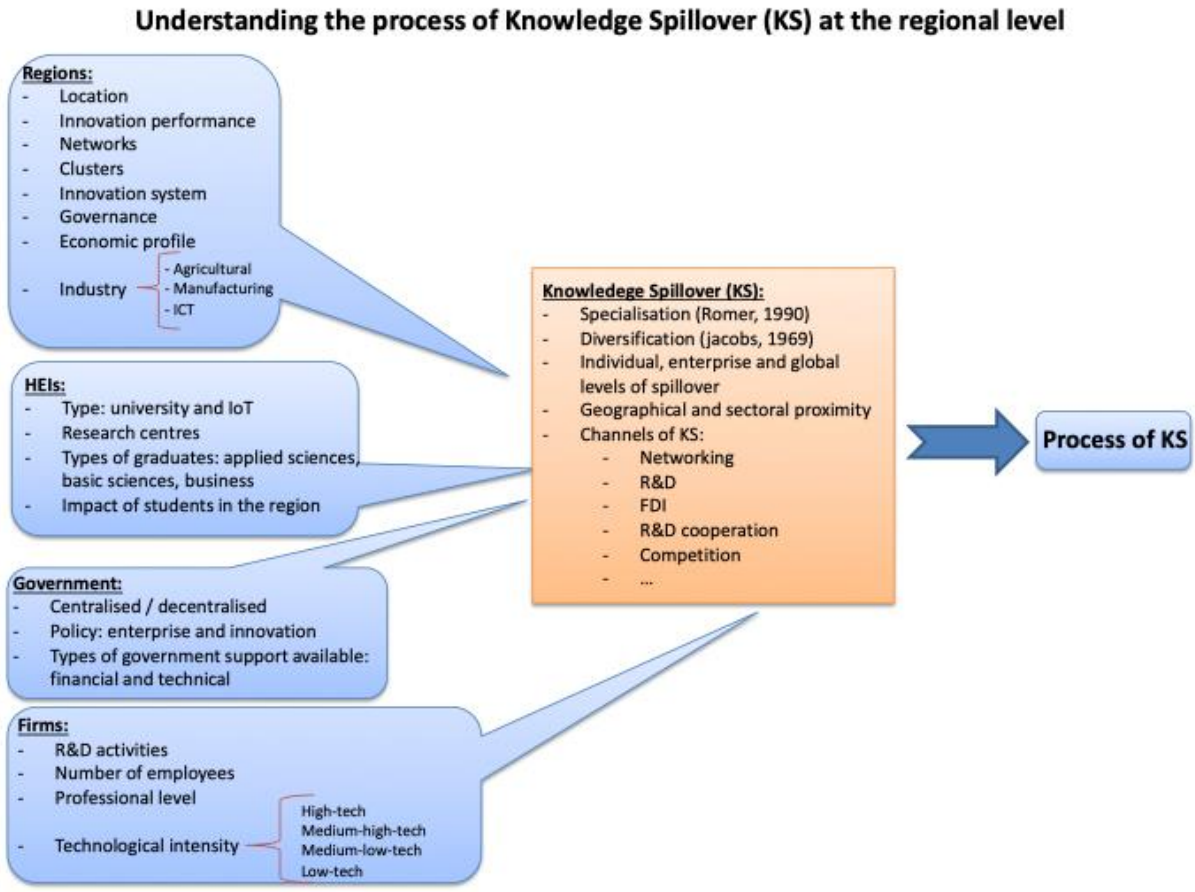

Figure 3.1 Conceptual Framework (Source: Author)

The review on theoretical and empirical studies on KS provided different prospects that explain how KS happens through a particular channel, or a small group of channels. But this offers limited explanations of the overall phenomenon. These channels of KS form the base of the framework adopted to conduct the current research. The current research investigates the process of KS through these channels, that is, they are the starting point of the research. It is through these channels that an understanding of KS is expected to culminate. The details of

this undertaking are explained in the next chapter, Chapter 4, Conceptual and methodological frameworks.

Chapter 4
Conceptual And Methodological Frameworks

Chapter 4 Conceptual And Methodological Frameworks

4.1 Introduction

Bearing in mind the definition of methodology as the theory of how research should be undertaken (Saunders, Lewis and Thornhill, 2009) and also as a science of studying how research is done scientifically (Kothari, 2004), this chapter focuses on describing how a research problem is systematically solved through an in-depth explanation of the overall research conducted, including the conception of its design, the philosophical paradigms, and the related discussions that justify the best way to approach and answer its research question.

This Methodology Chapter follows the logic for research proposed by Creswell (2013), in which the research problem, explaining the process of Knowledge Spillover (KS) at the regional level, determines the ideal research approach (quantitative, qualitative or mixed methods) and also the philosophical paradigm that defines the lenses through which the problem is viewed and how the study is conducted as both the research approach and the philosophical paradigm direct the research design and the methods (see Figure 4.1).

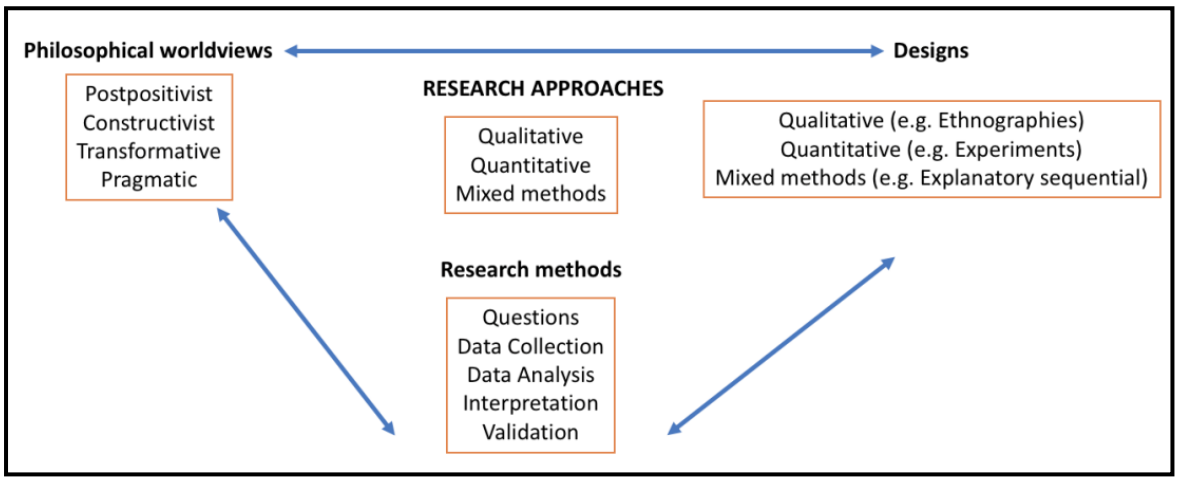

Figure 4.1 Framework for research (Source: Creswell, 2013, p. 35)

The first Section of this chapter is this introduction. The second Section presents the conceptual framework of this study. The third Section outlines the research question, aim and objectives as well as the research philosophy and method of reasoning. The fourth Section presents the research design and details each of the research phases of this mixed methods study. The fifth Section addresses how validity and reliability were achieved. The sixth Section provides information on the research ethics of the study and finally, the seventh Section presents information on the research ethics of the study. The chapter concludes with a brief summary.

4.2 Conceptual framework

The research problem was identified through extensive review of literature on Knowledge Spillover (KS) and innovation. Up-to-date findings from this review indicate that the process of KS has not been explained at the regional level. Moreover, even though KS is recognised as capable of contributing to regional innovation outcomes, it is still unclear how it happens. However, there are some studies dedicated to investigate the role of one (for example Carreira and Lopes, 2018; Marek, Titze, Fuhrmeister and Blum, 2017; and Boschma and Frenken, 2010), or a few (for example Halpern and Muraközy, 2007; Görg and Greenaway, 2004; and Harabi, 1997), particular channels of KS. Channels of KS are the means by and the sources through which KS happens and that can influence innovation outcomes. Based on the literature reviewed for this research fifteen channels of KS were identified (see section 3.4.3, Channels of knowledge spillover, in Chapter 3, Theoretical Frame).

Much previous research investigating channels of KS is not focused on explaining how KS happen. These studies are usually concerned with econometrics techniques that focus on either identifying KS effects or measuring them. The objective of these studies is almost never (with just a few exceptions) focused on explaining KS or KS-related aspects. Thus, these studies have used mostly quantitative data gathering and analysis techniques, qualitative techniques have rarely, if ever, been used in these previous studies. The literature review identified only two examples, Pickernell, Senyard, Clifton, Kay and Keast (2007) and Ko and Liu (2015), which applied qualitative techniques in order to provide a better understanding on the process of KS. However, these studies do not explain how KS happens at the regional level .Therefore, even though there are many studies investigating KS, an explanation of how it happens at the regional level and how it can lead to innovation, is missing. Consequently, this research is focused on explaining how the process of KS happens at the regional level. Therefore, this chapter details the methodology and research design to address this research question.

The conceptual framework—the system of concepts, assumptions, expectations, beliefs, and theories that supports and informs a research (Miles and Huberman, 1994) is the basis of the research problem. The research question stems from the theoretical framework, which consists of the theories in which the study is concerned, and usually focuses on the areas which become the basis of the study (Kumar, 2011). In the current research, the theoretical framework (see Chapter 3, Theoretical frame) concluded that the process by which KS happens within regions has not been fully explained and, due to its capacity to positively influence innovation and

regional development, it was decided to pursue the research question. Thus, the conceptual framework (Figure 4.2) shows how the research question was envisaged by considering different aspects that, according to previous research, influence KS propagation.

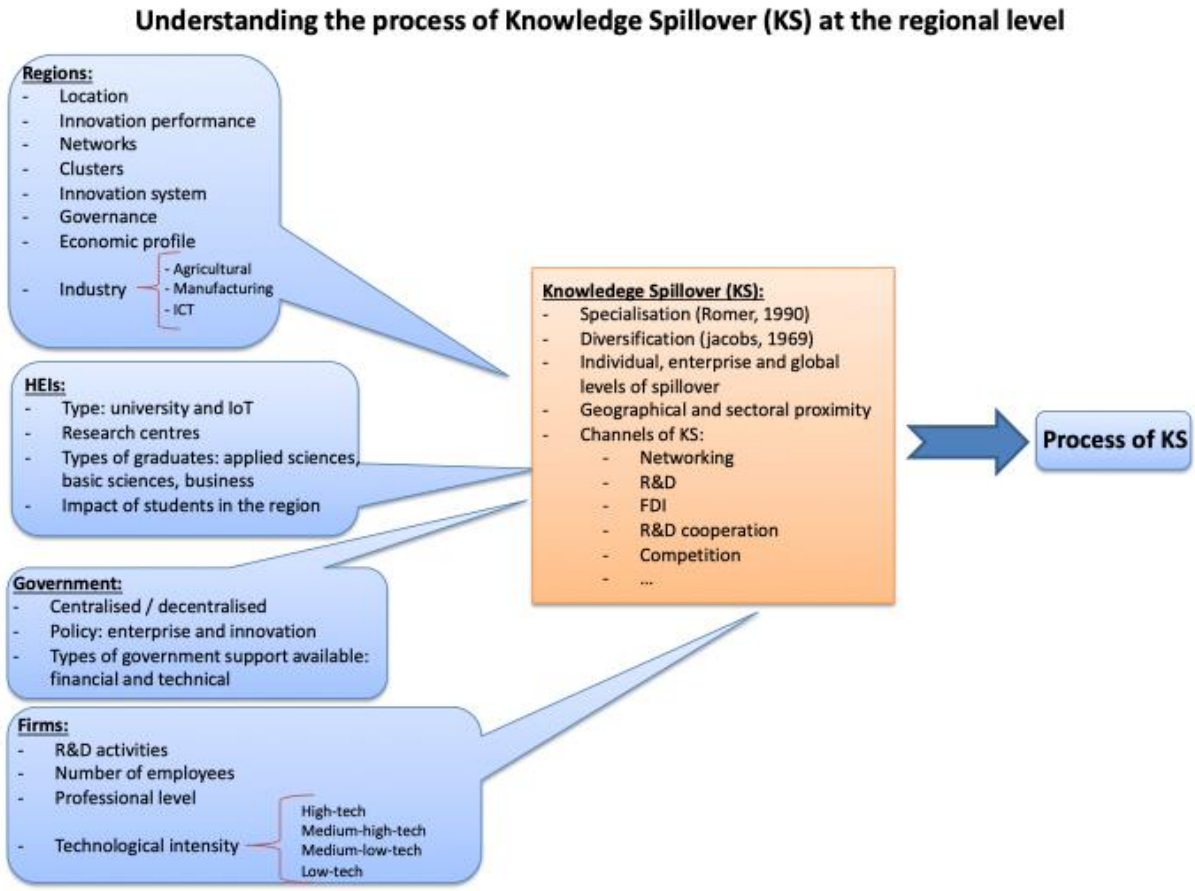

Figure 4.2 Conceptual Framework (Source: Author)

The first aspect considered in the conceptual framework is the regions which considers regional particularities that are important for KS, such as location (Feldman, 2000), innovation performance (Lundval, 2006, Audretsch, 1998), innovation system (Acs, Audretsch, Lehmann and Licht, 2016, Asheim, and Gertler, 2007) and the nature of the industries (Malerba, 2002, Verspagen and De Loo, 1999). The second aspect explores how Higher-Education-Institutions (HEIs) can contribute to KS in their regions (Haussen and Uebelmesser, 2018, Harrisson and Turok, 2017). The third aspect represents the government and how it promotes knowledge acquisition and exchange in the region (Leyden and Link, 2013, Edquist and Chaminade, 2006, Anselin, Varga and Acs, 1997). The fourth aspect that favours KS are the firms. The literature review revealed different characteristics that influence KS generation in firms, such as R&D activities (Niwa, 2016, Cozzi and Galli, 2014, Boschma and Frenken, 2010), number of employees (Iammarino and McCann, 2010) and technology intensity (Howells, 2002, Anselin, Varga and Acs, 2000).

These aspects determine and influence different channels of KS that can be available in a region and are important in order to analyse and understand how KS happens. By explaining how KS happens at the regional level, this research contributes to existing literature on whether KS is the result of a regional concentration of firms from the same industry sector (Hervás-Oliver *et al.*, 2018, Cainelli *et al.*, 2014, Romer, 1990) or from different industry sectors (Boschma *et al.*, 2017, Basile *et al.*, 2017, Jacobs, 1969) that are capable of propagating KS between firms.

4.3 Research question, aim and objectives

This research is structured in order to investigate how KS happens at the regional level based on channels of KS obtained from previous research. Table 4.1 presents the research question, aim and objectives.

Research question	How does the process of KS happen at the regional level?
Aim of the research	To explain the process of KS at the regional level
Research objectives	1 To determine the most and least important channels of KS 2 To determine the regional differences as regards channels and patterns of KS 3 To determine the differences between sectors with different technological intensity as regards channels and patterns of KS 4 To determine whether small firms attribute more importance to channels of KS than firms of larger sizes 5 To determine whether KS is region specific or generic

Table 4.1Research questions, aim and objectives (Source: Author)

The approaches and techniques used in order to meet these objectives as well as answering the research question, are discussed in detail in Section 4.4, Research design.

4.3.1 Tackling the research question

The identification of the research question led to the contemplation of issues such as research philosophy and approach, and the research onion, proposed by Saunders *et al.* (2009) (Figure 4.3) indicates the key issues underlying the research question.

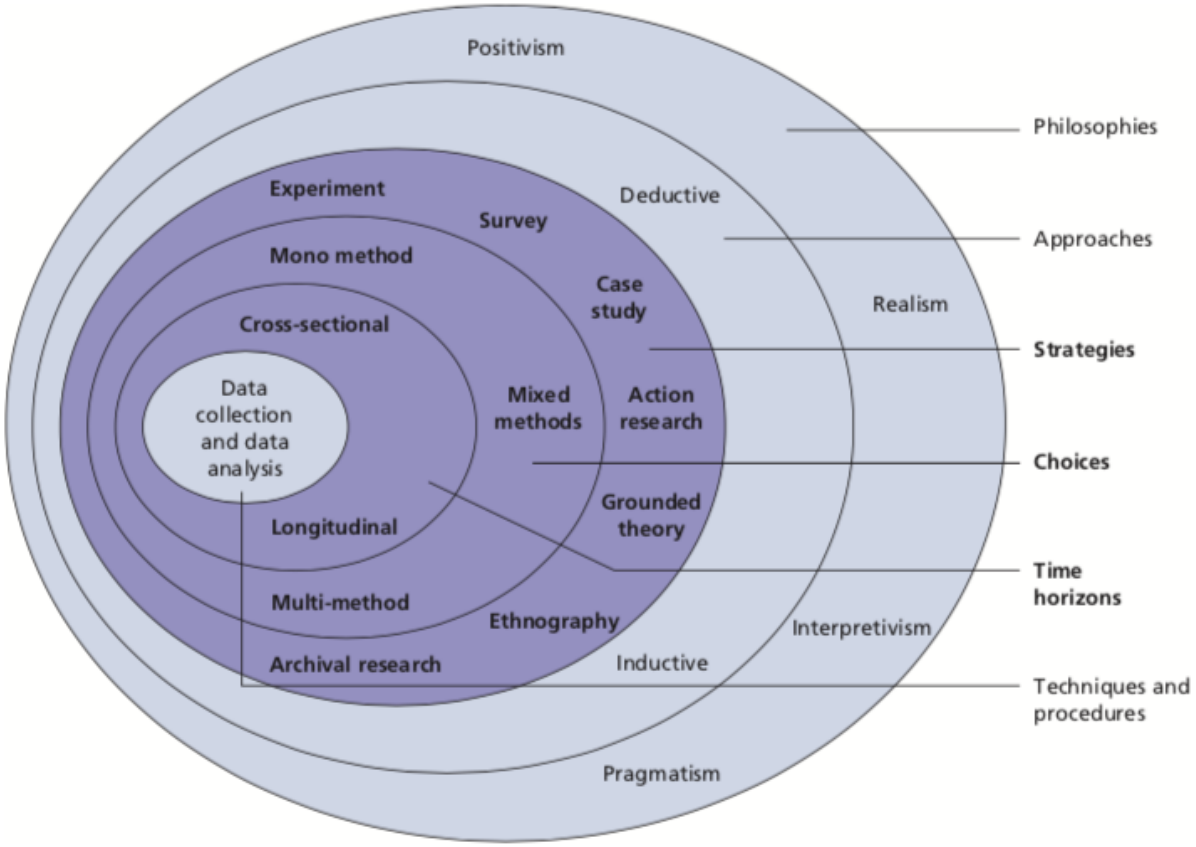

Figure 4.3 The research onion (Source: Saunders et al., 2009, p. 108)

The lighter coloured area in Figure 4.3 represents philosophical and research approach issues whilst the darker area represents issues related to the process of the research design. The manner by which the researcher chooses to answer the research question will be influenced by his research philosophy and approach. Subsequently, the research question will inform the author's choice of research strategy, choices of collection techniques and analysis procedures, and the time horizon over which he undertakes the research project (Saunders *et al.*, 2009).

4.3.2 Research philosophy: ontology, epistemology, paradigm and reasoning

The research philosophy is a term that relates to the development and nature of knowledge acquired from research and contains important assumptions about the way the world is viewed. These assumptions underpin the research strategy and the methods chosen as part of this strategy (Saunders *et al.*, 2009). Each researcher's worldview is part of a particular paradigm, a set of basic beliefs that deals with ultimate or first principles, in order to inform and guide research (Guba and Lincoln, 1994). The research and researcher's philosophy and approach to this study are presented in this sub-section.

There are three questions that need to be answered in order to reflect a research philosophy, namely ontological, epistemological and methodological questions. The ontological question refers to the form and nature of reality and, therefore, what can be known about it (Guba and Lincoln, 1994). Ontology denotes the assumptions about the nature of reality that shape the manner by which research objects are seen and studied (Saunders *et al.*, 2009). The epistemological question seeks to understand the relationship between the knower and what can be known, and the answer to this question depends on the ontology (Guba and Lincoln, 1994). Epistemology concerns assumptions about knowledge, what constitutes acceptable, valid and legitimate knowledge, and how we communicate knowledge to others (Saunders *et al.*, 2009, Burrel and Morgan, 1979). Finally, the methodological question explores how the inquirer discovers what he or she believes can be known (Guba and Lincoln, 1994) and reveals the way to systematically solve the research problem (Kothari, 2004).

Thus, ontology refers to beliefs about reality and epistemology denotes the relationship of the researcher with the research and how knowledge is obtained. The contents in Table 4.2, based on Saunders *et al.* (2009), shows relevant aspects that serve to identify the appropriate philosophy and approach to research.

Assumption type	**Questions**	**Continua with two sets of extremes**		
		Objectivism	←→	**Subjectivism**
Ontology	- What is the nature of reality? - What is the world like?	Real	←→	Nominal/decided by convention
		External	←→	Socially constructed
		One true reality	←→	Multiple realities (relativism)
		Granular (things)	←→	Flowing (processes)
		Order	←→	Chaos
Epistemology	- How can we know what we know? - What is considered acceptable knowledge? - What constitutes good-quality data?	Adopt assumptions of the natural scientists	←→	Adopt the assumptions of the arts and humanities
		Facts	←→	Opinions
		Numbers	←→	Narratives
		Observable phenomena	←→	Attributed meanings
		Law-like generalisations	←→	Individuals and contexts, specifics

Table 4.2 Philosophical assumptions as a multidimensional set of continua (Source: adapted from Saunders et al., 2009)

The consideration of these philosophical assumptions led this researcher to identify the research paradigm that roots the current study. Philosophical paradigms lead researchers to embracing a particular worldview, which is reflected in their research design and the methods employed (Bhattacherjee, 2012). A research paradigm represents the entire constellation of

beliefs, values and techniques shared by the members of a given community (Kuhn, 1970) that lead and guide research (Morgan, 2007). Table 4.3 shows examples of research paradigms.

Research paradigm	Related aspects
Postpositivist	- Determination - Reductionism - Empirical observation and measurement - Theory verification
Constructivist/interpretivist	- Understanding - Multiple participant meanings - Social and historical construction - Theory generation
Transformative	- Political - Power and justice oriented - Collaborative - Change-oriented
Pragmatism	- Consequences of actions - Problem-centred - Pluralistic - real-world practice oriented - Production of useful knowledge rather than understanding the true nature of the world
Critical realist	- Reality (domain): knowledge of what and why all things are - Actuality (actual domain): knowledge of what actually happens Experience (empirical domain): knowledge of what is perceived to be happening

Table 4.3 Philosophical paradigms (Source: Author)

Philosophical paradigms presented in Table 4.3 are further explained as follows.

1) *Postpositivism* argues that knowledge cannot be proven conclusively, it can only be disproven (Battacherjee, 2012). It aims to produce objective and generalisable knowledge about social patterns, with the intention to affirm the presence of universal properties in relationships among pre-defined variables (Taylor and Medina, 2013). According to Creswell (2013), postpositivism embraces a deterministic philosophy in which causes determine effects or outcomes, thus researchers need to identify and assess causes that influence outcomes. As a reductionist paradigm, there is a tendency to reduce ideas into a small group to test variables pertaining to hypothesis and research questions. The knowledge derived from postpositivist research is based on careful observation and measurement of the objective reality. Thus, the development of numeric measures of observations and the study of the behaviour of individuals is dominant in the postpositivism paradigm. Moreover, the world can be understood through specific laws and theories in this paradigm and these need to be tested or verified and refined. The postpositivism paradigm is influenced by the scientific method, thus research follows a pattern by initiating with a theory, collecting data that will either support or refute the theory, and subsequently providing reconsiderations, necessary adjustments and conducting additional tests (Creswell, 2013).

2) The *constructivist/interpretivist* paradigm is used to understand and describe human nature (Chilisa and Kawulich, 2012). It is based on the assumption that social reality is not singular or objective, but is rather defined by human experiences and social contexts (Battacherjee, 2012). According to Saunders *et al.* (2009), constructivism argues that it is essential for the researcher to understand differences between humans in the role as social actors. This stresses the difference between conducting research among people rather than objects. Moreover, according to Creswell (2013), constructivism is an approach typically used in qualitative research. Constructivism implies that individuals seek understanding of the world in which they live and work. Individuals conceive subjective meanings of their experiences as regards specific objects. As these meanings are often many and vary to a great extent, the research focuses on the complexity of the views as a much preferable substitute to reducing meanings into a small number of categories or ideas. The constructivist research is based on the participants' views of the situation under investigation. The questions asked are broad and general, giving liberty for participants to create the meaning of a situation, typically derived from discussions or interactions with other persons. The questions are open-ended in order to allow the participant to speak openly about the topic. These subjective meanings evolve historically and socially as they are formed through interactions between individuals and across historical and cultural norms that play a role in the life experience of the participant. Thus, in order to understand the historical and cultural settings of the participants, the constructivist paradigm addresses the processes of interactions among individuals and the specific contexts in which people live and work. The interpretation in constructivist research is influenced by the researchers' background, that is, their personal, cultural, and historical experiences. The purpose of the researcher is to interpret the meaning of the world from the perspective of other individuals (Creswell, 2013). Thus, constructivism aims "to understand the culturally different 'other' by learning to 'stand in their shoes', 'look through their eyes' and 'feel their pleasure or pain'" (Taylor and Medina, 2013, p. 4). In this sense, by highlighting the importance of context (Gill and Johnson, 2002), constructivism aims at generating or inductively developing a theory or pattern of meaning (Creswell, 2013).

3) The *transformative* paradigm focuses on the necessities of groups and individuals that are marginalised and may have some sort of disadvantage over others (Creswell, 2013). It is informed by critical theory, postcolonial discourses, feminist theories, race-specific

theories and neo-Marxist theories (Chilisa and Kawulich, 2012). According to Creswell, 2013), the transformative research includes an agenda for reforms capable of changing the lives of the participants, the organisations they work or where they live, and the researcher's life. Transformative designs often include specific social issues, such as empowerment, inequality, oppression and domination. These studies usually start the investigation with one of these social issues as the focal point. This type of philosophical paradigm is meant to consider studies that act collaboratively with the participants and have their contribution to design questions, collect data and analyse information. The research is also beneficial to the participants because it serves as a channel for them to express their consciousness or advancing an agenda for change to improve their lives (Creswell, 2013). The aim of the transformative paradigm is to destroy myths and empower people to change society radically (Chilisa and Kawulich, 2012).

4) *Pragmatism* as a research paradigm is defined by the necessary actions, situations and consequences above antecedent conditions. The focus is on applications, that is, what works in order to find solution to problems (Patton, 1990). Instead of stressing the method, the research focuses on the research problem and uses all research approaches available to solve it. Pragmatism is not dedicated to a specific philosophy, it relates to mixed methods research as researchers deliberately using both quantitative and qualitative assumptions in their investigation (Creswell, 2013) because their focus is solely on the objective of the research–one method "may be more appropriate than the other for answering particular questions" (Saunders *et al.*, 2009, p. 109). Thus, pragmatic research allows the existing freedom of choice found in mixed methods research as regards approaches, methods, techniques and procedures in order to meet their objectives and answer the research problem (Creswell, 2013). As a result, pragmatism is naturally appealing since it avoids pointless discussions about the ideal philosophical paradigm (Tashakkori and Teddlie, 1998). Pragmatism emphasises the *what* and the *how* to research based on intended consequences. Thus, there must have a real purpose for using both approaches (Creswell, 2013).

5) The *critical realist* paradigm is concerned with conceptions of what constitutes an explanation, a prediction, and what the objectives of social sciences ought to be (Fleetwood and Ackroyd, 2004). According to Bhaskar (1978), there are three domains

of reality that explain the philosophy of critical realism, namely empirical, actual and real. The empirical domain is where events are experienced either directly or indirectly by an observer. The actual domain is where events happen whether we experience them or not, which represents the world as we know it. The real domain hosts the generative mechanisms that produce events in the world (Bhaskar, 1978). Critical Realism has a strong emphasis on ontology and, as a consequence, the world is seen as existing independently of what we think about it (Zachariadis, Scott and Barrett, 2010). The critical realist paradigm is motivated by two ontological beliefs. One belief is that it has much to offer in the analysis of social sciences, as seen in the growing number of critical realist inspired articles. The other belief, negative in nature, is that many social sciences studies are committed to one or two mistaken ontological positions: the empirical realist ontology in which positivist orientated analysis is rooted, and the social constructionist ontology in which postmodernist or poststructuralist orientated analysis is rooted. Thus, critical realism provides a viable ontology of social sciences, allowing positivism and its empirical realist ontology to be abandoned without having to accept a social constructivist ontology (Fleetwood and Ackroyd, 2004). The fundamental question in the philosophy of science is: 'what properties do societies and people possess that might make them possible objects for knowledge?' (Bhaskar, 1978, pp. 13). This ontological question is actually the starting point for a philosophy of reality because the world is structured, differentiated, stratified and changing (Danemark, Ekström, Jakobsen and Karlsson, 2002).

4.3.3 Researcher philosophy

Rooted in a critical realist worldview, this researcher does not agree with the perspective of being exclusively part of either a realist or a relativist ontological perspective as sometimes the truth can be discovered using objective measurements in order to generalise findings. However, other times it is important to consider that reality is contextual, needs to be interpreted and cannot be generalised. Thus, it is important to simultaneously consider and confront both extremes of ontological perspectives because the world, and reality, exist regardless of the way people think of it.

Thus, this researcher's approach to reality (epistemology) depends on the type of knowledge that he needs to obtain. The world cannot be fully understood because this researcher believes that the idea of it is just a representation, the concept of real world is different to what it really

is. Reality can be represented in levels as, for example, you can understand something individually, but something is always connected to something else, as part of a system. Understanding the different parts of a system does not mean that the whole truth is uncovered because the system changes constantly and is bigger than its parts. Moreover, a system may also be seen as a part of a bigger system, thus it is not possible to completely understand even a system because it is part of something even bigger. Thus, truth may be only partially uncovered and, in order to do so, research requires different techniques and approaches, depending on what is adequate for the reality of the investigation and its objective.

4.3.4 Research philosophy

Because the focus of the current research is to explain the process of KS, the focus is initially on understanding KS in order to explain it. Understanding the phenomenon of KS cannot be rooted in a realist ontology because it requires different perspectives, or beliefs. In order to truly understand how the phenomenon of KS works, it is necessary to understand different views from stakeholders who are involved with KS propagation in their regions, including representatives from HEIs, government and industry. Thus, epistemologically, initially an objective approach. i.e. survey followed by quantitative techniques, is adopted in order to reveal *what* are the elements that will be explored by a much more meaningful and subjective approach, which is *how* these elements play a role in the process under investigation, which is KS at the regional level. In order to do that, interviews are conducted and, through the views of multiple participants, influenced by the social and historical context of their regions, they unveil the process of KS at the regional level and directly contribute to the theory on KS and innovation. Therefore, due to the main objective of the current research, which is to explain a phenomenon that is still not explained by previous studies, this is a study rooted in the constructivist paradigm.

4.3.5 Method of reasoning

Scientific inquiry, also called ‘methods of reasoning’ in research, can be divided as either inductive or deductive (Creswell, 2002; Bhattacherjee, 2012). The choice for the research enquiry depends on the researcher’s training and interest. However, both methods of reasoning are critical for the advancement of science (Bhattacherjee, 2012). Figure 4.4 demonstrates the functioning of the research cycle.

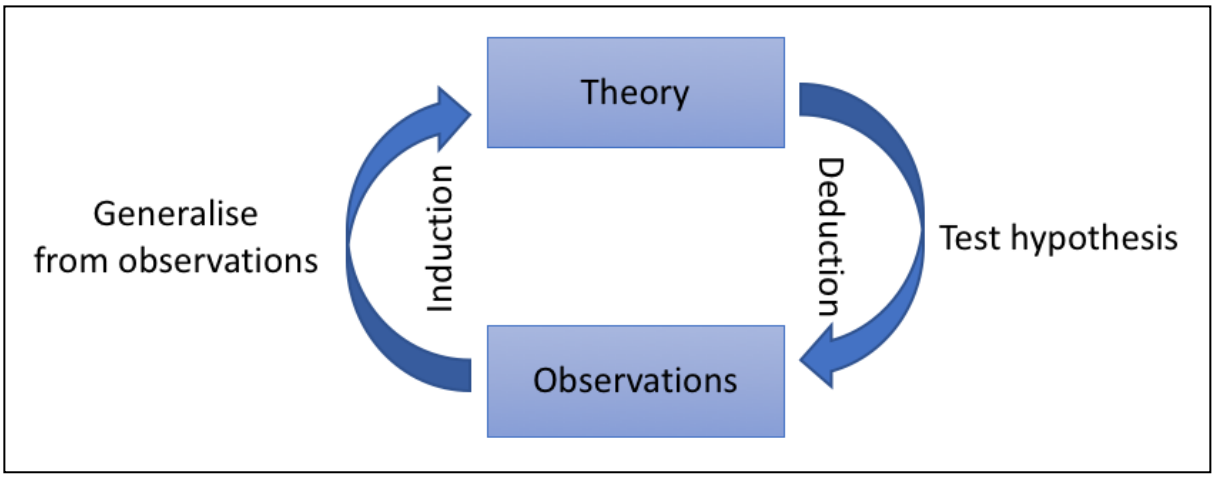

Figure 4.4 The cycle of research (Source: Bhattacheriee, p. 4)

Deduction in the Cambridge dictionary is defined as the process of reaching a decision or answer by thinking about the known facts, or the decision that is reached ("deduction," n.d.). Thus, deductive research focuses on testing concepts and patterns known from theory using observed data and, as a consequence, it is referred to as theory-testing research (Bhattacherjee, 2012). Deduction is the dominant method of reasoning in the natural sciences, where laws are the basis of explanation and allow the anticipation of their occurrence and permitting them to be controlled (Collis and Hussey 2003). Deduction emphasises some characteristics, as follows (Saunders *et al.*, 2009, p.127):

1 – Scientific principles
2 – moving from theory to data
3 – the need to explain causal relationships between variables
4 – the collection of quantitative data
5 – the application of controls to ensure validity of data
6 – the operationalisation of concepts to ensure clarity of definition
7 – a highly structured approach
8 – researcher independence of what is being researched
9 – the necessity to select samples of sufficient size in order to generalise conclusions

The definition of induction, according to the Cambridge Dictionary, is the process of discovering a general principle from a set of facts ("induction," n.d.). In studies that utilise an inductive approach, data needs to be analysed prior to developing a conceptual framework to guide the research (Saunders *et al.*, 2009). Inductive research has the goal of inferring theoretical concepts and patterns from observed data (Bhattacherjee, 2012). Thus, it is also

called theory-building research. The expected result of an inductive analysis is the formulation of a theory. According to Saunders *et al.* (2009, p. 127), the emphasis of inductive studies are as follows:

1 – gaining an understanding of the meanings humans attach to events
2 – a close understanding of the research context
3 – the collection of qualitative data
4 – a more flexible structure to permit changes of research emphasis as the research progresses
5 – a realisation that the researcher is part of the research process
6 – less concern with the need to generalise

Both inductive and deductive research are critical for the advancement of science. However, inductive research has more value when there are few prior theories or explanations, and deductive research is more applicable when there are many competing theories of the same phenomenon and the objective of the research is to know which theory works best and under what circumstances (Bhattacherjee, 2012).

> *This research focuses on explaining the process of KS at the regional level, which has not been explained by previous studies. Thus, the main objective of this research is to provide an explanation of a phenomenon through concepts (channels of KS) and patterns (patterns of KS) from observed data. As KS is a phenomenon that has not been explained, and in agreement with Bhattacherjee, (2012) and Saunders et al. (2009), the researcher considers that this study aims at theory-generation and therefore consists of a research with inductive reasoning. Moreover, this research is not deductive because it neither concentrates on testing concepts or patterns nor is it testing theory.*

4.4 Research design

Research is an organised and systematic way of finding answers to questions (Given, 2008). Research, in general terms, has three main approaches (Creswell, 2013), namely, quantitative (Ayer, 1959; Popper, 1959; Maxwell and Delaney, 2004), qualitative (Smith, 1983; Schwandt, 2000; Guba and Lincoln, 1989) and mixed methods (Johnson and Christensen, 2008; Creswell, 2013; Reichardt and Rallis, 1997). A research design consists of a plan with the procedures for research that include the steps from broad assumptions to detailed methods of data collection,

analysis and interpretation (Creswell, 2013). The choice for the ideal design in scientific research relies on the research problem and not on preferences for particular methods (Marshall, 1996).

Quantitative studies employ numeric data such as scores and metrics (Battacherjee, 2012) and involve the processes of collecting, analysing, interpreting and writing the study (Creswell, 2013). Based on Johnson and Onwuegbuzie (2004), the main characteristics of quantitative studies are as follows. First, testing and validating theories about how phenomena occur. Second, the generalisation of research. Third, quick process of data collection. Fourth, quick process of data analysis. Fifth, the provision of precise numerical data. Finally, its adequacy for studying large samples. Some limitations of quantitative research are mainly two, namely, missing out on phenomena occurring because of the confirmation bias, that is, the focus on theory or hypothesis testing rather than on theory or hypothesis generation and also that the knowledge generated may be too broad for direct application to specific situations (Johnson and Onwuegbuzie, 2004).

On the other hand, qualitative research relies mostly on non-numeric data, such as interviews and observations (Battacherjee, 2012) and is an approach for exploring and understanding the meaning individuals or groups ascribe to a social problem (Creswell, 2013). It is characterised by induction, discovery, exploration, theory/hypothesis generation, having the researcher as the primary instrument of data collection and qualitative analysis (Johnson and Onwuegbuzie, 2004; Marshall, 1997). The main weaknesses of qualitative research are as follows: (i) The knowledge generated may be too specific and not generalisable to other people or settings; (ii) It is more difficult to test hypothesis and theories; (iii) It may have lower credibility with administrators of programmes (iv) The results are more influenced by the researcher's personal biases and idiosyncrasies; (v) It takes long to collect the data and analyse it (Johnson and Onwuegbuzie, 2004).

Mixed methods approach, also known as mixed research, is the class of research that combines quantitative and qualitative approaches in a single study (Creswell, 2013; Johnson and Onwuegbuzie, 2004). The fundamental assumption of this form of inquiry is that the combination of quantitative and qualitative approaches affords a more thorough understanding of a research problem than either individual approach (Creswell, 2013). The goal of a mixed methods approach is to draw from the strengths and decrease the weaknesses of both approaches. Figuratively, considering a continuum with quantitative research at one end and

qualitative research at the other, mixed methods research would cover the large set of points in the middle area (Johnson and Onwuegbuzie, 2004).

In the case of the current research, based on its main objective that concerns explaining the process of KS at the regional level, it could be supposed that the problem demands solely a qualitative approach because of the humanistic nature of the verb 'to explain' (Marshall, 1997). However, in order to be able to explain the process of KS at the regional level, which is done through interviewing regional stakeholders, it is first necessary to identify the sources as to how this process happens so that stakeholders can be asked to elaborate on them. The sources for KS to happen consist of the channels of KS. The literature reviewed for this research has identified fifteen channels of KS. Different authors argue that each channel can lead to KS. However, in order to ascertain their importance at the regional level, they are examined in four different regions. The most important channels and main patterns of KS are subsequently used in the interviews with the expectation that they will lead to different interpretations on how KS happens at the regional level. Thus, the current research is not complete without quantitative techniques and, therefore, it consists of a mixed methods approach. A representation of the research design is presented in Figure 4.5.

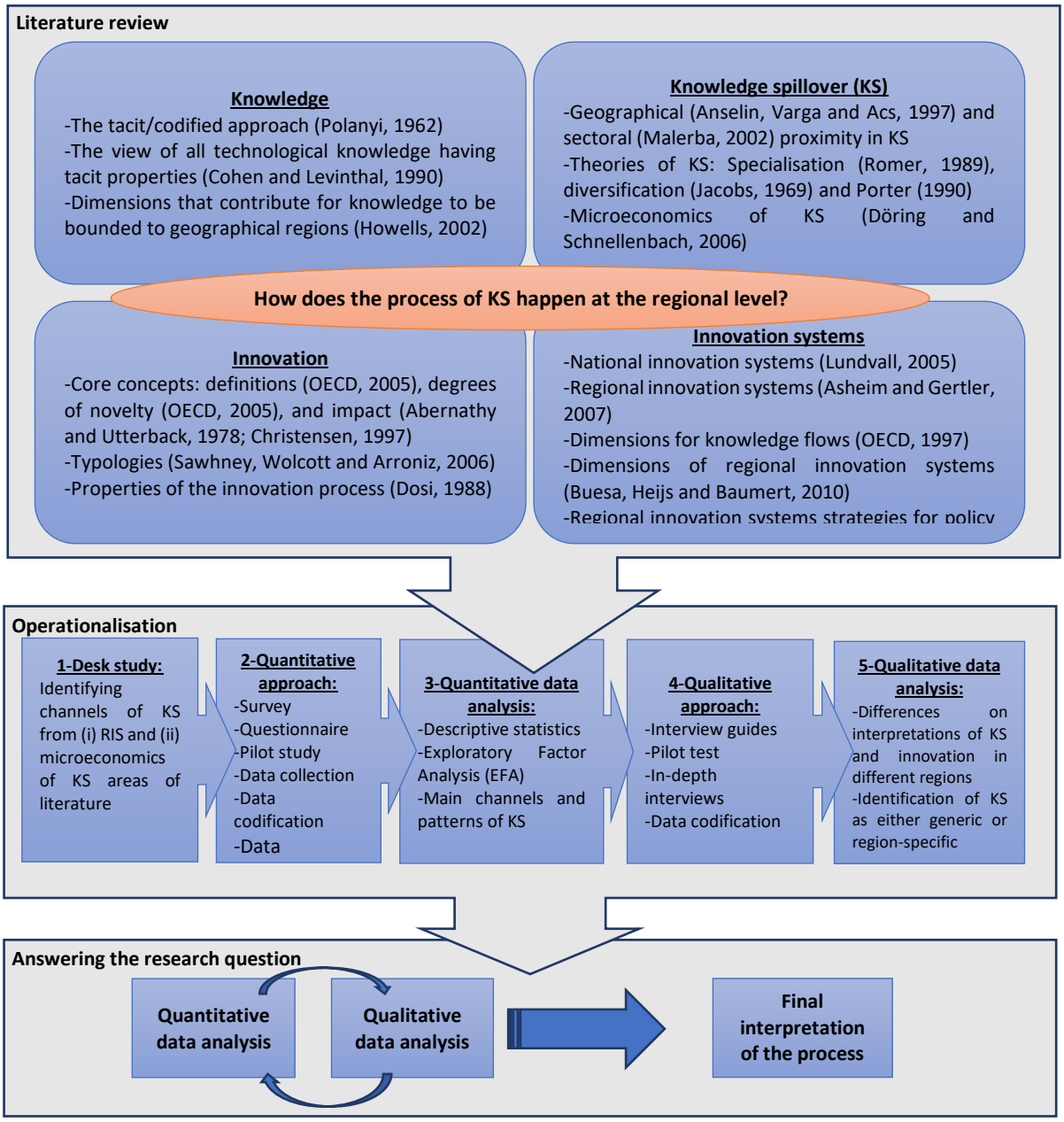

Figure 4.5 Research design (Source: Author)

The design of this research comprises of five different sequential phases, briefly explained as follows: Phase 1 consists of a desk research in order to identify channels of KS from previous studies. These channels of KS are different means that lead to KS and, even though these channels do not fully explain the process of KS, they are assumed in this research as the beginning of the process of KS. Phase 2 consists of administering a survey in order to identify the importance of these channels for manufacturing and ICT firms. Phase 3 provides quantitative analysis for Phase 4, in which interviews with people involved in regional KS propagation provide findings that, when analysed (Phase 5), explain the importance of channels of KS for the process of KS and provide views on how KS happens. Thus, it is necessary to

complete each phase in order to move to the next one. The design is based on the premise that in order to reach an understanding of the process of KS, the views of regional stakeholders are supported by the most important channels of KS. This type of design is explanatory sequential mixed methods because its purpose is to follow-up the quantitative results and explore the results in more depth, as argued by Creswell (2013), "the key idea is that the qualitative data collection builds directly on the quantitative results" (p. 274). Each phase of the research is explained in detail in the next sub-sections of this chapter.

4.4.1 Phase 1: Desk study

The first phase consists of a desk study aimed at identifying the channels of KS (i.e. the means by and the sources through which KS happens and that can influence innovation outcomes) from the literature, especially in two areas, namely, regional innovation systems and microeconomics of KS. The desk study initially identified previous research investigating channels of KS, which can be divided into two, namely those studies considering channels of KS individually and those considering groups of channels of KS. Subsequently, these studies were analysed in order to identify channels of KS that are relevant at the regional level and that are important for innovation outcomes (for details, see section 3.4.3, Channels of knowledge spillover, in Chapter 3, Theoretical Frame). Table 4.4 presents the results of the desk study.

	Channel of Knowledge Spillover	Reference
1	Interaction with employees from the same industry (specialisation)	Hervás-Oliver *et al.* (2018), Cainelli *et al.* (2014), Romer (1990)
2	Interaction with employees from different industries (diversification)	Boschma *et al.* (2017), Basile *et al*. (2017), Jacobs (1969)
3	Networking	Elvekrok *et al.* (2018), Forsman and Temel (2016), Miguélez and Moreno (2013)
4	Close geographical proximity	Carreira and Lopes (2018), Hervás-Oliver *et al.* (2018), Audretsch and Feldman (2004)
5	R&D	Niwa (2016), Cozzi and Galli (2014), Boschma and Frenken (2010), Audretsch and Feldman (1996)
6	University research	Lundberg, (2017), Harrisson and Turok (2017), Iammarino *et al.* (2012)
7	Hiring of university graduates	Haussen and Uebelmesser (2018), Faggian and Mccann (2009), Anselin, Varga and Acs (1997)
8	Hiring of skilled labour	Albalate and Fageda (2016), Breschi, Lissoni and Montobbio (2007), Audretsch and Feldman (1996)
9	Foreign Direct Investment (FDI)	Delgado-Márquez *et al.* (2018), Iammarino and McCann (2010)
10	R&D cooperation	Marek et al. (2017), Iammarino *et al.* (2012), Fritsch and Franke (2004)
11	Reverse engineering	Halpern and Muraközy (2007), Görg and Greenaway (2004), Harabi (1997), Levin *et al.* (1987)
12	Patent disclosures	Harabi (1997), Levin *et al.* (1987)
13	Imitation of organisational innovation	Halpern and Muraközy (2007), Görg and Greenaway (2004)
14	Competition between firms	Fons-Rosen *et al.* (2017), Fischer and Nijkamp (2009), Görg and Greenaway (2004)
15	R&D subsidies	Ramaciotti *et al.* (2017), Trajtenberg (2009)

Table 4.4 Channels of KS (Source: Author)

Each channel of KS explains partially how KS occurs. They are introduced by different authors that argue they can lead to KS. However, channels of KS do not lead to KS in isolation, but they are believed in the current research to be supported by other channels of KS existing in the same regional innovation system. However, the desk study was unable to identify studies that address a relevant number of channels that fully reflect how KS is propagated.

4.4.2 Phase 2: Quantitative approach

The quantitative approach consists of administering a survey. A survey is a research method that has key elements, namely, questionnaire, sample, standardised response coding and quantitative registering (Babbie, 1973). The questionnaire of the current research was adapted from Harabi (1997) because its structure enables the systematic study of the channels of KS. However, the questionnaire created for this research has some fundamental differences than the one used by Harabi's.

This is because the channels of KS used by Harabi (1997) (see Table 4.5) were derived from a questionnaire on industrial research and development (Levin, Klevorick, Nelson, Winter, Gilbert and Griliches, 1987) which is outdated and considers only seven channels of KS, which according to Levin *et al.* (1987), are appropriability conditions that cannot discriminate effectively more than a few industry groupings that, for Harabi's research, could have been adequate since this author only focused on the industry sectors pertaining to Switzerland. The questionnaire of the current research, on the other hand, tackles different regional contexts and thus considers a more complete number of channels of KS obtained from both the literature on innovation systems and microeconomics of KS (the latter a term coined by Döring and Schnellenbach, 2006-see Chapter 3, Theoretical frame, for more details). These channels of KS are supposed in the current research to be beneficial to a wider range of industry sectors, that is, high-tech, medium-high-tech, medium-low-tech, and low-tech firms (see Table 4.7). Another difference from Harabi's questionnaire regards the questions in Tables 4.5 and 4.6. The current research replaces the term "effectiveness" (Harabi, 1997) by "importance" believing this to be a more understandable and generic term. Also, the use of a five-point scale for the questions, rather than seven, to increase response rate (Babakus and Mangold, 1992), reliability (Jenkins and Taber, 1977) and being more comprehensible to respondents (Marton-Williams, 1986).

By the following seven means a firm may acquire technical knowledge of new and improved products developed by a competitor. How effective are these different means in your line of business?	
1	Acquisition of knowledge through licensing of the technology
2	Acquisition of knowledge through patent disclosures
3	Acquisition of knowledge through publications and open technical meetings
4	Acquisition of knowledge through informal conversations with employees of the innovating firm
5	Hiring away R&D employees with experience at competing firms
6	Acquiring the product and reverse engineering it
7	Acquisition of knowledge through independent R&D

Table 4.5 Harabi's questionnaire structure (Source: Harabi, 1997, p. 629)

In the current research, fifteen channels of KS are obtained from the review of the literature on innovation systems and microeconomics of KS (desk study – **Phase 1).** Accordingly, each channel of KS is converted into a question (Table 4.6). The possible answers range from 1-not important to 5-very important). The full questionnaire can be found in Appendix 1.

Channels of Knowledge Spillover	How important are these different aspects to your business?
Specialisation	Acquisition of knowledge through interacting with people from firms in the same industry sector as yours
Diversification	Acquisition of knowledge through interacting with people from firms in different industry sector to yours
Network	Acquisition of knowledge as a result of networking
Close geographical proximity	Acquisition of knowledge through interacting with people from firms located in your firm's city or its vicinity
R&D	Acquisition of knowledge through benefiting from R&D activities of other organisations in your firm's city or its vicinity
University research	Acquisition of knowledge due to research undertaken in a university located in your firm's city or its vicinity
Hiring of university graduates	Hiring students or graduates from a university located in your firm's city or its vicinity
Skilled labour	Hiring skilled employees with experience at firms located in your firm's city or its vicinity
Foreign Direct Investment (FDI)	Acquiring knowledge due to the presence of a multinational company located in your firm's city or its vicinity
R&D cooperation	Acquisition of knowledge though engaging in R&D cooperation with other firms
Reverse engineering	Acquisition of knowledge through acquiring the product and reverse engineering it
Patent disclosures	Acquisition of knowledge through patent disclosures
Imitation of managerial innovation	Acquisition of knowledge through imitating an innovative style of management
Competition	Acquiring knowledge due to being part of a competitive market
R&D subsidies	Acquisition of knowledge through R&D subsidies

Table 4.6 Conversion of KS channels into questions (Source: Author)

Data collection relied on online and face-to-face approaches. Online questionnaires were distributed through SurveyMonkey ®, an online survey development software. Face-to-face questionnaires were distributed during professional and academic innovation-related events attended by the researcher in South East Ireland, Bucharest-Ilfov Romania and Castilla-La Mancha Spain. These events were attended by business owners, who could answer the questionnaire *in loco*, and also by representatives from the academic and government spheres, who were an important source for indicating business owners to answer the questionnaires.

4.4.3 Phase 3: Quantitative data analysis

The third phase of the research concerns the analysis of the data derived from the survey (Phase 2) and applies descriptive statistics, One-way Analysis of Variance (ANOVA) and Exploratory Factor Analysis (EFA). After answers are coded according to the five-point scale from the questionnaire (from 1 to 5), they are subsequently inserted as inputs in the IBM SPSS Statistics ® version 22, a statistical analysis software. Quantitative data analysis is employed in order to determine the most and least important channels of KS and the regional differences as regards channels and patterns of KS.

The most and least important channels of KS are obtained through descriptive statistics, that is, through describing the basic aspects of the data in the study. Descriptive statistics allows the identification of the average importance of the channels of KS and a comparative analysis of each region and each category of technology intensity of industry sector (OECD, 2011), namely, low-tech, medium-low-tech, medium-high-tech and high-tech firms (Table 4.7).

High-tech industry sectors	**Medium-high-tech industry sectors**
- Aircraft and spacecraft	- Electrical machinery and apparatus, n.e.c.
- Pharmaceuticals	- Motor vehicles, trailers and semi-trailers
- Office, accounting and computing machinery	- Chemical excluding pharmaceuticals
- Radio, TV and communications equipment	- Railroad equipment and transport equipment, n.e.c.
- Medical, precision and optical instruments	- Machinery and equipment, n.e.c.
Medium-low-tech industry sectors	**Low-tech industry sectors**
- Building and repairing of ships and boats	- Manufacturing, n.e.c.; Recycling
- Rubber and plastic products	- Wood, pulp, paper, paper products, printing and publishing
- Coke, refined petroleum products and nuclear fuel	
- Other non-metallic mineral products	- Food products, beverages and tobacco
- Basic metals and fabricated metal products	- Textiles, textile products, leather and footwear

Table 4.7 Classification of manufacturing industries into categories based on technology intensity (Source: OECD, 2011, p. 1)

Thus, classifying industry sectors into categories of technology intensity was considered in this research in order to divide the diverse industry sectors surveyed into four general types and also to identify differences in the way that more technological firms (medium-high- and high-tech firms) attribute importance to channels of KS in comparison to less technological firms (low- and medium-low-tech firms). Moreover, it also allowed this research to perform Exploratory Factor Analysis (EFA) in each sample by region and also by category of technology intensity in order to compare the patterns of KS that derived from them.

4.4.4 Phase 4: qualitative approach

The qualitative approach in this research is divided into two parts, namely, interviews with regional stakeholders (see Appendix 2 for this interview guide) and interviews with experts on KS and innovation (KSIexperts[3]) (see Appendix 3 for this interview guide). Regional stakeholders are asked to interpret the process of KS by indicating the importance of the most important channels of KS identified in the quantitative data analysis (Phase 3). Another important outcome of the interviews with regional stakeholders is an interpretation of the core patterns of KS in order to identify how these mechanisms work (e.g. causality, importance and effects).

The interviews with KSIexperts was aimed at understanding whether KS is region-specific or a phenomenon with generic aspects that go beyond specific regions and industry sectors (see question 2 in Appendix 3). Moreover, in order to identify possible channels of KS that were not identified during the desk study (Phase 1), interviewees were also asked to give their opinion about the channels of KS that enable KS happen. Lastly, they were asked to explain the role of the most important channels of KS for the process of KS.

4.4.5 Phase 5: Qualitative data analysis

Phase 5 is the culmination of the overall study. The aim of this research, that is, explaining how the process of KS happens at the regional level, demands solving a problem of qualitative nature due to the need to provide explanation and interpretation. Qualitative data analysis (i) identified the importance of channels of KS in the region; (ii) interpreted patterns of KS as mechanisms inherent to RIS; and (iii) indicated whether KS is region-dependent or a generic process. As a result, qualitative data analysis allowed this research to organise and build knowledge to explain KS at the regional level.

[3] Experts on knowledge spillover and innovation (KSIexperts) are (i) relevant scholars that have their research on Knowledge Spillover (KS) and innovation, (ii) managers of clusters that serve as international references for developed regions, and (iii) policy-makers that are members of international institutions that promote programmes geared towards regional development of participating countries. An important characteristic of KSIexperts is their position as decision-makers in academia, industry or government.

4.5 Sampling

Previous Section described each research phase of this study. In this Section, details will be provided for sampling, pilot testing and data collection in both quantitative and qualitative approaches, which comprehends from Research Phases 2 to 5.

4.5.1 Quantitative approach sampling

Quantitative research cannot be undertaken without the use of sampling as the study of the entire population (census) is often impracticable (Singh, 2006). Thus, in order to understand the importance of channels of KS for firms from different technology intensity categories (from low- to high-tech), a survey was administered to ICT and manufacturing firms from multiple industry sectors. As KS is the result of many different types of interactions, investigating a wide array of industry sectors is expected to cover all possibilities for KS to happen. Moreover, this research surveyed four regions because it is important to consider findings from places where the innovation performance and KS vary according to different factors. South East Ireland is a strong innovator, Bucharest-Ilfov, Romania is a modest innovator, and Castilla-la Mancha, Spain is a moderate innovator (Hollanders, Es-Sadki and Kanerva, 2016). North East Brazil was considered in the research because, according to Pintec (IBGE, 2014), the Brazilian innovation survey, the North East region has the third largest number of innovative firms in the country, corresponding to 12.13% of the total number. In order to identify patterns of KS, this research focused on obtaining 75 valid responses per region. The goal for 75 valid responses was because, as the questionnaire was designed to cover 15 channels of KS the minimum of valid responses per region was 75. The reason for this is due to the need to identify patterns of KS through Exploratory Factor Analysis (see explanation below in sub-section, 4.8.2, Data analysis of quantitative findings). In addition, questionnaires were administered to firm representatives who are involved in or knowledgeable about decision making on innovation activities in the firm, that is, business owners, directors, managers, researchers or consultants.

4.5.2 Qualitative approach sampling

In order to conduct interviews with key informants that could support this research to explain the process of KS at the regional level (*research aim*), it was decided to consider two categories of interviewees, namely regional stakeholders and Experts on KS and Innovation (KSIexperts). Regional stakeholders were individuals from the same regions surveyed who were from

industry, academia and government and were also involved in innovation at the regional level. KSIexperts were (i) relevant scholars whose research is on Knowledge Spillover (KS) and innovation, (ii) managers of clusters that serve as international references for developed regions, and (iii) policy-makers that are members of international institutions that promote programmes geared towards regional development of participating countries. An important characteristic of KSIexperts was their position as decision-makers in academia, industry or government. KSIexperts were not necessarily from the same regions surveyed because the focus of these interviews was to obtain views from scholars and practitioners who were involved at the decision-making level in professions that require an understanding on how KS and innovation happen. Thus, the aim of this research, regarding number of interviewees, was to interview sixteen regional stakeholders (four representatives in each region, being at least one each in academia, industry and government) and eight KSIexperts.

4.6 Pilot testing

The data-gathering phase of the research process typically begins with pilot testing (Saunders *et al.*, 2009). Thus, before starting data collection and analysis, both instruments for data collection (quantitative and qualitative) were pilot tested. This Section provides details in this regard.

4.6.1 Quantitative approach pilot testing

The survey was pilot tested by four researchers in Ireland, based at Waterford Institute of Technology, whose research is based on investigating the innovation process; and by an economist in Australia who works for the government in the Bureau of Infrastructure, Transport and Regional Economics administering surveys on innovation at the regional level. They were asked to identify mistakes, inconsistencies and potential points for improvement. Following a discussion on the content of the questionnaire, number of questions and time for completion, these individuals found that the questionnaire was adequate and clear for firm representatives. However, there were two suggestions that were considered by the researcher namely, the inclusion of a question regarding number of employees in order to allow inferences on differences by firm size, and also inserting the questions about the importance of channels of KS in a table, so they would be clearer and more concise for potential respondents.

The next step in pilot testing the survey was to administer it fully in one of the research regions. North East Brazil was randomly chosen for this pilot test. Prior to pilot testing the questionnaire

in this region, the questionnaire was translated into Portuguese, as English is not widely spoken in the country. Initially the survey was completed by two firm owners. These respondents were able to complete the questionnaire in about five minutes each and had no suggestions or problems regarding understanding the questions. Subsequently, the questionnaire was pilot tested in North East Brazil. Respondents were asked to express any doubts or concerns when filling out the questionnaire. Out of the 2000 questionnaires that were administered and the 91 valid responses, no suggestions were made to change the survey content or structure. Thus, as there were no issues highlighted by these respondents, the responses were considered as valid. Therefore, North East Brazil was included as one of the four regions surveyed in this research,

4.6.2 Qualitative approach pilot testing

The interview guide was pilot tested with three employees from Waterford Institute of Technology (WIT) who are involved with innovation support for start-ups incubated in this HEI. Initially, it was planned to consider questions about the importance of channels of KS to the region and also specific questions that aimed at understanding how patterns of KS work as mechanisms that show how a group of channels of KS behave, that is, how they are interrelated and influence each other. However, based on the feedback from the respondents, these questions were considered to be too burdensome and time consuming. Therefore, they were removed from the interview guide. As a result, the time taken to do the interviews was reduced from two hours to approximately thirty minutes.

4.7 Data collection and analysis

This Section presents details on how data was collected and analysed (see Figure 4.6).

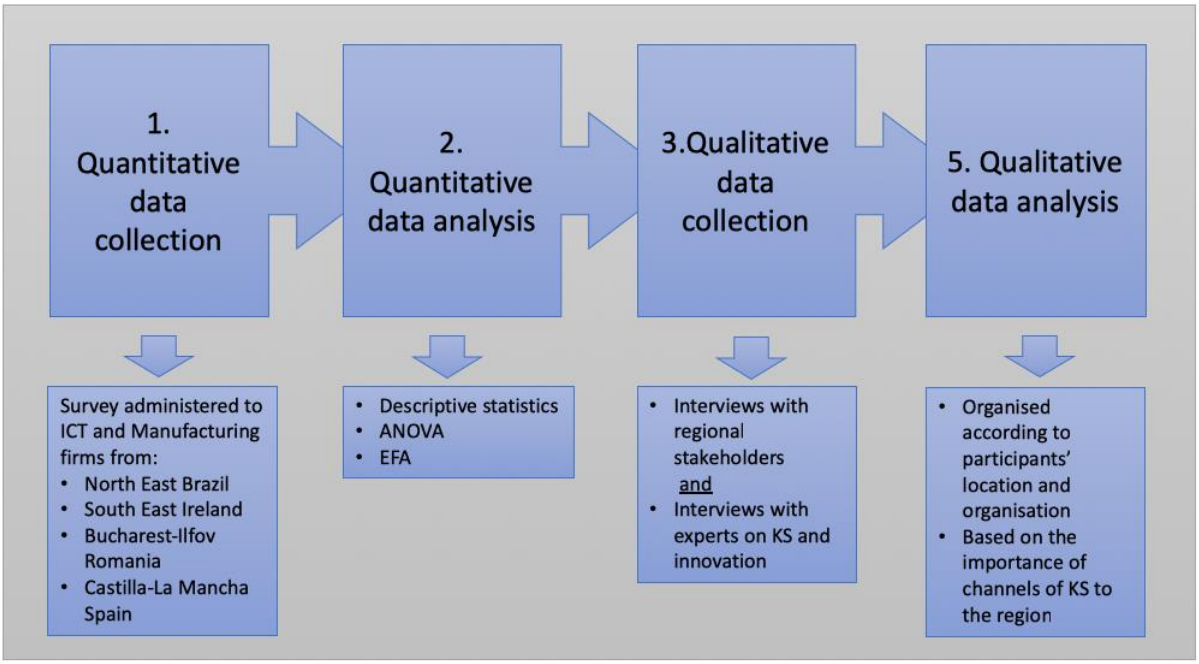

Figure 4.6 Data collection and analysis flow chart (Source: Author)

As shown in Figure 4.6, data collection and analysis were performed in a sequence, starting with the quantitative approach, which was based on a survey, and followed by the qualitative approach, which in its turn relied on interviews with two different types of interviewees, namely regional stakeholders and KSIexperts.

4.7.1 Data collection of quantitative approach

Survey data was collected from ICT and manufacturing firms. Manufacturing firms were from a diverse range of industry sectors in order to obtain the degree by which low- to high-tech firms attribute importance to channels of KS. ICT firms were considered in order to capture the perspective of firms that are key enablers of innovation, and account for 40% of business enterprises expenditures on R&D in many countries (OECD, 2017b).

The order by which the survey was administered is as follows. North East Brazil was the first region surveyed, followed respectively by South East Ireland, Bucharest-Ilfov Romania and Castilla-La Mancha Spain. The survey was planned to obtain 75 valid responses in each region. Once 75 valid responses were obtained in one region, the researcher progressed to the next region. The reason for establishing a goal of 75 valid responses per region was due to Research Objectives 2, which is to determine regional differences as regards patterns of KS. Thus,

patterns of KS are yielded through performing EFA and this statistical technique specifies a minimum requirement, which is to have at least five times as many observations as the number of variables (Hair, Anderson, Tatham and Black, 1998). Thus, for an EFA with 15 variables (representing the 15 channels of KS), it is necessary to have at least five times as many observations. Thus, the goal of 75 valid responses per region was the result of the number of channels of KS multiplied by 5.

Most of the data from the four regions was obtained online. Invitations were sent to industry representatives by email with a link that directed them to the survey questionnaire. The survey questionnaire was reproduced on SurveyMonkey ®, an online survey development software that stored all the electronic data. Email addresses that received the link for the survey questionnaire were from ICT and manufacturing firms identified in websites of organisations that represent them, such as business associations, industry syndicates and confederations, and development agencies. The survey was also promoted by the Irish Software Innovation Network (ISIN) and the Executive Agency for Higher Education, Research, Development and Innovation Funding (UEFISCDI) in Romania. Moreover, data was also collected on a face-to-face approach in innovation related events that took place in South East Ireland, Bucharest-Ilfov Romania and Castilla-La Mancha Spain. As a result, 7,292 questionnaires were administered and 439 valid responses were obtained (response rate of 6.02%). For a detailed breakdown of responses by region and industry sector, see Section 5.5 and 5.6 in Chapter 5, An empirical analysis on channels and patterns of knowledge spillover.

4.7.2 Data analysis of quantitative findings

Quantitative data analysis was based on descriptive statistics, One-way Analysis of Variance (ANOVA) and Exploratory Factor Analysis (EFA). Descriptive statistics and ANOVA were used in order to estimate the average importance of channels of KS (means of scores obtained) by firm size, region and category of technology intensity. Exploratory Factor Analysis (EFA) was performed in order to obtain the patterns of KS (see Table 4.8 for requirements).

These quantitative techniques addressed Research Objectives 1 to 4, which refer to determining the most important channels and patterns of KS. Channels of KS, for example specialisation, networking and hiring skilled labour, are the means by which KS can happen and patterns of KS show the existing relationship between channels of KS, that is, they are identified as an underlying dimension that represents a group of channels of KS.

Descriptive statistics was used in order to estimate the average importance of channels of KS (means of scores obtained) by firm size, region and category of technology intensity. EFA was employed in order to yield patterns of KS. Factors are represented by patterns of KS because they are mechanisms that reflect the behaviour of a group of channels of KS in a regional environment, as they increase or decrease in importance simultaneously. However, based on Hair, Anderson, Tatham and Black (1998), there are requirements as regards factor formation and validity that need to be followed (see Table 4.8).

Requirement	Explanation
Sample size	In EFA, samples of fewer than 50 observations should not be factor analysed, and preferably the sample should be 100 or larger. As a general rule, the minimum is to have at least five times as many observations as the number of variables to be analysed.
Cronbach's Alpha	Measure of reliability that ranges from 0 to 1, with values of 0.60 to 0.70 deemed the lower limit of acceptability.
Measure of sampling adequacy (MSA)	Measure calculated both for the entire correlation matrix and each individual variable evaluating the appropriateness of applying factor analysis. Values above 0.50 for either the entire matrix or an individual variable indicate appropriateness. The measure can be interpreted with the following guidelines: >0.80, meritorious; >0.70, middling; >0.60, mediocre, >050, miserable; and below 0.50, unacceptable. The researcher should always have an overall MSA value of above 0.50 before proceeding with the factor analysis.
Communality	Total amount of variance an original variable shares with all variables included in the analysis. Variables should generally have communalities of greater than 0.50 to be retained in the analysis.
Total variance explained	Total variation in the set of variables as represented by the trace of the factor matrix. This total is used as an index to determine how well a particular factor solution accounts for what all the variables together represent. If the variables are very different from one another this index will be low. Conversely, if they are similar, they will be high.
Factor loadings	Correlation between the original variables and the factors, and the key to understanding the nature of a particular factor. Factor loadings in the range of ±0.30 to ±0.40 are considered to meet the minimal level for interpretation of structure. Loadings ±0.50 or greater are considered practically significant.

Table 4.8 Requirements observed while employing factor analysis (Source: Author)

In addition, an important procedure for performing EFA concerns factor rotation. Unrotated factors solutions, according to Hair *et al.* (1998), consist of extracting factors in the order that variances are extracted. Thus, the first factor tends to be a general factor with almost every variable loading significantly, and it accounts for the largest amount of variance. The second

and subsequent factors are then based on the residual amount of variance, i.e. the following factors account for successively smaller portions of variance. As an alternative, factor rotation enables visualising a different perspective because the reference axes of the factors are turned about the origin until some other position has been reached. The objective of rotating factors is to facilitate interpretation by redistributing the variance from earlier factors to later ones to achieve a simpler, theoretically more meaningful factor pattern (Hair *et al.*, 1998). According to Hair *et al.* (1998), the major rotation methods are as per Table 4.9.

Method	Description
1. Quartimax	It simplifies the rows of a factor matrix by rotating the initial factor so that a variable loads high on one factor and as low as possible on all other factors
2. Varimax	It centres on simplifying the columns of the factor matrix and, as a result, maximises the sum of variances of required loadings of the factor matrix.
3. Equimax	This method is a compromise between the Quartimax and Varimax approaches. It tries to concentrate on simplification of both the rows and the columns.

Table 4.9 Major rotation methods (Source: Author)

As Hair *et al.* (1998) suggested there is no specific rule to guide the researcher in selecting a particular rotational technique, this researcher opted for the rotation methods that yielded higher factor loadings that did not overlap to other factors, i.e. patterns of KS.

Once yielded, patterns of KS are subsequently compared in order to reveal the core patterns of KS, that is, groups of channels of KS that are repetitive, i.e. revealing patterns that are consistent in different regions and categories of technology intensity. In order to obtain a more in depth understanding on how KS happens at the regional level, it is important to understand how patterns work as mechanisms that show how a group of channels of KS behave, that is, how they increase or decrease in importance when firms change their perception about a particular channel within the same pattern. An example of a mechanism is causation. Some channels of KS, when increasing or decreasing importance, may affect the others in the same group. Another mechanism is importance. Some channels may be more important than others in order to make that particular pattern to increase or decrease importance as a whole. These mechanisms, however, cannot be interpreted through EFA, but rather through performing qualitative approaches, such as interviews with people who are knowledgeable about what happens in their own RIS. This interpretation takes place in the next phase of the research.

ANOVA was another quantitative technique performed in order to determine whether small firms attribute more importance to channels of KS than firms of larger sizes. ANOVA and Tukey's Test were performed so they can reveal whether there are statistically significant differences between firms of different sizes. ANOVA is a statistical technique that tests for differences among the means of the populations by observing the amount of variation within each of these samples, relative to the amount of variation between the samples (Kothari, 2004). ANOVA followed by the Tukey's test can determine statistically significant differences between the means of different groups and detect which of these groups are different from each other.

4.7.3 Data collection of qualitative approach

The research design regarding qualitative data collection involved interviewing 16 regional stakeholders and eight KSIexperts. The four initial regional stakeholders that were contacted to help with the dissemination of the survey were invited to participate in the interviews and also requested to suggest other potential participants. This produced a snowball effect because the sample of regional stakeholders increased as the first interviewees were successful in inviting other relevant key respondents to take part in the research.

As regards KSIexperts, these individuals were sourced based on relevant studies on KS and decision-making experience with KS and innovation in either policy-making or cluster development. They were identified in international innovation-related events, such as the European Week of Regions and Cities University Master Class (Belgium), International Conference on Regional Science: Innovation and Geographical Spillovers: New Approaches and Evidences (Spain) and three *e*DIGIREGION[4] International Conferences (in Romania, Spain and Ireland respectively). As a result, 29 KSIexperts were identified and 9 participated in the interviews (response rate of 31.03%). Only one policy-maker that did not accept the invitation, however, this individual recommended another more suitable person to take his place. The other 19 invitations that were not accepted were from publishing authors on KS.

[4] *e*DIGIREGION was an EU FP7 funded project aiming at building sustainable transnational cooperation between regional research-driven clusters.

4.7.4 Data analysis of qualitative findings

Qualitative data was analysed from interview transcripts through manual techniques, which aimed at (i) identifying explanations for the most important channels of KS that contribute to KS and innovation in regions; (ii) identifying causal relationships between channels of KS; (iii) identifying the role of industry, HEIs and government in KS; and (iv) determining whether the process by which KS happens is generic or region-specific. Data analysis also focused on identifying differences in the responses based on participants' region and type of organisation (HEI, industry or government).

4.8 Validity and reliability

The purpose of this Section is to present the measures that were taken in order to ensure validity and reliability in this research. As it consists of a mixed methods research, it is important to ensure validity and reliability of quantitative and qualitative approaches (Creswell, 2013).

4.8.1 Validity

Validity concerns the extent to which data collection methods accurately measure what they are intended to measure, i.e. validity shows the extent to which research findings are really about what they profess to be about (Saunders *et al.*, 2009). Thus, this sub-section presents the validity of both quantitative and qualitative findings of this mixed methods research.

4.8.1.1 Validity of quantitative findings

In terms of a quantitative approach, validity is the degree to which an empirical measure adequately reflects the real meaning of the concept under consideration. (Babbie, 1973). Validity is concerned with how well the concept is defined by the measures (Hair *et al.*, 1998). There are three main types of validity, namely, content, criterion-related and construct (Cooper and Schindler, 1998).

Content validity of a measuring instrument is the extent to which it provides adequate coverage of the topic under study. The instrument is considered adequate when the elements under investigation constitute adequate coverage of the problem (Cooper and Schindler, 1998). As regards the current research, the questionnaire needed to cover the channels of KS from the literature on the microeconomics of KS and innovation systems. **Criterion-related validity** reflects the success of measures used for prediction or estimation (Cooper and Schindler,

1998). In the current research, the objective of the measures is to estimate the existence of a condition, which is the importance of channels of KS to firms. **Construct validity** consists of measuring or inferring the presence of abstract characteristics for which no empirical validation seems possible (Cooper and Schindler, 1998). For the current research the interest is to infer, that is, to reach a conclusion based on evidence and reasoning. The most important channels of KS are assumed to be the start of the process of KS and the patterns of KS are predicted to represent mechanisms that explain the process of KS at the regional level.

In order to assure validity, i.e. that the instrument measures what it is supposed to measure in the three categories, the survey questionnaire, an adapted version of Harabi's (1997) questionnaire (see sub-section 4.4.2, Phase 2: Quantitative approach, in this Chapter for more details on why it was considered outdated and restricted), was initially debated with five different scholars whose expertise is around innovation (located in Ireland and Australia). As a result, there were two suggestions that were considered by this researcher namely, the inclusion of a question regarding number of employees and also inserting the questions about the importance of channels of KS in a table (See Section 4.7, Pilot testing, in this Chapter, for more details on how the questionnaire was pilot tested) and then pilot-tested in North East Brazil.

4.8.1.2 Validity of qualitative findings

In qualitative validity, Creswell (2013) recommends that the researcher incorporates validity strategies into their proposal. For the current research, the researcher followed a strategy recommended by Gibbs (2007). This strategy concerns triangulating different data sources of information by examining evidence from the sources and using it to build a coherent justification for themes. When themes are established based on converging several sources of data or perspectives from participants, this process is part of the validity of the study. For the current research, sources of data come from four different regions and the sources from each region are subsequently compared in order to check for validity.

4.8.1.3 Overall validity

Bearing in mind the need of research to generate accurate and precise data in order to correctly address its research question, this researcher believes that both the survey questionnaire and the interview guide were carefully developed and that the findings reflect what is required in order to understand and explain the process of KS at the regional level.

4.8.2 Reliability

Reliability for a study that follows an inductive approach, according to Easterby-Smith, Thorpe and Lowe (1991), can be assessed by posing the question of whether similar observations can be made by different researchers on different occasions. Thus, in order to allow future research to produce similar results, this sub-section presents reliability of both quantitative and qualitative findings.

4.8.2.1 Reliability of quantitative findings

Reliability of quantitative findings is concerned with estimates of the degree to which a measurement is free of random or unstable error (Cooper and Schindler, 1998). It is the extent to which a set of variables is consistent in what it is intended to measure. Reliability is different from validity as it does not relate to what should be measured (Hair *et al.*, 1998). There are three main perspectives on reliability, namely, stability, equivalence and internal consistency (Cooper and Schindler, 1998).

a) Stability: a measure is stable if a research secures consistent results with repeated measurements of the same person with the same instrument (Cooper and Schindler, 1998). Also, "if multiple measurements are taken, reliable measures will all be consistent in their values" (Hair *et al.*, p. 92, 1998). The questionnaire proved to be a reliable instrument as it contains two measures of importance for channels of KS. Firstly, it requests respondents to rate the importance of each channel of KS, from 1 to 5. Subsequently, it requires them to choose the five most important channels of KS. By comparing the results of both measures through a correlation analysis (average importance and the percentage that each channel of KS was chosen as the top five most important-see questions 5 and 6 in Appendix 1), the correlation coefficient showed, in every region and technology intensity of industry sector, a strong positive linear relationship. Thus, indicating that respondents were fully attentive when answering the whole questionnaire, and not unconcerned in order to finish it quickly.

b) Equivalence: this considers how much error may be introduced by different investigators (in observation) or different samples of items being studied (in questioning or scales). Thus, equivalence is concerned with variations at one point in time among observers and samples of items. What is measured in this perspective is the degree to which alternative forms of the same measure produce same or similar results (Cooper and Schindler, 1998). The current research administered the questionnaire in three different periods of time, each of them focusing on a

particular region. In each region, results were similar and (i) the five most important channels of KS were the same in all the regions and technology intensity of industry sectors (thus called main channels of KS); and (ii) there were consistent coincidences between patterns of KS (thus called core patterns of KS).

c) Internal consistency: this refers to the degree to which instrument items are homogeneous and reflect the same underlying constructs. This approach to reliability uses one administration of an instrument or test to assess consistency or homogeneity among the items. Cronbach's alpha has the most utility for multi-item scales at the interval level of measurement (Cooper and Schindler, 1998) and consists of a measure of reliability that ranges from 0 to 1, with values of 0.60 to 0.70 deeming the lower limit of acceptability (Hair *et al.*, 1998). The Cronbach's alpha for the current survey is 0.88.

4.8.2.2 Reliability of qualitative findings

Qualitative research also needs to be reliable, that is, consistent and stable (Creswell, 2013). This research followed the two strategies to ensure reliability that were suggested by Gibbs (2007). The first strategy refers to checking the manuscripts for mistakes during transcriptions. The second strategy concerns examining the process of coding answers in order to assure that there is no drift in the definition of these codes.

4.8.2.3 Overall reliability

This research was concerned with reliability of both quantitative and qualitative techniques employed in order to explain how KS happens within regions. The overall reliability of these research findings was achieved by securing the measurement of quantitative findings from possible errors and also assuring that transcriptions were accurate according to the answers given by interviewees while expressing their opinions. As a result, the researcher assumes that the assessments conducted were consistent, trustworthy and also that possible reasons that could threaten these research findings were addressed.

4.9 Research ethics

Research involves collecting data from people. Therefore researchers need to protect research participants and develop trust with them (Creswell, 2013). As a result, the researcher submitted his research project, including details on the plan and design of the project, to the Waterford

Institute of Technology (WIT) (where the researcher was registered and based for the duration of his PhD research) Research Ethics Committee. Since this research considered that data would be stored for a period of 5 years in a safe place and securely discarded after this period, that research participants would receive full guarantee of anonymity, and also that there would be an information sheet and a consent form (see Appendix 4) to be signed by participants, the conduct of the project has been fully approved and conveyed to Academic Council.

4.10 Chapter summary

Base on the overall aim of this research, i.e. explaining the process of KS at the regional level, this chapter identified that the research philosophy the current study is rooted in is constructivist and also identified that the method for reasoning is inductive. In this Chapter, the research design was addressed and the phases of this mixed methods study were presented in detail. The following diagram (Figure 4.7) represents the data collection procedure.

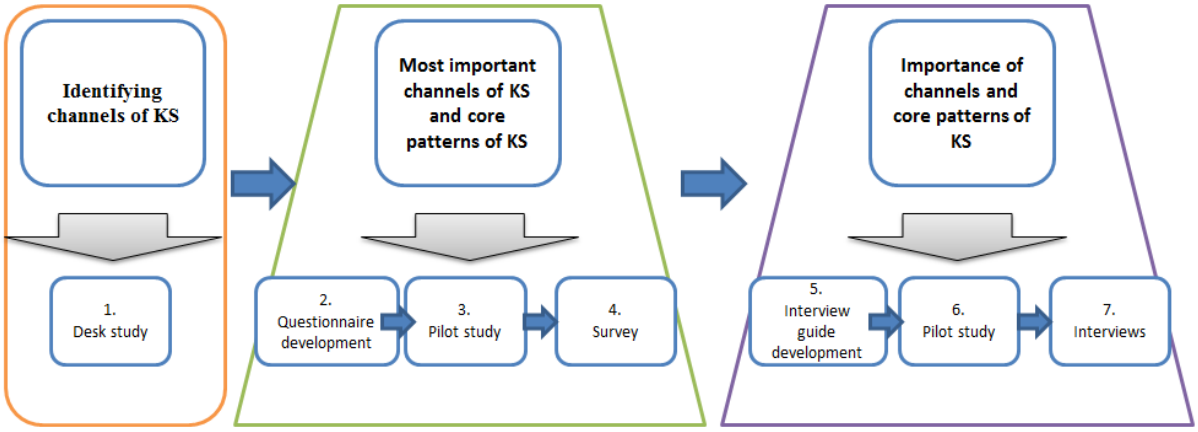

Figure 4.7 Data collection representation (Source: Author)

Assurances for validity and reliability were also presented for both quantitative and qualitative approaches. In addition, this Chapter addressed how research ethics was guaranteed. The next Chapter, based on the guidelines here presented, presents and analyses the findings of the quantitative approach, which relies on a survey.

Chapter 5
An Empirical Analysis On Channels and Patterns of Knowledge Spillover

Chapter 5 An Empirical Analysis On Channels and Patterns of Knowledge Spillover

5.1 Introduction

Based on the aim of this research, which is to explain how Knowledge Spillover (KS) happens at the regional level, this Chapter presents and analyses the results of this study's survey (Phase 2 and 3 of this research (see Figure 5.1)). These results refer to understanding how respondent firms, from different technological and regional backgrounds, attribute importance to channels of KS and how these channels are interrelated.

The findings enabled the identification of differences and similarities in the responses of firms according to their size, technology intensity category (from low- to high-tech firms) and the region in which they are located. The investigation of these aspects is essential for this research because it identifies the five most widely recognised channels of KS and the patterns of KS, which are central subjects of the interviews conducted with regional stakeholders and experts on KS and innovation (KSIexperts) in the next phase of this research (Phase 4 of this research (see Figure 5.1)).

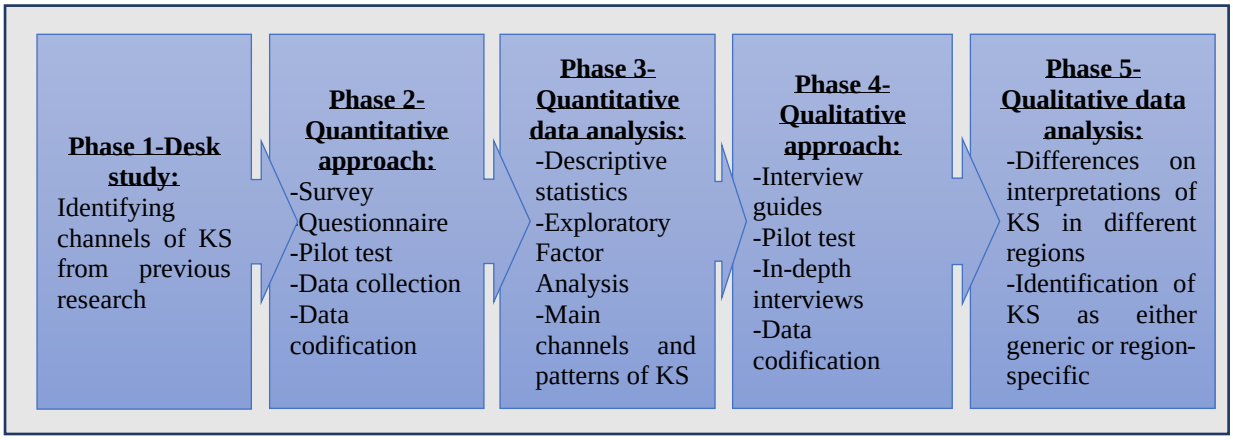

Figure 5.1 Research phases (Source: Author)

Thus, this chapter is concerned with identifying aspects of the research that are subsequently considered and explored during the qualitative analysis. Key informants interviewed explained the importance of the five most widely recognised channels for KS and regional innovation, which led to a discussion on both types of findings, quantitative and qualitative, that enabled this research to meet its aim, i.e. to explain the process of KS at the regional level.

This chapter consists of nine sections. The first section is this introduction. The second explains how the quantitative techniques employed tackle the research objectives. The third section informs about the demographics, that is, details regarding the sample, such as sample size by region and category of technology intensity, response rates and industry sectors surveyed. The fourth section provides findings regarding firm size, testing the hypothesis of whether micro and small firms attribute more importance to channels of KS than firms of larger sizes. The fifth section assesses the regions surveyed, namely, North East Brazil, South East Ireland, Bucharest-Ilfov Romania and Castilla-La Mancha Spain as regards the importance of channels of KS and how they are interrelated. The the sixth section assesses the importance of channels of KS and how they are interrelated by dividing respondent firms in these regions according to categories of technology intensity, namely, low-tech, medium-low-tech, medium-high-tech and high-tech industry sectors (OECD, 2011). For more information on this categorisation, see Chapter 4, Conceptual and methodological frameworks. The seventh section identifies the five most widely recognised as well as the three least recognised channels of KS. The eighth section identifies the most repetitive patterns of KS and, finally, the ninth section is the chapter summary.

5.2 The quantitative approach in this research

The research design adopted to explain the process of KS at the regional level (see Figure 5.1) considers five objectives, as follows (see Table 5.1).

Research question	How does the process of KS happen at the regional level?
Aim of the research	To explain the process of KS at the regional level
Research objectives	1 To determine the most and least important channels of KS 2 To determine the regional differences as regards channels and patterns of KS 3 To determine the differences between sectors with different technological intensity as regards channels and patterns of KS 4 To determine whether small firms attribute more importance to channels of KS than firms of larger sizes 5 To determine whether KS is region specific

Table 5.1 Research questions, aim and objectives (Source: Author)

By employing quantitative techniques, such as descriptive statistics, Exploratory Factor Analysis (EFA) and One-way Analysis of Variance (ANOVA), this research met four research objectives, as summarised in Table 5.2.

Research Objective	Description
1) To determine the most and least important channels of KS	The most and least important channels of KS are determined through the results of the survey as it determines the score of importance of channels of KS for firms in four different regions. The channels attributed with the most importance are those that obtain the five highest averaged scores of importance. Likewise, the channels attributed with the least importance are those that obtain the three lowest averaged scores of importance.
2) To determine the regional differences as regards channels and patterns of KS	The regional differences are obtained by comparing the importance of the channels and patterns of KS between regions. The patterns of KS are obtained by performing EFA in order to establish how channels of KS are interrelated. Thus, the comparison between these patterns is based on contrasting the channels of KS that they represent in order to identify the most common interrelationships.
3) To determine the differences between sectors with different technology intensity as regards channels and patterns of KS	This Research Objective focuses on understanding how each technology category orders the importance of KS channels. The comparison of results between high-, medium-high-, medium-low- and low-technology industry sectors enables the identification of a consistent set of channels that is important for all firms despite technological variation. Moreover, running a factor analysis on the four technology intensity industry categories supports understanding how higher- (or lower-) technology firms group channels of KS according to their interrelationship.
4) To determine whether small firms attribute more importance to channels of KS than firms of larger sizes	In order to examine this objective, ANOVA and Tukey's Test were performed to determine whether there are statistically significant differences between firms of different sizes. ANOVA is a statistical technique that tests for differences among the means of the populations by observing the amount of variation within each of these samples, relative to the amount of variation between the samples (Kothari, 2004). ANOVA followed by the Tukey's test can determine statistically significant differences between the means of different groups and detect which of these groups are different from each other.

Table 5.2 Description of the four Research Objectives addressed in this chapter (Source: Author)

The next section explores the sample surveyed by showing the response rate, regions and industries surveyed. It details the number of respondent firms per industry sector and region surveyed, i.e. South East Ireland, North East Brazil, Bucharest-Ilfov Romania, and Castilla-La Mancha Spain. Moreover, next section also shows the categorisation of industry sectors surveyed according to OECD (2011), i.e. from low- to high-tech industry sectors.

5.3 Demographics

The survey was administered to 7,292 industry representatives which yielded 439 valid responses (response rate of 6.02%). The respondents were all from manufacturing and ICT firms. The majority of the respondents were business owners (39.86%). However, directors (25.97%), managers (23.01%), consultants (5.01%), researchers (4.10%), administrative staff (1.37%), engineers (0.46%), and secretaries (0.22%) also took part in the survey. Thus, overall, the survey was administered mostly to respondents involved at the decision making level of either management or innovation in their firms from four regions worldwide, namely, South East Ireland, North East Brazil, Bucharest-Ilfov Romania and Castilla-La Mancha Spain. Castilla-La Mancha yielded 146 responses, Bucharest-Ilfov 97, South East Ireland 105, and Northeast Brazil 91. This resulted in a response rate per region respectively of 6.8%, 3.74%, 18.95% and 4.55%% (see Table 5.3).

	ADMINISTERED	VALID RESPONSES	RESPONSE RATE (%)	Required number of responses in the region to run EFA
South East Ireland	554	105	18.95	75
North East Brazil	2,000	91	4.55	75
Bucharest-Ilfov	2,592	97	3.74	75
Castilla-La Mancha	2,146	146	6.8	75
Total	7,292	439	6.02	75

Table 5.3 Response rate (Source: Author)

Since the research design involved performing EFA (Exploratory Factor Analysis) in order to analyse the interrelationships between channels of KS, the required number of responses per region was 75 as a general rule of this multivariate technique is to have at least five times as many observations as the number of variables to be analysed (Hair *et al.*, 1998). Thus, as there are 15 variables (channels of KS), it is necessary to have a minimum number of 75 respondents (5 multiplied by 15) in each region.

There were 23 participating industry sectors in the four regions surveyed. The industry sector that most contributed to this survey was Software, corresponding to 27.33% of the overall sample. The region that provided the most significant number of software firms was Castilla-La Mancha, equivalent to 39.17% of the total number of software firms surveyed, followed by Bucharest-Ilfov (24.17%), North East Brazil (20.83%) and South East Ireland (15.83%). Machinery was the second most expressive sample of firms (12.98% of the overall sample), with South East Ireland leading the sample with 45.61% of the firms, followed by North East

Brazil (21.05%), Bucharest-Ilfov (19.30%), and Castilla-La Mancha (14.04%). As well as software and machinery, other major sectors were internet (7.74%), clothing (6.83%%), chemicals (6.38%), and food (5.92%) (see Table 5.4 for the full list of valid responses by industry sector).

Sector	#	%
Software	120	27.33
Machinery	57	12.98
Internet	34	7.74
Clothing	30	6.83
Chemicals	28	6.38
Food	26	5.92
Telecommunications	23	5.24
Metal	17	3.87
Energy	16	3.64
Agriculture	15	3.42
Biotechnology	11	2.51
Plastic	11	2.51
Pharmaceutical	8	1.82
Beverages	8	1.82
Aerospace	5	1.14
Automotive	5	1.14
Education	2	0.46
School supplies	1	0.23
Computers	6	1.37
Furniture	7	1.59
Medical devices	7	1.59
Recycling	1	0.23
Ship building	1	0.23

Table 5.4 Responses by industry sector (Source: Author)

Considering technology intensity of industry sector, most of the sample consisted of High-tech firms (48.75%), followed by Medium-high-tech (20.50%), Low-tech (20.27%), and Medium-low-tech (10.48%). In addition, most of the high-tech firms were from Castilla-La Mancha (42.06%), followed by Bucharest-Ilfov (22.90%), South East Ireland (20.56%) and North East Brazil (14.48%). Medium-high-tech firms were most represented by South East Ireland (32.22%), followed by North East Brazil (28.89%), Castilla-La Mancha (21.11%), and Bucharest-Ilfov (17.78%). The representation of Medium-low-tech firms was led by

Bucharest-Ilfov (39.13%), then Castilla-La Mancha (28.26%), South East Ireland (21.4%), and North East Brazil (10.87%). The order of low-tech firms was North East Brazil (32.58%), Castilla-La Mancha (26.97%), South East Ireland (24.72%) and Bucharest-Ilfov (15.73%) (see Table 5.5).

	#	Castilla-La Mancha (%)	South East Ireland (%)	Bucharest-Ilfov (%)	North East Brazil (%)
High-tech	214	42.06	20.56	22.90	14.48
Medium-high-tech	90	21.11	32.22	17.78	28.89
Medium-low-tech	46	28.26	21.74	39.13	10.87
Low-tech	89	26.97	24.72	15.73	32.58

Table 5.5 Technology intensity – summary of responses per region (Source: Author)

5.4 Importance of channels of KS by firm size

This section identifies whether small firms (micro and small) attribute more importance to channels of KS than firms of larger sizes. These findings relate to Research Objective 2 (To distinguish the importance attributed to channels of KS between firm size) and they also contribute to the overall aim of the research, which is to explain KS at the regional level.

5.4.1 Average importance of channels of KS (by firm size)

The scores of importance attributed to each channel of KS are represented by the average importance (from 1 – Not important to 5 – Very important). Table 5.6 shows the scores given to each channel of KS according to firm size.

Channels of KS	Micro	Small	Medium	Large
Specialisation	4.20	4.23	4.17	4.34
Diversification	3.62	3.61	3.79	3.83
Networking	4.10	3.98	4.15	4.14
Geographical proximity	3.46	3.28	3.37	3.34
R&D	3.36	3.49	3.48	3.57
University research	3.39	3.34	3.36	3.57
Hiring university graduates	3.32	3.5	3.73	3.83
Hiring skilled labour	3.57	3.82	3.89	4.06
Foreign Direct Investment (FDI)	2.85	2.99	3.24	3.29
R&D cooperation	3.54	3.61	3.69	3.66
Reverse engineering	2.67	2.87	3.05	2.94
Patent disclosures	2.44	2.55	2.65	2.63
Imitation of organisational innovation	3	3.22	3.25	3.2
Competition between firms	3.72	3.71	3.87	3.49
Support on R&D from the government	3.33	3.67	3.71	3.8

Table 5.6 Average score of importance of channels of KS by firm size (Source: Author)

The scores of importance given to channels of KS show similarities in the way which firms of different sizes perceive the importance of channels of KS. The channel of KS that yielded the highest score of importance was *Specialisation* for all firm sizes. *Networking* obtained the second highest score for all firm sizes. The channel with the third highest score was *Hiring Skilled Labour* for small, medium and large firms. However, micro firms consider *Competition between firms* as the channel with the third highest score of importance.

Patent Disclosure was the channel with the lowest score of importance for all firm sizes. *Reverse engineering* followed as the channel with the second lowest score for all firm sizes and Foreign Direct Investment (*FDI*) was the third lowest score for micro, small and medium firms. Large firms considered *Imitation of organisational innovation* as third lowest score of importance.

5.4.2 One-way analysis of Variance (ANOVA)

This sub-section identifies whether the sample surveyed, distributed by firm size, presents scores of importance that are statistically different. This information is important in order to understand if firms of a particular size attribute more importance to channels of KS, suggesting that this firm size may benefit more from KS than the others. This information is also important in order to explore the hypothesis presented in Chapter 4, Conceptual and methodological frameworks, on whether small firms attribute more importance to channels of KS than large firms, as suggested by McCann and Mudambi (2005).

The methods chosen for this investigation was a One-way ANOVA followed by Tukey's Test because, by comparing means of different groups, these methods can reveal whether there are statistically significant differences between them. Therefore, One-way ANOVA followed by Tukey's test reveals whether the sample of micro and small firms could obtain a statistically significant higher score of importance for channels of KS than larger firms. Thus, the first variable (dependent) corresponds to the scores of importance for the 15 channels of KS given by the companies. The second variable, independent, is company size (four categories: micro, small, medium and large). The current research follows the three assumptions for ANOVA (Illowsky and Dean, 2016); namely 1, each population from which a sample is taken is assumed to be normal; 2, all samples are randomly selected and independent; and 3, the populations are assumed to have equal standard deviations (or variances).

Even though 429 responses were obtained, the majority were from micro-enterprises and small firms (171 micro-enterprises, 148 small firms, 75 medium-sized firms and 35 large firms). Because the sample of large firms consisted of 35 responses, 35 responses were randomly chosen from each of the other firm-size categories. Thus, as a means to avoid disparities, this ANOVA test consisted of 140 companies. The dependent variable, 'Score of importance', varied from 1 to 5 (from not important to very important), and there were four independent variables, each corresponding to a category of firm size. As illustrated in Table 5.7, the means of 'Score of importance' in the sample varied from 3.36 (micro firms) and 3.58 (large firms) and its standard deviation ranged from 1.15 to 1.23. Number of data points (N) was 525 because it corresponds to the number of channels of KS (15) multiplied by the number of firms per category of firm size (35).

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Micro firms	**525**	**3.36**	**1.23**	**0.05**	**3.25**	**3.46**	**1.00**	**5.00**
Small firms	**525**	**3.5**	**1.16**	**0.05**	**3.40**	**3.60**	**1.00**	**5.00**
Medium firms	**525**	**3.54**	**1.22**	**0.05**	**3.43**	**3.64**	**1.00**	**5.00**
Large firms	**525**	**3.58**	**1.15**	**0.50**	**3.48**	**3.68**	**1.00**	**5.00**
Total	**2100**	**3.49**	**1.19**	**.03**	**3.44**	**3.54**	**1.00**	**5.00**

Table 5.7 Descriptive statistics of the ANOVA sample (Source: Author)

The results of the ANOVA are as shown in Table 5.8.

	Sum of Squares	Df	Mean Square	F	Sig
Between Groups	14.428	3	4.809	3.391	.017
Within Groups	2972.491	2096	1.418		
Total	2986.920	2099			

Table 5.8 ANOVA Table (Source: Author)

The analysis of Table 5.8 shows that the null hypothesis of ANOVA can be rejected because all the means are not equal and there are statistically significant differences between the means. Firm size had a significant effect on the importance given to channels of KS at the $p < .05$ level for the four categories [$F (3, 2096) = 3.39$, $p = .017$]. Due to the existence of significance, a Post Hoc (Tukey) test was conducted. Post Hoc comparisons using the Tukey HSD test revealed that the mean score for micro companies ($M = 3.36$, $SD = 1.23$) was significantly different (Sig. = .014) to the mean score for large firms ($M = 3.58$, $ST = 1.15$).

Thus, the results from ANOVA cannot confirm the hypothesis that small firms attribute more importance to channels of KS than large firms because they revealed significant statistical differences between micro and large firms and that micro firms actually attribute less importance to channels of KS than large companies.

5.5 Regional analyses

The information provided in this sub-section focuses on the scores of importance of channels of KS in each of the four regions surveyed. The objective is to identify the most and the least important channels of KS and the patterns of KS in each region in order to address Research Objectives 2 and 3 and also to define the content of the interview guide, as the five most important channels of KS are discussed with key informants (Phase 4 of the research design).

5.5.1 Average importance of channels of KS (by region)

Table 5.9 shows the average score of importance of each channel of KS. The results are divided and subsequently analysed according to the regions surveyed.

Channels of KS	North East Brazil	South East Ireland	Bucharest-Ilfov Romania	Castilla-La Mancha Spain
Specialisation	**4.24**	**4.18**	**4.25**	**4.18**
Diversification	3.74	**3.57**	**3.81**	**3.53**
Networking	**4.2**	**4.05**	**4.05**	**3.98**
Geographical proximity	3.65	3.09	3.57	3.25
R&D	**4.02**	2.99	3.55	3.32
University research	**3.96**	2.91	3.49	3.29
Hiring university graduates	3.75	3.21	**3.73**	3.37
Hiring skilled labour	**3.93**	**3.34**	**4.08**	**3.68**
Foreign Direct Investment (FDI)	3.41	2.70	3,22	2.77
R&D cooperation	**4.03**	3.03	3.55	**3.75**
Reverse engineering	3.2	2.41	3.01	2.74
Patent disclosures	3.05	2.04	2.81	2.39
Imitation of organisational innovation	3.54	3.06	3.24	2.90
Competition between firms	3.86	**3.67**	**3.59**	**3.74**
Support on R&D from the government	3.86	**3.42**	3.55	3.47

Table 5.9 Average score of importance of channels of KS by region surveyed (Source: Author)

In North East Brazil, **t**he channel of KS with the highest score of importance is *Specialisation* (4.24). The order of the other channels with meaningful scores of importance: *Networking* (4.2), *R&D cooperation* (4.03), *R&D* (4.02), *University research* (3.96) and Hiring skilled labour (3.93). The channels with the lowest importance in the region were *Patent disclosures* (3.05), *Reverse engineering* (3.2), and Foreign Direct Investment (*FDI)* (3.41).

In South East Ireland, the channel of KS with the highest average score of importance is *Specialisation* (4.18), followed by *Networking* (4.05), *Competition between firms* (3.67), *Diversification* (3.57), *Support on R&D from the government* (3.42), and *Hiring skilled labour* (3.34). The channel of lowest average score of importance is *Patent disclosures* (2.04), followed by *Reverse engineering* (2.41), and *FDI* (2.70).

In Bucharest-Ilfov, the channel of KS of highest average score of importance is *Specialisation* (4.25), other channels that yielded high averages scores of importance were: *Hiring skilled labour* (4.08), *Networking* (4.05), *Diversification* (3.81), *Hiring university graduates* (3.73),

and *Competition between firms* (3.59). The channels of KS that were identified with the lowest average score of importance were *Patent disclosure* (2.81), *Reverse engineering* (3.01), and *FDI* (3.22).

In Castilla-La Mancha, *Specialisation* was the channel of KS with the highest average score of importance score (4.18), *Networking* the second (3.98), *R&D cooperation* the third (3.75), *Competition between firms* the fourth (3.74), *Hiring skilled labour* the fifth (3.68), and *Diversification* the sixth (3.53). The lowest average score of importance channel of KS was attributed to *Patent disclosures* (2.39), followed by *Reverse engineering* (2.74), and *FDI* (2.77).

5.5.2 Reliability of the data and the research questionnaire (by region)

The objective of this sub-section is twofold. First, to provide results by each region on the second measure considered in the survey called *top five most important channel of KS*, which is a percentage value as it is based on the probability each channel has to be selected among the *top five highest scores of importance channel.* Second, to determine the Pearson's correlation coefficient (r) between this measure and *average score of importance*. The results of the measure *top five highest scores of importance of KS* by region is in Table 5.10.

Channels of KS	North East Brazil	South East Ireland	Bucharest-Ilfov Romania	Castilla-La Mancha Spain
Specialisation	73.63	80	75.26	76.02
Diversification	15.38	34.29	38.14	26.02
Networking	56.04	65.71	57.73	58.22
Geographical proximity	16.48	20.95	29.9	23.29
R&D	35.16	8.57	25.77	24.66
University research	41.76	23.81	22.68	31.51
Hiring university graduates	31.87	27.62	31.96	30.14
Hiring skilled labour	41.76	36.19	49.48	39.04
Foreign Direct Investment (FDI)	17.58	13.33	8.25	7.53
R&D cooperation	39.56	29.52	28.87	58.22
Reverse engineering	14.29	16.19	16.49	14.38
Patent disclosures	4.4	7.62	10.31	7.53
Imitation of organisational innovation	19.78	2.67	24.74	21.92
Competition	38.46	54.29	30.93	47.26
Support on R&D from the government	43.96	40.95	34.02	19.18

Table 5.10 Choice of firms for the five most important channel of KS (regional samples) (Source: Author)

The main objective in considering this second measure in the questionnaire was to verify consistencies in the findings obtained from scores of importance, i.e. average importance. To that end, the Pearson's correlation coefficient (r) was applied and expected that, if there was positive and strong correlation between *average scores of importance* and *top five highest scores of importance*, it would indicate that both measures were correlated and, therefore, confirm the capacity of the questionnaire to generate reliable sources of information. The results are per Table 5.11.

Region	Correlation coefficient (r)
North East Brazil	0.8865
South East Ireland	0.8673
Bucharest-Ilfov Romania	0.9161
Castilla-La Mancha Spain	0.8981

Table 5.11 Correlation coefficients by regions surveyed (Source: Author)

The correlation coefficients in the four regions are above 0.80, showing that a strong positive correlation exists. This means that both measures, *average scores of importance* and the *top five highest scores of importance* are moving in the same direction and can increase and decrease values concomitantly.

5.5.3 Exploratory Factor Analyses (EFA) in the regions

This sub-section is divided into two parts. The first part presents data that validates the application of Exploratory Factor Analysis (EFA) and also justifies the creation of underlying factors in the four regions. The second part details how the channels of KS are interrelated, that is, how patterns of KS are formed.

5.5.4 Requirements for performing EFA in the regions

The Cronbach's alpha for each regional sample shows that the question that measures the average scores of importance (see question five in Appendix 1) has internal consistency, that is, all its variables measure the same general outcome and the statistics present reliability. The Cronbach's alpha (α) results are as follows (Table 5.12).

Region	Cronbach's alpha (α)
North East Brazil	0.891
South East Ireland	0.882
Bucharest-Ilfov Romania	0.830
Castilla-La Mancha Spain	0.871

Table 5.12 Cronbach's alpha by region surveyed (Source: Author)

In all four regions, the Cronbach's alpha was well above the minimum of 0.60 to 0.70 suggested by Hair *et al.* (1998). Thus, the channels of KS contained in the questionnaire (question 5 on average importance – Appendix 1) proved to be consistent in measuring factors.

The research also considered the Measure of Sample Adequacy (MSA) in order to evaluate the appropriateness of applying EFA. The MSA utilised was the Kaiser-Meyer-Olkin (KMO) test and the results are per Table 5.13.

Region	KMO
North East Brazil	0.820
South East Ireland	0.845
Bucharest-Ilfov Romania	0.742
Castilla-La Mancha Spain	0.836

Table 5.13 KMO by region surveyed (Source: Author)

South East Ireland, North East Brazil and Castilla-La Mancha Spain, were above 0.80, indicating a meritorious result (Hair et al, 1998). Bucharest-Ilfov, above 0.70, yielded a

middling MSA (Hair et al, 1998). Moreover, the current research also checked the communalities, as shown in Table 5.14.

North East Brazil		South East Ireland		Bucharest-Ilfov Romania		Castilla-La Mancha Spain	
Channel of KS	**Extraction**	**Channel of KS**	**Extraction**	**Channel of KS**	**Extraction**	**Channel of KS**	**Extraction**
Specialisation	0.724	Specialisation	0.598	Specialisation	0.545	Specialisation	0.782
Diversification	0.775	Diversification	0.591	Diversification	0.533	Diversification	0.539
Networking	0.662	Networking	0.707	Networking	0.710	Networking	0.611
R&D	0.582	Geographical proximity	0.753	Geographical proximity	0.720	Geographical proximity	0.691
University research	0.756	R&D	0.757	R&D	0.736	R&D	0.735
Hiring university graduates	0.708	University research	0.535	Hiring university graduates	0.609	University research	0.778
Hiring skilled labour	0.675	Hiring university graduates	0.789	Hiring skilled labour	0.776	Hiring university graduates	0.572
FDI	0.591	Hiring skilled labour	0.511	Reverse engineering	0.653	Hiring skilled labour	0.652
R&D cooperation	0.608	FDI	0.693	Patent disclosures	0.672	**FDI**	**0.480**
Reverse engineering	0.688	R&D cooperation	0.551	Imitation of organisational innovation	0.617	Reverse engineering	0.696
Patent disclosures	0.744	Reverse engineering	0.635	Competition between firms	0.511	Patent disclosures	0.671
Imitation of organisational innovation	0.798	Patent disclosures	0.763	FDI	0.576	Imitation of organisational innovation	0.638
Competition between firms	0.735	Competition between firms	0.732	R&D cooperation	0.636	Competition between firms	0.606
Support on R&D from the government	0.581	Support on R&D from the government	0.637	**Support on R&D from the government**	**0.439**	**Support on R&D from the government**	**0.496**

Table 5.14 Communalities in channels of KS (by region) (Source: Author)

Most of the values of the communalities, in each region, are above 0.50. However, there are three exceptions *Support on R&D from the government* (0.439) for Bucharest-Ilfov. As regards Castilla-La Mancha, both *FDI* (0.480) and *Support on R&D from the government* (0.496) did not meet the threshold suggested by Hair *et al.* (1998) of at least 0.50. The researcher attempted to run these EFA without such variables or using other rotation methods, however, repeating low communalities and lower factor loadings required running EFA with 11 variables (channels of KS), which would limit the analysis. Thus, this was the best arrangement without reducing the number of variables to 11.

5.5.5 Performing EFA on the regional samples

After testing the requirements necessary for performing EFA, the number of variables (channels of KS) were reduced into factors (patterns of KS). Table 5.15 provides the patterns (P) and channels of KS per factor in each region surveyed.

North East Brazil			South East Ireland			Bucharest-Ilfov Romania			Castilla-La Mancha Spain		
P	**Channels**	**Factor loading**	**P**	**Channels**	**Factor loading**	**P**	**Channels**	**Factor loading**	**P**	**Channels**	**Factor loading**
1	1. Networking	0.582	1	1. Geographical proximity	0.81	1	1. Diversification	0.637	1	1. Reverse engineering	0.746
	2. R&D	0.669		2. R&D	0.798		2. Networking	0.821		2. Patent disclosures	0.732
	3. University research	0.840		3. University research	0.64		3. Geographical proximity	0.824		3. Imitation of organisational innovation	0.707
	4. Hiring university graduates	0.816		4. FDI	0.675		4. R&D	0.792		4. Competition	0.601
	5. Hiring skilled labour	0.732	2	5. Specialisation	0.695	2	5. reverse engineering	0.744		5. Support on R&D from the government	0.62
	6. FDI	0.670		6. Diversification	0.727		6. Patent disclosures	0.726	2	6. Hiring university graduates	0.697
	7. R&D cooperation	0.593		7. Networking	0.696		7. Imitation of organisational innovation	0.761		7. Hiring skilled labour	0.787
	8. Support on R&D from the government	0.755		8. Competition	0.649		8. Competition	0.658		8. FDI	0.543
2	9. Specialisation	0.584	3	9. Hiring university graduates	0.859	3	9. Specialisation	0.563	3	9. Specialisation	0.826
	10. Imitation of organisational innovation	0.813		10. Hiring skilled labour	0.636		10. FDI	0.582		10. Diversification	0.523
	11. Competition	0.806		11. Support on R&D from the government	0.69		11. R&D cooperation	0.733		11. Networking	0.736
3	12. Reverse engineering	0.747	4	12. R&D cooperation	0.593		12. Support on R&D from the government	0.568	4	12. Geographical proximity	0.535
	13. Patent disclosures	0.744		13. Reverse engineering	0.709	4	13. Hiring university graduates	0.73		13. R&D	0.703
4	14. Diversification	0.813		14. Patent disclosures	0.822		14. Hiring skilled labour	0.799		14. University research	0.831

Table 5.15 Patterns of KS (by region) (Source: Author)

According to Table 5.15, in North East Brazil, factor analysis (principal components method) indicated that the 14 channels of KS can be reduced to four factors, or patterns of KS. The cumulative percentage of total variance extracted by these four factors is 68.778%. These factors have variables with significant loadings and, as an orthogonal solution was applied (Quartimax rotation method), the factors are independent of one another. Moreover, the rotated component matrix showed that the variable *Geographical proximity* did not present an adequate factor loading in any rotation method, thus it was removed.

In South East Ireland, factor analysis (principal components method), using a Varimax rotation method, reduced 14 channels of KS into 4 patterns of KS. The cumulative percentage of total

variance extracted by these four factors is 66.096%. Also, as the rotated component matrix yielded unsatisfactory factor loadings for the variable *Imitation management*, thus it was removed.

In Bucharest-Ilfov, Varimax reduced 14 channels of KS into 4 patterns. The cumulative percentage of total variance extracted by these four factors is 62.374%. The variable *University research* had to be removed as it did not present satisfactory factor loadings by the rotated component matrix.

In Castilla-La Mancha, Varimax reduced 14 channels into 4 channels and the cumulative percentage of total variance extracted by them factors is 63.906%. The rotated component matrix showed that the variable *R&D cooperation* did not yield a satisfactory factor loading, thus it was removed.

Thus, as well as obtaining significant factor loadings (Table 5.15), the percentage of variance criterion also ensured practical significance for the derived factors by yielding cumulative variances above 60%, which are satisfactory (Hair *et al.*, 1998).

5.6 Analysis on the technological intensity categories

This section presents the channels of KS with the highest and the lowest scores of importance and the patterns of KS for each category of technology intensity in order to address Research Objectives 3 and 4 and prepare questions for the interviews (phase 4 of the research design).

The technological intensity categories are based on OECD (2011) classification of manufacturing industries into categories based on R&D intensities, namely low-tech, medium-low-tech, medium-high-tech, and high-tech industry sectors (see sub-section 4.4.3 Phase 3: Quantitative data analysis, in Chapter 4 Conceptual and methodological frameworks for more details). Whilst the previous section explores the sample of firms surveyed based on their location, this section explores the sample of firms according to the categories of technology intensity to which they belong

Thus, this section follows the same structure as the previous section (Section 5.5 Regional analyses) and, at the end of the chapter, the findings of both sections are analysed in order to inform Phase 4 of the research, which incorporates the interviews with key informants.

5.6.1 Average importance of channels of KS (by technology intensity category)

Table 5.16 shows the average scores of importance of each channel of KS for high-tech, medium-high-tech, medium-low-tech and low-tech firms.

Channels of KS	Low-tech	Medium-low-tech	Medium-high-tech	High tech firms
Specialisation	**4.18**	**4.24**	**4.21**	**4.21**
Diversification	3.6	**3.78**	**3.77**	**3.59**
Networking	**3.97**	**3.93**	**4.1**	**4.1**
Geographical proximity	3.56	3.39	3.41	3.25
R&D	3.57	3.30	3.64	3.32
University research	**3.65**	3.41	3.5	3.22
Hiring university graduates	3.25	3.24	3.69	3.56
Hiring skilled labour	3.51	**3.76**	**3.72**	**3.84**
Foreign Direct Investment (FDI)	*2.96*	*3.07*	*3.13*	*2.92*
R&D cooperation	**3.61**	3.57	**3.86**	3.48
Reverse engineering	3.03	3.11	2.99	2.59
Patent disclosures	2.76	2.91	2.86	2.23
Imitation of organisational innovation	3.36	3.33	3.2	3
Competition between firms	**3.66**	**3.65**	**3.84**	**3.69**
Support on R&D from the government	**3.73**	**3.70**	3.67	3.41

Table 5.16 Average score of importance of channels of KS by category of technology intensity surveyed (Source: Author)

For low-tech industries surveyed, the highest score of importance attributed to a channel of KS was *Specialisation* (4.18). The second most important channel of KS was *Networking* (3.97). The third most important channel of KS was *Support on R&D from the government* (3.73). Other relevant channels of KS are as follows: *Competition between firms* (3.66), *University research* (3.65), and *R&D cooperation* (3.61). The lowest score of importance was attributed to *Patent disclosures* (2.76), followed by *FDI* (2.96), and *Reverse engineering* (3.03).

The main channels of KS for the medium-low–tech firms surveyed are as follows: (1st) *Specialisation* (4.24); (2nd) *Networking* (3.93); (3rd) *Diversification* (3.78); (4th) *Hiring skilled labour* (3.76); (5th) *Support on R&D from the government* (3.70); and (6th) *Competition*

between firms (3.65). The three lowest scores of importance are *Patent disclosures* (2.91), *FDI* (3.07), and *Reverse engineering* (3.11).

Among the medium-high-tech firms in the survey, *Specialisation* was of highest average score of importance (4.21), *Networking* was second highest (4.10), and *R&D cooperation* was the third (3.86). The average score of importance of other channels was as follows: *Competition between firms* (3.84); *Diversification* (3.77); and *Hiring skilled labour* (3.72). The channels that obtained the lowest average were *Patent disclosures* (2.86), *Reverse engineering* (2.99), and *FDI* (3.13).

The channels of KS with highest scores of importance for high-tech firms was *Specialisation* (4.21), followed by *Networking* (4.1), *Hiring skilled labour* (3.84), *Competition between firms* (3.69), and *Diversification* (3.59). The lowest scores of importance were attributed to *Patent disclosures* (2.23), followed by *Reverse engineering* (2.59), and *FDI* (2.92).

5.6.2 Reliability of the data and the research questionnaire (by technology intensity category)

As the section on the analysis of regions, this section provides results in each category of technology intensity regarding the measures of the *average scores of importance* and the *top five highest scores of importance* for channels of KS. The results of the measure of the *top five highest scores of importance* by technology intensity category is in Table 5.17.

Channels of KS	Low-tech	Medium-low-tech	Medium-high-tech	High-tech
Specialisation	83.15	67.39	75.56	75.70
Diversification	32.58	34.78	28.89	25.23
Networking	53.93	56.52	53.33	64.95
Geographical proximity	30.34	30.43	21.11	18.69
R&D	20.22	34.78	21.11	22.90
University research	29.21	19.57	37.78	28.97
Hiring university graduates	17.98	17.39	27.78	39.25
Hiring skilled labour	35.96	34.78	36.67	46.73
Foreign Direct Investment (FDI)	11.23	6.52	11.11	12.15
R&D cooperation	35.96	52.17	46.67	38.32
Reverse engineering	14.61	21.74	17.78	13.08
Patent disclosures	5.62	8.70	12.22	6.07
Imitation of organisational innovation	28.09	28.26	17.78	22.42
Competition	46.07	34.78	47.78	42.52
Support on R&D from the government	32.58	41.3	36.67	29.44

Table 5.17 Choice of firms for the channels of KS with the five highest scores of importance (categories of technology intensity samples) (Source: Author)

The Pearson's correlation coefficient (r) was applied in order to identify whether the measure of the *top five highest scores of importance* showed related results to average importance. The results are illustrated in Table 5.18.

Technological intensity category	Correlation coefficient (r)
Low-tech	0.8955
Medium-low-tech	0.8913
Medium-high-tech	0. 8780
High-tech	0.9094

Table 5.18 Correlation coefficients by technological intensity category surveyed (Source: Author)

The correlation coefficients in the four categories are around 0.90, showing that a strong positive correlation exists. This means that the measures, *average scores of importance* and the *top five highest scores of importance* for channels of KS increase and decrease values at the same time.

5.6.3 EFA in the technology intensity categories

This section is divided into two parts. The first part explains how the EFAs performed in order to reveal patterns of KS for different categories of technology intensity were validated. The second part shows how the patterns of KS were grouped. It was possible to perform only three EFAs with the sample of firms divided by technology intensity because the number of medium-low-tech firms surveyed (n=46) did not reach the threshold of 75 observations for 15 variables (channels of KS), which is a general rule of this multivariate technique to have at least five times as many observations as the number of variables to be analysed (Hair *et al.*, 1998).

5.6.3.1 Requirements for performing EFA in technology intensity categories

The measures of scores of importance for each category of technology intensity have internal consistency as the Cronbach's alpha shown in Table 5.19 yielded results well above of the threshold of 0.60 (*Hair et al.*, 1998).

Technological intensity category	Cronbach's alpha (α)
Low-tech	0.936
Medium-high-tech	0.860
High-tech	0.847

Table 5.19 Cronbach's alpha by technology intensity category (Source: Author)

The Measure of Sample Adequacy (MSA) was obtained through the Kaiser-Meyer-Olkin (KMO) test and both the results obtained by the sample from Low- and High-tech firms (ranging from 0.80 to 0.90) are considered meritorious by Hair *et al.* (1998). The KMO for Medium-high-tech firms is middling (*Hair et al.*, 1998) (Table 5.20).

Region	KMO
Low-tech	0.891
Medium-high-tech	0.741
High-tech	0.825

Table 5.20 KMO by technology intensity category surveyed (Source: Author)

In addition to Cronbach's alpha and MSA, communalities were also determined (Table 5.21).

Low-tech		Medium-high-tech		High-tech	
Channels of KS	**Extraction**	**Channels of KS**	**Extraction**	**Channels of KS**	**Extraction**
Specialisation	0.678	Specialisation	0.633	Specialisation	0.640
Diversification	0.520	Diversification	0.587	Diversification	0.471
Networking	0.641	Networking	0.747	Networking	0.629
Geographical proximity	0.719	Geographical proximity	0.747	Geographical proximity	0.627
R&D	0.653	R&D	0.764	R&D	0.702
University research	0.614	University research	0.731	University research	0.709
Hiring university graduates	0.560	Hiring university graduates	0.776	Hiring university graduates	0.649
Hiring skilled labour	0.633	Hiring skilled labour	0.804	Hiring skilled labour	0.727
Reverse engineering	0.708	FDI	0.781	FDI	0.533
Patent disclosures	0.693	R&D cooperation	0.738	R&D cooperation	0.590
Imitation of organisational innovation	0.709	Reverse engineering	0.671	Reverse engineering	0.630
Competition between firms	0.537	Patent disclosures	0.752	Imitation of organisational innovation	0.624
Support on R&D from the government	0.634	Imitation of organisational innovation	0.720	Competition between firms	0.598
		Competition between firms	0.743		
		Support on R&D from the government	0.585		

Table 5.21 Communalities in channels of KS (by technology intensity category) (Source: Author)

The three technology intensity categories considered to perform factor analysis presented communalities above 0.50, which is the threshold suggested by Hair *et al.* (1998).

5.6.3.2 Performing EFA in the samples from technology intensity categories

The fulfilment of the requirements for performing EFA led the researcher to reduce the variables (channels of KS) into factors (patterns of KS). Table 5.22 provides the resulting factors (F) and variables per factor in each category of technology intensity surveyed.

Low-tech			Medium-high-tech			High-tech		
P	**Channel**	**Factor loading**	**P**	**Channel**	**Factor loading**	**P**	**Channel**	**Factor loading**
1	1. Specialisation	0.775	**1**	1. Specialisation	0.765	**1**	1. R&D	0.697
	2. Diversification	0.710		2. Diversification	0.700		2. FDI	0.573
	3. Networking	0.758		3. Networking	0.810		3. R&D cooperation	0.715
	4. Geographical proximity	0.844		4. Support on R&D from the government	0.508		4. University research	0.825
	5. R&D	0.659	**2**	5. University research	0.749	**2**	5. Specialisation	0.753
	6. University research	0.706		6. R&D cooperation	0.805		6. Networking	0.749
	7. Hiring university graduates	0.598		7. Patent disclosures	0.713		7. Geographical proximity	0.607
2	8. Hiring skilled labour	0.628	**3**	8. Geographical proximity	0.792		8. Diversification	0.553
	9. Reverse engineering	0.825		9. R&D	0.706	**3**	9. Reverse engineering	0.726
	10. Patent disclosures	0.815		10. FDI	0.773		10. Imitation of organisational innovation	0.741
	11. Imitation of organisational innovation	0.805	**4**	11. Reverse engineering	0.624		11. Competition	0.653
	12. Competition	0.708		12. Imitation of organisational innovation	0.746	**4**	12. Hiring university graduates	0.712
	13. Support on R&D from the government	0.720		13. Competition	0.735		13. Hiring skilled labour	0.809
			5	14. Hiring university graduates	0.781			
				15. Hiring skilled labour	0.856			

Table 5.22 Patterns of KS (by category of technology intensity) (Source: Author)

According to Table 5.22, the EFA (principal components method) performed with the sample of low-tech firms, excluded two variables (R&D cooperation and FDI) that did not present adequate factor loadings in any rotation method. Subsequently, the EFA, through Varimax rotation method, reduced 13 channels of KS into 2 factors, or patterns of KS. The cumulative percentage of total variance extracted by these two factors is 63.831%.

The EFA (principal components method) for the sample of Medium-High-Tech firms was performed with all variables and, through Varimax rotation method, it yielded 5 factors, in which extracted 71.864% of the total variance.

The EFA (principal components method) for the sample of Hi-Tech firms, utilising Varimax rotation method, did not consider two variables as they did not present adequate factor loadings, namely, *Patent disclosures* and *Support on R&D from the government*. It yielded 4 factors that extracted 66.526% of the total variance.

5.7 Channels of KS with the highest and lowest scores of importance

This section identifies the channels of KS with the highest scores of importance for surveyed manufacturing and ICT firms in two different iterations, i.e. both the regional and technological

context. It also pinpoints the five channels of KS with the highest scores of importance, which are assumed (i) to be the most important for the firms surveyed, and (ii) that they can propagate KS within regions. Hence, these channels are subject for discussion with the interviewees in the qualitative strand (see Research Design in Chapter 4, Conceptual and methodological frameworks). On the other hand, the three channels of KS that yielded the lowest scores of importance could not be confirmed in this research as effective channels of KS, contrary to the thinking of authors who proposed those channels' capacity to propagate KS. The selection of the five most important channels of KS therefore is based on the following guidelines (Table 5.23):

Step	Action
1st	Order the average importance of the channels from the highest to the sixth highest
2nd	For channels of KS with the same average importance, the one with the highest percentage of being chosen in the top five by firms will be preferred over the other
3rd	Select five channels with the highest number of repetitions (coincidences) within the six highest values

Table 5.23 Guidelines for selecting the channels of KS with the highest scores of importance (Source: Author)

Based on findings from Table 5.24, Channels of KS that yielded the six highest scores of importance within each geographical, the channels generated are ordered from the highest to the lowest according to the geographical location of respondent firms (Table 5.24).

North East Brazil		**South East Ireland**		**Bucharest-Ilfov Romania**		**Castilla-La Mancha Spain**	
Channel of KS	**Score**	**Channel of KS**	**Score**	**Channel of KS**	**Score**	**Channel of KS**	**Score**
Specialisation	4.24	Specialisation	4.18	Specialisation	4.25	Specialisation	4.18
Networking	4.20	Networking	4.05	Hiring skilled labour	4.08	Networking	3.98
R&D cooperation	4.03	Competition	3.67	Networking	4.05	R&D cooperation	3.75
R&D	4.02	Diversification	3.57	Diversification	3.81	Competition	3.74
University research	3.96	Support on R&D from the government	3.42	Hiring university graduates	3.73	Hiring skilled labour	3.68
Hiring skilled labour	3.93	Hiring skilled labour	3.34	Competition	3.59	Diversification	3.53

Table 5.24 Channels of KS that yielded the six highest scores of importance within each geographical region (Source: Author)

Similarly, Table 5.25 shows channels of KS that yielded the six highest scores of importance within each category of technology intensity.

Low-tech firms		Medium-low-tech firms		Medium-high-tech firms		High-tech firms	
Channel of KS	**Score**	**Channel of KS**	**Score**	**Channel of KS**	**Score**	**Channel of KS**	**Score**
Specialisation	4.18	Specialisation	4.24	Specialisation	4.21	Specialisation	4.21
Networking	3.97	Networking	3.93	Networking	4.10	Networking	4.10
Support on R&D from the government	3.73	Diversification	3.78	R&D cooperation	3.86	Hiring skilled labour	3.84
Competition	3.66	Hiring skilled labour	3.76	Competition	3.84	Competition	3.69
University research	3.65	Support on R&D from the government	3.70	Diversification	3.77	Diversification	3.59
R&D cooperation	3.61	Competition	3.65	Hiring skilled labour	3.72	Hiring university graduates	3.56

Table 5.25 Channels of KS that yielded the six highest scores of importance within technology intensity categories (Source: Author)

The five most important channels of KS, based on the four regions surveyed, are obtained by identifying the five channels that repeat the most out of the six, as shown in Table 5.26.

Channel of KS
1. Specialisation
2. Networking
3. Hiring skilled labour
4. Competition
5. Diversification

Table 5.26 Five most important channels of KS – regional analysis (Source: Author)

Similarly to the previous procedure, the five most important channels of KS in the four categories of technology intensity are displayed in table 5.27.

Channels of KS
1. Specialisation
2. Networking
3. Hiring skilled labour
4. Competition
5. Diversification

Table 5.27 Five most important channels of KS – technology intensity analysis (Source: Author)

Therefore, it becomes visible that the channels of KS with the highest scores of importance, according to their order of importance, are the same in both analyses (regional and technological intensity). The difference is the order of channels between the fourth and fifth positions. It is worth highlighting that different regions attribute importance to channels of KS in a similar order, and so do the different categories of technology intensity, revealing that low-tech firms attribute importance to channels of KS in the same way as high-tech firms do. *Specialisation* was continuously the channel of KS with the highest score of importance regardless of the geographical region and the category of technology intensity because it was considered as so in 100% of the segments (8 out of 8). *Networking* was considered the channel of KS with the second highest score of importance in 87.5% (7 out of 8) of the cases and was considered in 100% of the segments. *Hiring skilled labour* was among the top six scores of importance in 87.5% of the cases. *Competition* was among the top six highest scores of importance in 87.5% of the cases (6 out of 8). Finally, as for *diversification*, it was among the top six in 75% of the cases.

The most important channels of KS that were selected are summarised in Table 5.28. Filled spaces represent the channels of KS that yielded the top five highest scores of importance in the region or category of technology intensity.

Most important channels of KS	North East Brazil	South East Ireland	Bucharest-Ilfov Romania	Castilla-La Mancha Spain	Low-tech	Medium-low-tech	Medium-high-tech	High-tech	Counts
1. Specialisation									8
2. Networking									8
3. Hiring skilled labour									4
4. Competition									5
5. Diversification									5
6. Support on R&D from the government									3
7. Hiring university graduates									1
8. R&D cooperation									3
9. R&D									1
10. University research									2

Table 5.28 Selection of the most important channels of KS (Source: Author)

As regards the order of importance of the least important channels of KS (Table 5.29), in both types of analyses (regional and technological intensity), the order of scores of importance is the same.

The three least important channels of KS
1 Patent disclosures
2 Reverse engineering
3 FDI

Table 5.29 The three least important channels of KS – regional and technological intensity analyses (Source: Author)

In the regional approach, the order of preference is the same in all regions surveyed. *Patent disclosures* is the channel of KS with the lowest score of importance, *reverse engineering* is the second lowest, and *FDI* is the third lowest. In the technology intensity approach, patent disclosure is consistently the channel of KS with the lowest score of importance. Reverse engineering and FDI present respectively the second and the third lowest scores of importance for high-tech and medium-high-tech firms. As for low-tech and medium-low-tech firms, FDI and reverse engineering present respectively the second and third lowest score of importance for channels of KS.

5.8 Core patterns of KS

A pattern of KS is an underlying mechanism that represents the interrelation between channels of KS and through which KS can be propagated. It is a mechanism because it shows how a group of channels of KS behave, that is, how they increase or decrease in importance when firms change their perception about a particular channel within the same pattern. A core pattern of KS, however, is a pattern of KS representing the interrelations that repeat and are consistent in different regions and industry sectors. Thus, a core pattern of KS is a patterns obtained through different iterations with Exploratory Factor Analysis (EFA) that considers the channels of KS that coincide, or repeat, the most in the resulting factors. The different iterations that are at stake in this research regarding patterns of KS are geographical regions and technology intensity categories. Thus, the purpose of this sub-section is to identify repetition among all patterns of KS in order to reveal the coinciding channels that form the core patterns of KS.

The core patterns of KS (blue areas in Figures 5.2 to 5.6) are revealed through aligning the patterns of KS resulting from conducting the EFA. Each column represents a segment of control, or iteration, in the research (each region and technological intensity category that had a sample large enough to conduct a factor analysis) and provides a resulting factor (pattern of

KS) that contains variables (channels of KS) of interest for investigation. Thus, the core patterns of KS are the result of a series of combinations performed in order to identify the pattern that is more representative, or consistent, between the firms located within the different regions and technology intensity of industry sectors surveyed.

North-East Brazil	South-East Ireland	Bucharest-Ilfov Romania	Castilla-La Mancha Spain	Low-tech firms	Medium-high-tech firms	High-tech firms
	Specialisation	R&D	Specialisation	Specialisation	Specialisation	Specialisation
Diversification	Diversification	Diversification	Diversification	Diversification	Diversification	Diversification
	Networking	Networking	Networking	Networking	Networking	Networking
	Competition	Geographical proximity		Geographical proximity	Support on R&D from the government	Geographical proximity
				R&D		
				University research		
				Hiring university graduates		

Figure 5.2 First core pattern of channels of KS (Source: Author)

The first core pattern of channels of KS (blue area in Figure 5.2) comprises of three different channels of KS, namely, *diversification*, *specialisation* and *networking*. *Diversification* is present in all the seven factors aligned (100% repetition). *Networking* is missing in one factor (86% redundancy) and *Specialisation* is missing in two factors (71% repetition).

North-East Brazil	South-East Ireland	Bucharest-Ilfov Romania	Castilla-La Mancha Spain	Low-tech firms	Medium-high-tech firms	High-tech firms
University research	Geographical proximity	Geographical proximity	Geographical proximity	Geographical proximity	Geographical proximity	University research
R&D	R&D	R&D	R&D	R&D	R&D	R&D
FDI	FDI	Networking	University research	University research	FDI	FDI
Hiring university graduates	University research	Diversification		Networking		R&D coperation
Hiring skilled labour				Diversification		
Networking				Specialisation		
R&D coperation				Hiring university graduates		
Support on R&D from the government						

Figure 5.3 Second core pattern of channels of KS (Source: Author)

The second core pattern of channels of KS (Figure 5.3) consists of four channels of KS. They are presented with their respective redundancy as follows. *R&D* is existent in all factors (100% repetition). *University research* is absenting in two factors (71% repetition). Geographical

proximity is also missing in two factors (71% repetition). FDI is missing in three factors (57% repetition).

North-East Brazil	South-East Ireland	Bucharest-Ilfov Romania	Castilla-La Mancha Spain	Low-tech firms	Medium-high-tech firms	High-tech firms
Imitation of organisational innovation	Networking	Imitation of organisational innovation	Imitation of organisational innovation	Imitation of organisational innovation	Imitation of organisational innovation	Imitation of organisational innovation
Competition	Competition	Competition	Competition	Competition	Competition	Competition
Specialisation	Specialisation	Patent disclosures	Support on R&D from the government	Patent disclosures	Reverse engineering	Reverse engineering
	Diversification	Reverse engineering	Patent disclosures	Reverse engineering		
			Reverse engineering	Hiring skilled labour		
				Support on R&D from the government		

Figure 5.4 Third core pattern of channels of KS (Source: Author)

The third pattern (Figure 5.4) involves two channels of KS, *competition* and *imitation of organisational innovation*. They respectively yield 100% and 86% of repetition.

North-East Brazil	South-East Ireland	Bucharest-Ilfov Romania	Castilla-La Mancha Spain	Low-tech firms	Medium-high-tech firms	High-tech firms
Reverse engineering	Reverse engineering	Reverse engineering	Reverse engineering	Reverse engineering	Reverse engineering	Reverse engineering
Patent disclosures	Patent disclosures	Patent disclosures	Patent disclosures	Patent disclosures	Imitation management	Imitation management
	R&D cooperation	Imitation management	Imitation management	Hiring skilled labour	Competition	Competition
		Competition	Competition	Competition		
			Support on R&D from the government	Imitation management		
				Support on R&D from the government		

Figure 5.5 Fourth core pattern of channels of KS (Source: Author)

The fourth core pattern of channels of KS (Figure 5.5) is formed by reverse engineering (100% repetition) and patent disclosures (71% repetition).

North-East Brazil	South-East Ireland	Bucharest-Ilfov Romania	Castilla-La Mancha Spain	Low-tech firms	Medium-high-tech firms	High-tech firms
Hiring university graduates	Hiring university graduates	Hiring university graduate	Hiring university graduates	Hiring university graduates	Hiring university graduate	Hiring university graduates
Hiring skilled labour	Hiring skilled labour	Hiring skilled labour	Hiring skilled labour	Specialisation	Hiring skilled labour	Hiring skilled labour
Networking	Suport on R&D from the government		FDI	Diversification		
R&D				Networking		
University research				Geographical proximity		
FDI				R&D		
R&D cooperation				University research		
Suport on R&D from the government						

Figure 5.6 Fifth core pattern of channels of KS (Source: Author)

Finally, the fifth core pattern of channels of KS (Figure 5.6) consists of two channels of KS, namely, *hiring university graduates* and hiring skilled labour. They were repeated in 100% and 86% of the patterns, respectively.

Core pattern of KS	Channels of KS	Explanation
1. Industrial setting	Specialisation, Diversification and Networking	KS happens because the industrial setting of the region results from interactions between firms from the same and different industry sectors that take part in networking.
2. Technological innovation environment	Geographical proximity, R&D, FDI and University Research	KS happens through the technological innovation environment of a region which comprises mostly of R&D activities that are usually conducted by multinational firms (FDI) and universities in close geographical proximity.
3. Competition	Competition between firms and Imitation of organisational innovation	KS derived from competition happens because competition between firms in the same region leads these firms to imitate organisational innovations of competitors.
4. Industrial secrecy	Reverse engineering and Patent disclosures	KS happens through industrial secrecy because firms often appropriate part of the knowledge of innovative firms that are not willing to transmit this knowledge. This can happen through the reverse engineering of products and obtaining knowledge from patent disclosures
5. Workforce	Hiring skilled labour and Hiring university graduates	KS is originated through the workforce of the region because of the hiring of individuals who possess innovative knowledge, as is the case of skilled labour and university graduates.

Table 5.30 The core patterns of KS explained (Source: Author)

Based on the repetition among different iterations derived from the sample surveyed, as observed in Figures 5.2 to 5.6, the core patterns of KS represent the channels of KS that interrelate the most with the other channels in that pattern. For convenience, each core pattern has been allocated a name (see Table 5.30). The core pattern names, the channels by core pattern, and the explanation of each core pattern are detailed in Table 5.30.

5.9 Chapter summary

This Chapter presented quantitative findings of a survey with 439 respondent firms, from low- to high-tech industry sectors and also from four different regions, namely South East Ireland, North East Brazil, Bucharest-Ilfov Romania and Castilla-La Mancha Spain. The findings presented in this chapter address four research objectives of the current study, as follows.

1. To determine the most and least important channels of KS
2. To determine the regional differences as regards channels and patterns of KS
3. To determine the differences between sectors with different technological intensity as regards channels and patterns of KS
4. The determine whether small firms attribute more importance to channels of KS than firms of larger sizes

Objectives 1 to 4 of this research were formulated in order to identify the differences between regions and categories of technology intensity in the way that firms attribute importance to channels of KS. However, findings presented in this chapter revealed that there are more similarities than differences as the most important channels and patterns of KS were consistently similar across regions and firms from all categories of technology intensity.

The major contributions of these findings is that they challenge concurring theoretical perspectives on KS that posit KS and innovation as either caused by the concentration of firms from the same industry sector (Porter, 1990; Romer, 1989) or caused by the concentration of firms from different industry sectors (Jacobs, 1969). The data presented here show that there is no hard view on KS, and different theories can be complementary, rather than being mutually exclusive. Moreover, as these previous studies (Porter, 1990; Romer, 1989; Jacobs, 1969) were also dedicated to identifying the differences by which various industry sectors generate and benefit from knowledge spillover, determining the differences between categories of technology intensity showed that lower- and high-tech industry sectors present similar results in the way that firms attribute importance to channels of KS. Hence, these findings suggest that there is not much difference in the way firms from lower-tech industry sectors perceive the importance of channels of KS.

Chapter 6
Perspectives From Regional Stakeholders And Experts On Knowledge Spillover And Innovation (KSIexperts)

Chapter 6 Perspectives From Regional Stakeholders And Experts On Knowledge Spillover And Innovation (KSIexperts)

6.1 Introduction

The qualitative approach and data analysis (Research Phases 4 and 5 (see Figure 6.1)) is based on interviews with key informants who are involved with Knowledge Spillover (KS) propagation and regional innovation. The main purpose of these two Research Phases is, based on survey findings, to identify how KS happens at the regional level.

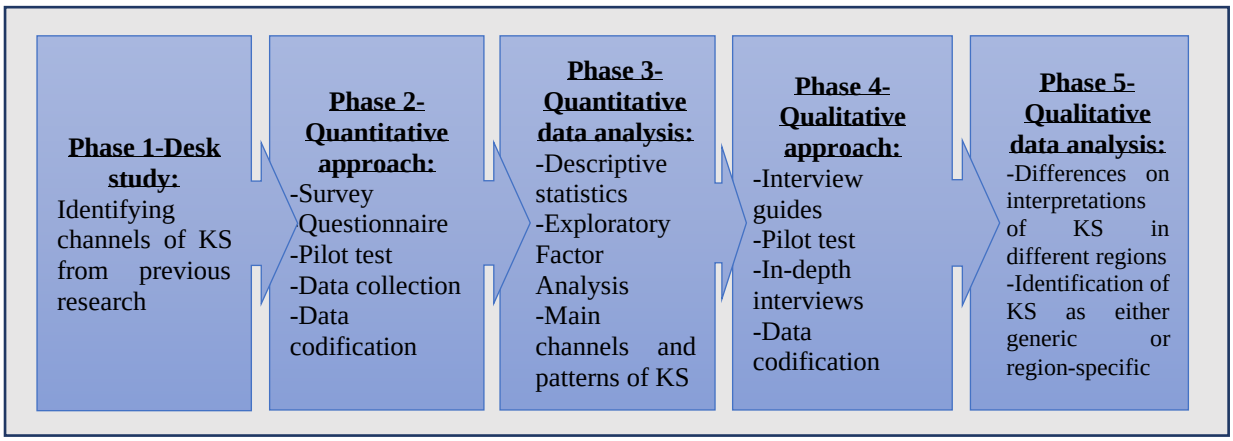

Figure 6.1 Research phases (Source: Author)

There were two categories for key informants interviewed in this research. The first category represents regional stakeholders, individuals from Higher Education Institutions (HEIs), regional government and industry who are involved with innovation in the four regions covered in this research. The second category represents experts on KS and innovation (KSIexperts). KSIexperts are relevant scholars whose research is based on KS and innovation, managers of clusters that serve as international references for developed regions, and policy-makers that are members of international institutions that promote programmes geared towards regional development. An important characteristic of KSIexperts is their position as decision-makers in academia, industry or government.

The interview findings presented in this Chapter provide opinions about the impact of the channels of KS that respondents in the quantitative survey (Phase 2 of this research. See Chapter 4, section 4.4.2 Phase 2: Quantitative approach) considered to be the most important. The interviews contributed to the discussion on how KS happens at the regional level (*research aim*) (see Chapter 7, The Knowledge Spillover (KS) Process And The Propagation Of KS In

Regions) and therefore addressed *Research Objective 5, To determine whether KS is region specific or generic*.

The structure of this chapter is divided into 8 main parts. The first part is this introduction. The second part describes information about the participants, their regions and sectors. The third part provides findings regarding the impact of the most important channels of KS by considering the importance and relevance of these channels to the regions, how KS happens in the regions and how it could happen more effectively. The fourth part presents an analysis on whether KS is region-specific or a generic phenomenon The fifth part presents the determinants of KS. The sixth part explains the importance of HEIs and regional governments for KS. The seventh part discusses the value of KS. Finally, the eighth part provides a chapter summary.

6.2 Participant information

This sub-section presents the profile of the interviewees. The first category of interviewees, regional stakeholders, consisted of individuals from the regions surveyed in this research. The second category, KSIexperts, comprised of individuals who were not necessarily from the same regions surveyed because the focus of these interviews was to obtain views from scholars and practitioners who are involved at the decision-making level in professions that require an understanding on how KS and innovation happens. Table 6.1 provides an overview of the number of interviewees from both categories by type of organisation.

	HEI	Regional government	Industry	Total
South East Ireland	3	0	1	4
North East Brazil	1	2	1	4
Bucharest-Ilfov Romania	1	1	2	4
Castilla-La Mancha Spain	1	0	2	3
KSIExperts - not from these regions	4	4	1	9
Total	10	7	7	24

Table 6.1 Key informants divided by region and type of organisation (Source: Author)

Because of ethical reasons, the anonymity of the respondents was protected by providing each with a designator code (for example IREHEI1, is the designator for an interviewee from a Higher Education Institution (HEI) based in Ireland; BRAIND2 is the designator for an interviewee from industry based in Brazil; and so on). The first category of interviewees, regional stakeholders, is detailed in Table 6.2 as regards profile, region and type of organisation.

Code	Profile	Region	Type of organisation
IREHEI1	Senior researcher in Regional Innovation Systems	South East Ireland	HEI
IREHEI2	EU-funded projects manager	South East Ireland	HEI
IREHEI3	Manager of innovation and incubation centre	South East Ireland	HEI
IREIND1	Manager of ICT cluster	South East Ireland	Industry
BRAHEI1	Professor of technological innovation	North East Brazil	HEI
BRAIND1	Senior consultant on business innovation	North East Brazil	Industry
BRAIND2	Manager of business consulting company	North East Brazil	Industry
BRAGOV1	Former secretary for Science, Technology and Higher Education in the state of Ceará government	North East Brazil	Government
ROMGOV1	Head of innovation funding department in the national government agency for higher education, research, development and innovation funding	Bucharest-Ilfov Romania	Government
ROMHEI1	Senior lecturer in engineering and electronics	Bucharest-Ilfov Romania	HEI
ROMIND1	Manager of ICT cluster	Bucharest-Ilfov Romania	Industry
ROMIND1	Senior business consultant	Bucharest-Ilfov Romania	Industry
SPAIND1	Co-founder and projects manager of innovation consultancy company	Castilla-La Mancha Spain	Industry
SPAHEI1	Professor of ICT and innovation	Castilla-La Mancha Spain	HEI
SPAGOV1	Executive in the public financing sector	Castilla-La Mancha Spain	Government

Table 6.2 Regional stakeholders by profile, region and type of organisation (Source: Author)

The second category of interviewees, KSIexperts, is detailed in Table 6.3 as regards profile, location and type of organisation.

Code	Profile	City	Type of organisation
EXP1	Eu official from Commission for Economic Policy – European Committee of the Regions	Brussels, Belgium	Policy-making
EXP2	Professor of innovation and political sciences	Berlin, Germany	HEI
EXP3	Professor of economic geography	Dublin, Ireland	HEI
EXP4	Consultant in cluster development	Copenhagen, Denmark	Industry
EXP5	Professor of economics and innovation	Barcelona, Spain	HEI
EXP6	Professor of innovation and economic development	Athens, Greece	HEI
EXP7	Evaluator of EU policy for the European Commission	Brussels, Belgium	Policy making
EXP8	Policy analyst for the European Parliament	Brussels, Belgium	Policy making
EXP9	Deputy Head of Unit of the European Commission	Brussels, Belgium	Policy making

Table 6.3 KSIexperts by profile, region and type of organisation (Source: Author)

The next sub-section of the chapter presents an analysis of regional stakeholders and KSIexperts as regards their interpretations as to the impact of the most important channels of KS.

6.3 The impact of the most important channels of KS

The analysis presented in this sub-section focuses on the views of twenty-four key informants interviewed regarding the importance of five channels of KS, derived from the survey findings, in their regions (ref. Phase 2, see Chapter 4), as follows.

1. Concentration of firms from the same industry sector;
2. Concentration of firms from different industry sectors;
3. Networking;
4. Competition between firms;
5. Hiring skilled labour.

Key informants were asked to give their opinions on how these channels of KS contribute to KS and innovation in their regions and also on how these channels of KS can actually propagate KS.

6.3.1 Concentration of firms from the same industry sector

The perceptions of the twenty-four regional stakeholders interviewed as regards to the concentration of firms from the same industry sector, as it is detailed in this section, is generally positive and perceived as the main source by which KS and innovation can happen. Specialisation provides an environment in which firms can obtain solutions for common problems (IREHEI3; BRAGOV1). Such agglomeration in a region is considered to be ideal when companies have common specific capacities and problems (IREHEI3). According to IREHEI3, this favours regional innovation because it allows finding the competencies that are real within the region and make the region more competitive. However, in order for concentrated companies from the same industry sector to benefit from their location, it is necessary to know how to take advantage of this proximity (IREHEI3). Examples of such advantages are as presented in Table 6.4.

Informants	Advantages
IREIND1	Concentrated companies from the same industry sector attract other companies also from the same industry sector, because it is perceived that skilled labour is present there as well as suppliers from the production chain.
BRAHEI1, BRAIND2, SPAHEI1, SPAGOV1, ROMIND2	Cost reduction through economies of scale: companies increase their negotiation power by buying raw material and hiring services collectively.
IREIND1, BRAIND2 and BRAHEI1	Concentration of firms attract multinational companies due to their need to obtain solution from the region regarding supplies, outsourcing and skilled labour
BRAIND2	Gain of scope: having capabilities for greater production allows companies to sell their products in more market places
BRAIND2, ROMHEI1, ROMIND1	Cooperation: companies that are close to each other have employees who are always interacting and these interactions lead to know what they do in order to match competences.
IREHEI2	Awareness of common research needs that can be solved by cooperating with a research institution.
BRAIND2	More likelihood to be supported by the government on innovation activities as many companies concentrated have a bigger impact on the region as regards wealth and jobs generation.

Table 6.4 Advantages of concentrating companies from the same industry sector in a region (Source: Author)

Concentration of firms from the same industry sector was assumed by the informants to be the most important type of industry concentration. Some informants expressed this preference and defended that same industry concentration not only allows opportunities for companies to cooperate and become more specialised (BRAHEI1, BRAIND2, SPAIND1), but also that it

allows opportunities for innovation activities (IREHEI3, BRAIND1). Regions that have many firms from the same industry sector and universities are more likely to attract larger firms looking for outsourcing (BRAHEI, ROMIND1), skilled labour (SPAIND1) and also the research opportunities with the university (ROMHEI1). If government agencies can provide funding or any support for firms to conduct innovation activities, the chances of large firms to move to the region are even higher (BRAHEI1). However, according to BRAIND1, the success by which companies interact and cooperate towards innovation may be related to the technology intensity of the industry sector in the region. Geographical concentrations of low-tech companies from the same industry sector tend to benefit only through cost reductions in the production chain. High-tech companies, on the other hand, may benefit from external R&D from Higher Education Institutions (HEI) and research centres. Thus, it is very important to have research institutions within technological regions in order to allow innovation activities (BRAIND1) and supply companies with good practices (IREHEI3).

It was also identified that specialisation allows firms to become more competitive (BRAHEI1, BRAIND2, SPAIND1, IREHEI3) and innovative (IREHEI3, BRAIND1, ROMIND1, EXP9). One of the reasons for this is that the dynamics of a specialised region often supports and increases existing levels of KS (EXP4). In addition, it was observed that this effect happens in both high and low-tech concentrations of firms from the same industry sector. Specialisation is conducive to KS in concentrations of high-tech firms because of interactions that happen day-by-day lead to R&D cooperation and thus technological knowledge and know-how (IREHEI3, BRAIND1, ROMIND1). Specialisation is also conducive to KS in low-tech firms (BRAIND1, BRAHEI1, SPAHEI1, EXP3), but the kind of benefits that the interaction between low tech firms is more likely to bring leads to non-technological innovation. Moreover, large firms are likely to move to a specialised region because they need the skilled labour that is available in that location for their innovation activities (SPAIND1). If this region has universities (ROMHEI1) and government agencies that can fund or support innovation activities (BRAHEI1), the chances of large firms moving there are even higher.

The viewpoint that R&D benefits only high-tech companies (BRAIND1) is contradicted by BRAHEI1 who gave examples of regions in the rural areas of North East Brazil that, even though they are specialised in the low-tech industry sector, such as clothing and flower production, they are cooperating with development agencies and large companies in order to introduce incremental innovations and increase their capacity to network and develop

innovations. BRAHEI1 recognises that these cases are the minority in the region, but they still show that the concentration of low-tech companies from the same industry sector has a very positive impact in the region in terms of financial results and further specialisation.

There are many characteristics of successful concentrations of firms from the same industry sector, as per the examples that follow (to mention but a few). First, when SMEs and large companies are involved in working groups within professional representative bodies and help to identify their research needs in order to present them to the government (IREHEI2, ROMIND2). Second, many firms from the same industry sector attract large firms which are willing to collaborate with small firms for outsourcing (BRAHEI1, ROMIND1). Third, a large attendance and propensity for collaboration in industry events. Fourth, a concentration of firms attract multinational companies because it can provide support such as supply of goods and services, outsourcing and skilled labour (IREIND1, BRAIND2, BRAHEI1). Fifth, research problems stemming from companies are directed to HEIs to help find a solution (IREHEI3). Sixth, constant informal meetings evolve into the required trust that is the basis for subsequent synergy, allowing business between companies (ROMIND1). Seventh, acquisition of a skillset associated with the industry (IREIND1) and high levels of firm collaboration (SPAGOV1) lead to an attraction of skilled labour to the region. Eighth, a well-established industry sector in the region engages with HEIs and also, the amount of education framework built by these engagements supports local companies to innovate (IREIND1). Ninth, when it is clear that the capabilities of the industry can contribute to regional development, there is support from the government for these companies (BRAIND2).

The interviews with regional stakeholders suggest that the concentration of firms from the same industry sector leads to other consequences that can also facilitate KS. Concentration of firms from the same industry sector leads to networking between owners and employees from different companies (ROMIND1, IREHEI2 and IREHEI3), and when a trust and mutual interest relationship is built, there can be R&D cooperation between firms (ROMIND1, IREHEI3, EXP4; EXP5; EXP6; EXP9) as well as between firms and HEIs (SPAGOV1, SPAHEI1). When these interactions happen, the region tends to attract more high-skilled workers. As a consequence of firms availing of these channels of KS, regions become more innovative (ROMHEI1, IREHEI3). According to SPAHEI1 and EXP3, the main importance of concentrating firms from the same industry sector is critical mass, i.e. the region becomes

self-sustainable as regards innovation support and activities. Critical mass enables industry and HEIs to share technologies and experiences (SPAHEI1).

Concentration of firms from the same industry sector was considered a critical channel of KS for all KSIexperts In fact, three of them emphasised this channel as one of the most important for KS to happen. Five considered geographical concentration of firms from the same industry sector as generally important for the process of knowledge spillover. On the other hand, three experts warned that companies must be engaged in cooperative activities in order for a geographical concentration of firms from the same industry sector to be important in the process of KS. One expert (EXP2) conveyed that this kind of industry setting can be very important to concentrate firms in the same area, but it can also lead to lock-in situations, i.e. strong technological ties between organisations involved in innovation in a region. The importance of the concentration of firms from the same industry sector for knowledge spillover, according to KSIexperts, consists of different points, as presented in Table 6.5.

KSIExperts views on the importance of the concentration of firms from the same industry sector for Knowledge Spillover
• Favours learning through relocation of employees to the region and imitation (EXP1) • Given that enterprises are innovative and search for new and better solutions, such concentration can strongly support innovation (EXP2) • Cluster dynamics often support an increase in existing levels of knowledge (EXP4) • Cluster effects proved to be positive allowing, among other aspects, technology transfer in the form of staff mobility between the firms (EXP9) • Leads innovative companies to network and expand their markets (EXP7)

Table 6.5 KSIExperts views on the importance of the concentration of firms from the same industry sector for Knowledge Spillover (Source: Author)

Some of the KSIexperts interviewed identified that the concentration of firms from the same industry sector is a source for further channels of KS, namely, hiring skilled labour and networking (EXP1 and EXP9). These experts explained that the concentration of firms from the same industry sector enables the attraction of skilled labour to the firms and the technological knowledge is spread within the region through staff mobility between firms. Concentration of firms from the same industry sector is a source to networking because when firms are growing, they need to expand operations and depend on each other to exchange information and benchmark (EXP7).

6.3.2 Concentration of firms from different industry sectors

It was identified that the concentration of firms from different industry sectors is of decisive importance for KS and innovation to happen. For example, research and industry opportunities

can be identified in crossovers between different industry sectors (IREHEI2). A company has a lot to gain just by interacting with different industry sectors just for the simple reason that there is a lot of different perspectives that people come from, which is valuable when you are going through innovation processes (IREHEI1). Moreover, different industry sectors in a region attract multinational firms because they can support them with products, services and skilled labour (IREIND1, BRAIND2 and BRAHEI1). However, the impact of innovation outcomes that the concentration of firms from different industry sectors causes in a region is not perceived with the same importance as the concentration of firms from the same industry sector, even though both are very important.

On the other hand, the regional setting of the concentration of firms from different industry sectors may have disadvantages for regional innovation outcomes. For example, six regional stakeholders could not identify benefits in innovation from the concentration of firms from different industry sectors, i.e. regional diversification of industry sectors. In such a setting they are still isolated as regards innovation activities, as it only favours infrastructure and also the means of distribution and logistics (BRAHEI1). As a result, firms do not interact, let alone cooperate together in innovation projects. They may be there in the region due to tax reductions or for being close to the seaport, airport or the capital. However, sharing the same location because of these conditions does not imply that firms will cooperate together in a common project. There is no cooperation between industry sectors in order to create innovation (BRAIND1). Moreover, diversification brings rivalry between industry sectors, they all compete for the attention of the government as regards available funding for innovation activities (BRAIND2). Instead of focusing on diversity, which implies cost-related issues, public policies on innovation should focus on a specific industry because this brings competitive advantage (ROMIND2). Moreover, IREHEI1, SPAHEI1 and SPAGOV1 do not expect to see innovation-related benefits happening as an effect of diversification in their region.

The benefits of the concentration of firms from different industry sectors are not widely accepted as fundamental for regional innovation. For example, out of the nine regional stakeholders who consider it beneficial to the region, two emphasised that this importance is secondary to the concentration of firms from the same industry sector (BRAGOV1, SPAGOV1). According to these informants, the concentration of firms from the same industry sector generates more benefits than the concentration of firms from different industry sectors.

However, any concentration of firms is positive because it generates economies of scale and other advantages that encourage the innovation process (BRAGOV1, SPAGOV1). Thus, the findings suggest that the concentration of firms from the same industry sector (specialisation) is more likely to generate KS than the concentration of firms from different industry sectors (diversification).

There were also interviewees who did not find a difference between the importance of the concentration of firms from the same industry sector and different industry sectors to facilitate KS. One regional stakeholder stated that there was no difference between these two types of concentration of firms in the potential to innovate, but that the real question revolves around the problem that firms have to solve. If there is a common problem for the firms in the region, then any kind of firm concentration is important for innovation activities and outcomes, regardless of industry sector: "It does not matter whether the concentration of companies is from the same industry sector or different ones. Go back to the definition of innovation, innovation is about solving a problem for the market. So companies that are from different industries, if you want them to cluster in innovation, the cluster has to have shared problems" (IREHEI3).

Most KSIexperts considered that concentration of firms from the same industry sector as key for KS and innovation (EXP1, EXP2, EXP4, EXP5, EXP6, EXP8 and EXP9). Moreover, this view of attributing the same importance to same industry and different industries concentration is shared by four out of the nine KSIexperts. EXP3 suggested that what is important for KS in any industrial geographic concentration is the generation of critical mass in order to allow the region to become self-sustainable in innovation support and activities. EXP 7 focused on KS happening from different industries concentration from the perspective of the natural need that firms have, which is to grow at a certain stage. When firms are growing, competition becomes secondary and they need to network and cooperate in order to meet the demands of bigger and more competitive markets. EXP8 believes that what counts is the importance that firms in the region attach to knowledge and whether they are from the high-tech sectors or not. For EXP6, what indicates the importance of industry concentration is the effectiveness of the firms to innovate. However, it was recognised by interviewees that it is more likely for firms from the same industry sector to find common problems through networking, since these firms are alike and engage in R&D cooperation (IREHEI2, IREHEI3, BRAGOV1 and SPAGOV1).

Views on how the concentration of firms from different industry sectors can benefit geographical regions are expressed by KSIexperts in Table 6.6.

KSIexperts views of the importance of the concentration of firms from different industry sectors for Knowledge Spillover
• Favours learning through relationships along value chains. (EXP1) • A rich variety of enterprises can benefit from cross-sectoral opportunities because different industry sectors may lead to new innovation opportunities. It is more a matter of the mix of industries and the critical number of enterprises required to become noticed from outside as a strong region with concentration of companies. (EXP2) • I believe there are huge potentials in cross sectoral innovation processes. Maybe this factor is not so important today – but I foresee that it will grow in the future. (EXP4) • Very important if there is an eco-system that fosters exchanges and cooperation and demonstrates the added value and win-win situations for cooperation along value chains. (EXP9)

Table 6.6 KSIexperts views of the importance of the concentration of firms from different industry sectors for KS (Source: Author)

From the views in Table 6.6, it can be seen that most of the experts believe that there are at least three conditions for knowledge to spill over within regions that have a concentration of firms from different industry sectors, they are as follows: first, there must be complementarity between industry sectors for KS (EXP2); second, the number of firms located in the region is crucial. It is necessary to be large enough in order to allow networking and cooperation (EXP2); and third, the external environment of these firms plays a role. If there are organisations that engage with these firms and promote interactions towards solving common problems, this setting is likely for knowledge to spill over (EXP9).

However, as stated by a number of regional stakeholders and KSIexperts, it is more difficult for KS to spur from regions with concentration of firms from different industry sectors. This is because: (i) the region must have innovative firms that contribute to development (EXP2, EXP3); (ii) the region in which this setting happens must have interaction of firms, universities and research centres (IREHEI3, BRAIND1, BRAIND2, BRAGOV1, SPAHEI1, EXP2, EXP9) or comprise of a developed urban area supported by existing mature infrastructures that allow knowledge to flow from firm to firm (EXP5); and (iii) in the government, it is more difficult to approve public policies on innovation focusing on different industry sectors (ROMGOV1).

6.3.3 Networking

According to BRAGOV1, networking is necessary for KS as it spreads the richest value of the innovation process, which is the learning that comes out of it. Innovative organisations do things differently and innovate systematically, and when they share their practices to less

innovative firms (BRAGOV1), it helps these less innovative firms to survive and grow (SPAIND1) by learning and analysing good and bad business practices. Innovative firms also benefit from sharing their ideas because, when they do so, they are also learning in the process. Thus, the process of networking and analysing decisions with other firms is very beneficial for the innovative firm because firms learn from these interactions (BRAGOV1). Thus, networking allows the exchange of good practices, learning from each other and envisaging new opportunities (SPAIND1). Cooperation, an important element of regional innovation, is a result of networking (EXP1, ROMGOV1, ROMIND1) as long as all partners involved decide to go for a common project and have something to benefit from it (ROMGOV1). However, once synergy is identified between parties, trust must be built between them for cooperation to work (ROMIND1).

From the perspective of the firm, it is important for employees to network with people from other organisations because of the opportunities to acquire new knowledge from employees in other firms (BRAGOV1). From a research centre point of view, networking is valuable because of two reasons, namely, it makes companies aware of its research offerings, expertise and capabilities; and secondly, it is valuable to identify industry research needs so research centres can respond to these needs (IREHEI2).

From a regional perspective, networking plays an important role for firms to get involved in innovation activities (IREIND1). Networking usually develops from some sort of industry representation in the region, namely, syndicates, and industry associations (BRAIND1), government agencies (IREHEI1, IREHEI2, IREHEI3) and industry confederations (BRAHEI1, BRAIND2, IREIND1). In addition, networking may happen between companies and between companies and other organisations, such as government agencies, universities and research centres (IREIND1, ROMIND2, BRAGOV1, SPAHEI1).

According to IREIND1, the most important requirement for networking to work positively in a region is a productive environment capable of bringing together actors from universities, government and industries in order to discuss the creation of a common framework with the goal of improving the region in its totality as regards to innovation performance. As a result, networking allows companies to collectively explore and benefit from the options of research collaboration available in HEIs that reflect their needs and can help them to become more innovative (IREIND1). Key benefits for companies to engage in networking are growth (SPAIND1), access to the global markets (IREIND1 and SPAHEI1) and taking the lead in the

performance of a market. These benefits vary according to the number and type of regional stakeholder involved in the networking process (ROMGOV1).

However, even though networking is considered by all the 24 key informants as positive for innovation outcomes, regional frameworks for networking are insufficient in the four regions investigated (IREHEI1, BRAHEI1, BRAIND1, BRAIND2, ROMHEI1, ROMIND2, SPAIND1, SPAHEI1 and SPAGOV1). The reasons for this assertion, as regards impediments to networking, are indicated in Table 6.7.

Barriers to networking
• Geographical concentration of networking opportunities in the capital and larger urban areas, limiting access and therefore opportunities for knowledge exchange between companies from other parts of the region (IREHEI1). • Nonattendance at networking events: "company representatives do not go to networking opportunities because they think of fast results and do not want to invest time or take risks with innovation activities" (BRAHEI1). • Limited opportunities for innovation. Interactions are restricted only to buying and selling products. There is hardly any structure that can support innovation through networking (BRAIND1, BRAIND2) • Lack of involvement of regional actors. Networking among company owners should consider all the employees of a company, the university and the government (BRAGOV1). • Networking with universities and research centres is difficult because they work with different timeframes, companies demand immediate returns while the other organisations are oriented towards research and publications (SPAGOV1). • Networking events are usually promoted by industry. There is no awareness of opportunities to network and cooperate with the government or universities (ROMHEI1). • Lack of trust. Networking takes time to evolve into a more mature relationship, in which a certain level of trust is built in order to cooperate in innovation projects (ROMIND1). • The business culture is closed as regards knowledge-sharing. There is no trust between business owners (SPAIND1). • Government does not provide adequate support for companies to network (SPAIND1). • Networking leads companies to innovation only in geographical concentration of companies from the same industry sector (SPAHEI1).

Table 6.7 Impediments for networking identified (Source: Author)

However, despite difficulties, networking was considered as a positive aspect of regions for all the key informants that participated in the interviews. It was identified by KSIexperts that networking may lead to KS as (i) it favours learning through relationships along value chains (EXP1); (ii) it leads to unplanned knowledge and in non-linear processes (EXP4); and (iii) it is fundamental to exchange and recombine knowledge.

6.3.4 Competition between firms

The majority of the regional stakeholders (11) considered that competition between firms directly favours innovation performance (IREHEI1, IREHEI2, BRAIND1, BRAIND2,

BRAHEI1, BRAGOV1, ROMIND1, ROMHEI1, ROMGOV1, SPAIND1, SPAGOV1). However, two regional stakeholders posited that competition between firms indirectly favours innovation performance (IREIND1 and ROMIND2) and two think it does not favour innovation performance (IREHEI3 and SPAHEI1).

The argument that competition between firms directly favours innovation is that competition forces firms to develop and create solutions for new problems (SPAGOV1). It is in difficult moments that companies become more creative, search for alternatives to their problems and find more solutions for their problems through innovation. One of the parameters for the innovation process is to benchmark, that is, to know what the competition is doing (BRAGOV1). The pressure from competitors acquiring market share makes companies look for solutions and become more innovative (BRAIND1) because of the need to stay ahead of rival companies. On the other hand, if companies do not have to face competition, there is no challenge to make them change and look for alternatives (ROMHEI1).

According to IREHEI2, the impact of competition on a company depends on the scale of this company. If it decides to sell to the local market, the kind of competition it faces positively impacts on its innovation performance because of the geographical proximity, i.e. the company's employees have different opportunities to meet the employees from competitors and learn from their interactions. IREHEI2 explained that firms innovate through competition because they learn from competitors what products are well accepted in the market and may be copied. Once they learn how to copy and manufacture these products, they try to differentiate themselves from the competition through process innovation with a focus on efficiency. However, according to IREHEI2, when the market of the firm is located outside its region and other firms within geographical proximity do not compete in this market, the relationship between competition and innovation does not happen in the same way because competing firms do not interact as often as they would if they were located in the same region.

Two regional stakeholders said that competition between firms indirectly favours innovation performance. They interpret competition as positive in order to spread good practices to companies in the same market, that indirectly leads to innovation, and keeps the market fair and well-balanced, resulting in fair prices for companies (business-to-business commercialisation) and the population of the region (IREIND1 and ROMIND2). The view that competition between firms does not favour innovation performance is that companies that seek

innovation want to do things differently than the competition, thus competition is not related to innovation (IREHEI3 and SPAHEI1).

The majority of KSIexperts (EXP1, EXP2, EXP4, EXP6, EXP7, EXP9) found competition beneficial for KS for different reasons. The aspects that support these views are as follows: (i) competition is important for KS because it favours learning through imitation (EXP1); (ii) it helps firms to innovate and improve the quality of their goods (EXP2): and (iii) competition is an important incentive for companies to engage in innovation and R&D processes (EXP3). Therefore, competition leads to KS because it favours imitation, which contributes to incremental innovations, but not to breakthrough innovations (EXP9). Only one expert argued that "competition does not imply KS, on the contrary, he stated that firms do not want to share valuable knowledge" (EXP7).

6.3.5 Hiring of skilled labour

Skilled labour are individuals who had a career path or a good amount of knowledge already learnt in a particular industry sector (IREHEI1). Hiring skilled labour is recognised by all regional stakeholders and KSIexperts as crucial in any given region. It is also relevant for KS because knowledge is embedded in people, and moving people who know this knowledge will also spread the knowledge to other companies (EXP7). From the perspective of the firm, according to SPAGOV1, hiring skilled labour is important for solving business problems and, indirectly, to transmit knowledge to existing employees. Thus, knowledge is indirectly transmitted from the company to its employees primarily because a person is hired to solve a particular business problem, and not just to teach their skills to other employees (SPAGOV1).

From the regional perspective, hiring skilled labour is crucial for KS because these employees can change from one firm to another and, consequently, transmit their knowledge and skills to different firms in the same region (SPAHEI1, IREHEI2, EXP2, EXP7). Innovative industry sectors and enterprises demand more skilled labour. Without such labour, the processes of innovation may not be realised because the existing employees in the region do not know how to do the work that is required (SPAHEI1). Thus, skilled labour leads to the development of regional innovation (ROMGOV1, SPAIND1, EXP4, EXP7) because people who have the required skill-set and the experience drive the innovation programmes of different companies within a region (IREHEI2).

Comparing between hiring skilled labour from other regions or developing it in the region, BRAGOV1 and EXP2 indicated that the latter is preferable because hiring skilled people from outside the region only helps to solve specific problems whilst developing skilled labour in the region matches enterprises' demands more effectively because the skills these enterprises need their employees to learn is best provided by the organisations located in their own region (EXP2). Likewise, for BRAGOV1, companies should also focus on developing their own employees because they know the particularities of the company, and sometimes hiring skilled employees may not work well because the reality that they are used to is very different, and may lead to difficulties for them to absorb the new organisational culture (BRAGOV1).

Hiring skilled labour from other regions is usually a viable option only for multinationals and large companies (BRAIND2, BRAGOV1, BRAHEI1, ROMHEI1, ROMIND1 and SPAHEI1), which is relevant because it allows for new opportunities of synergy when divergent knowledge merges during research (EXP2). The development of a high-skilled workforce in the region happens mostly by two means, company training and HEIs, as indicated by regional stakeholders BRAIND1, BRAIND2, IREIND1, ROMHEI1 and ROMIND1. A problem identified with company training is that companies "usually train people without experience, and such employees may take time, months or years, depending on the activity, to reach an ideal performance level" (BRAIND1).

Firms should ideally be supplied with high skilled employees by a robust apprenticeship framework across all different disciplines that are important for the economy of the region (IREIND1), such a process could enable partnerships between HEIs and firms in order to hire students when they graduate (ROMHEI1). However, HEIs do not always provide the skills that are necessary and match with the needs of firms in the region because HEIs do not understand the real problems and aspirations of the firms in the region (ROMIND1, EXP9). SPAGOV1 and BRAIND1stated that the type of skills and knowledge that HEIs transmit does not always consider the specific needs of the firms in the region where they are located because there is no interaction, such as networking and R&D cooperation, between industry and university (BRAIND1 and ROMIND1).

Other aspects related to hiring high skilled labour identified from the interviews are the incentives to retain or attract skilled labour to the region. The first incentive is money, paying higher salaries to high skilled employees to stay in the company and in the region (IREHEI1, ROMIND2). The second incentive is a concentration of companies from the same industry

sector in order to facilitate mobility and options for the high skilled workers in case they want to work in other firms in the same region (IREHEI2, IREHEI3, IREIND1). The third incentive is quality of living in the region in order to enable a long term stay in the region (IREHEI2 and IREHEI3). The fourth and last incentive identified is the existence of a strong industry base in the region, which could persuade potential entrepreneurs, investors and high-skilled employees to work and invest in the region (IREHEI2, IREHEI3).

Table 6.8 summarises the key aspects related to attracting and retaining high-skilled employees in a region.

Aspects identified related to attracting and retaining high-skilled employees in the region
• Hiring skilled labour leads to knowledge spillover at the company and regional level (SPAGOV1, IREHEI2 and KSIexperts) • Requirements for high skilled labour in the region are as follows: high salary (IREHEI1), concentration of companies from the same industry sector (IREIND1), quality of living and the existence of a strong industry representative in the region (IREHEI3). • Hiring skilled labour from other regions is conducted mainly by large or multinationals firms (BRAIND2, BRAGOV1, BRAHEI1, ROMHEI1, ROMIND1, SPAHEI1) • Most companies rely on HEIs and their own training in order to obtain high-skilled employees (BRAIND1, BRAIND2, BRAGOV1, ROMHEI1, ROMIND1) • HEIs need to be more effective in transmitting relevant knowledge to industry in their region (IREIND1, SPAGOV1, ROMIND1, BRAIND1)

Table 6.8 Aspects identified related to attracting and retaining high-skilled employees in the region (Source: Author)

6.4 Knowledge spillover: a generic or region specific process?

Quantitative findings of the current research indicate that firms from different regions and categories of technological intensity attribute very similar importance to channels of KS, suggesting that the process of KS may be generic, i.e. basically the same in different regions. Thus, the views from KSIexperts presented in this section are very important to understand whether KS is generic or region specific, i.e. whether KS happens in the same way in different regions or if it varies according to the region where it happens.

Eight out of nine KSIexperts argued that it was different (EXP1, EXP2, EXP3, EXP4, EXP6, EXP7, EXP8 and EXP9). KS outcomes depending on the existence of key organisations, such as are HEIs, government agencies and innovative firms (EXP1, EXP2, EXP3, EXP4, EXP5, EXP8). In addition, EXP3 explained that ‘knowledge spillovers operate via different channels, such as labour, spin-offs, company linkages and so forth. So the specific characteristics of the region: few or many companies, few or many networks, industrial, sectoral and organisational structure; will have implications for the process of knowledge spillover’. One expert said it

was roughly the same, “but it is facilitated or complicated depending on specific interactions at regional level and depending on collaboration traditions among different agents” (EXP5).

In order to identify additional channels of KS, different to those identified by previous research (see Phase 1 of Research Design in Chapter 4, Conceptual and methodological frameworks), KSIexperts were asked to indicate the channels that can cause KS in regions (see Table 6.9).

Channels of KS proposed by KSIexperts	From the literature review
Hiring former employees of another firm or by cooperating with other firms. (EXP1).	Hiring skilled labour and R&D cooperation.
Spin-offs from university research and existing structures of collaboration, human resources and competences ready to apply such new knowledge (EXP2).	University research and R&D cooperation.
There are channels and determinants. Channels include: labour mobility between companies; media; linkages between companies; indirect linkages via non-firm institutions; suppliers visiting multiple companies and so forth. These channels can work poorly or very well depending on determinants: network policies; critical mass of firms and workers; softer factors such as a culture of cooperation; a place-based sectoral identity (EXP3).	Hiring of skilled labour, R&D cooperation, Networking. However, the idea of differing between channels of KS and determinants of KS was not previously considered in the current research.
High-levels of trust between firms in the same region lead to R&D cooperation (EXP4, EXP5, EXP6, EXP9).	R&D cooperation. Trust has not been considered in the current research as a channel of KS. Trust was also mentioned by one of the regional stakeholders as a facilitator that leads networking into R&D cooperation (ROMIND1).
Existence of skilled labour and, mainly, existence of common forums where these labour meets (EXP5).	Hiring skilled labour.
Conviction that in the long run openness is a win-win situation; high quality universities in the region; companies active in areas with high profitability and technical skills (EXP6).	University research.
People, capital and technology that can circulate freely (EXP7).	Hiring skilled labour
Human resources, local policy, knowledge infrastructure (universities, think-tanks) etc. One of the most important channel is related to the human resources understood both as the level of education in the region and the attitude of the local/regional authorities to the issue (EXP8).	Hiring skilled labour and hiring university graduates..

Table 6.9 Channels of KS according to KSIexperts (Source: Author)

Thus, KSIexperts did not reveal additional channels of KS that were not covered by this research. These findings suggest that the channels of KS considered in this research were coherent not only with previous research (see Phase 1 of research design), but also with the views of key informants. This means that this research did not fail by omitting a channel of KS that could change the consistent results obtained by firm size, region and industry sector regarding the five highest scores of importance of KS among survey respondents. However, while trying to identify additional channels of KS. However, the KSIexperts revealed two aspects that are key for this regional phenomenon, namely determinants of KS (EXP3); (i) trust and (ii) learning (EXP1, EXP4, EXP5, EXP6 and EXP9). The next sub-section of this chapter provides more details about these determinants of KS.

6.5 Determinants of KS

When asked to outline channels of KS, EXP3 introduced to this research the concept of determinants of KS. According to EXP3, determinants of KS are the aspects that can hinder or facilitate the effect of channels of KS. Apart from introducing the concept, the interviews conducted with regional stakeholders and KSIexperts also revealed two determinants of KS, namely trust and learning (ROMIND1, BRAGOV1, SPAIND1, EXP4, EXP5, EXP6 and EXP9). Trust is a determinant of KS because it enables simple constant interactions to evolve to more meaningful knowledge interactions between firms and innovative organisations, in which the level of knowledge that is transmitted through channels of KS is much higher (ROMIND1). Learning is a determinant of KS because, the more ready and active the firm is as regards to learning, the more effective is the channel of KS.

Trust is relevant for KS to happen because it is the main determinant that, according to ROMIND1, facilitates firms from the same and different industry sectors, in close geographical proximity, to interact, discuss about the issues they face and generate KS as a consequence. The relationship between a firm and another organisation, because of constant informal meetings between employees, evolves into the required trust that is the basis for subsequent synergy, networking, business (ROMIND1) and R&D cooperation (ROMIND1, ROMHEI1, IREHEI3, EXP4; EXP5; EXP6; EXP9). Therefore, interview findings suggest that trust has the capacity to influence KS through different sources, namely specialisation, diversification, networking and R&D cooperation.

Learning, on the other hand, is a determinant of KS that is directly involved with all channels of KS because knowledge, to be indirectly transferred, needs the recipient of the knowledge to be able to learn from it. According to respondents, learning has an important role for the following channels of KS: specialisation, diversification (EXP1), networking (BRAGOV1, SPAIND1), reverse engineering, imitation of organisational innovation (EXP1), competition between firms (IREHEI2, EXP1) and hiring of skilled labour (IREHEI1). A concentration of firms from the same industry sector favours learning through relocating employees as they go to work for other firms in the same region and carry their knowledge with them (EXP1). Also, such concentration induces firms to imitate the products and organisational innovations from the firms the new employee used to work. A concentration of firms from different industry sectors also favours learning through relationships along the value chain, which leads to new and different forms of business (EXP1). Thus, networking is also decisive for KS to happen because it leads firms to learn new knowledge that can be used for innovation (BRAGOV1, SPAIND1). Competition between firms, in order to generate KS, depends on the capacity and capability of the firms to learn from the competitors (IREHEI2). Hiring skilled labour also depends on the capacity of the hiring firm and its employees to learn from the new knowledge of the new employee (EXP2).

6.6 The importance of HEIs and regional government for knowledge spillover

Most KSIexperts agreed on the importance of three types of organisation that are important for KS and innovation to happen in any given region, namely innovative firms, HEIs and government agencies (EXP1, EXP2, EXP3, EXP4, EXP5, EXP8). For example, EXP7 said universities provide knowledge to people who live and work in the region and are usually part of research networks, which facilitates the attraction of researchers and specialised labour to the region. However, it was also indicated that HEIs are only of slight importance for KS because they depend on the legislative and financial framework in the region and whether it sets incentives and obligations to work with firms (EXP9). In addition, HEIs cannot provide the knowledge that the region needs to innovate because they do not understand business needs (EXP9).

The regional government, through agencies that can support innovation activities in firms, was also considered important for KS (EXP1, EXP2, EXP3, EXP4, EXP5, EXP8) because it can implement policies to promote R&D in the region, fund R&D, attract high-skilled labour, support geographical concentration of firms from the same industry sector (EXP1), and also

promote research cooperation between university and industry (EXP2). However, it was also stressed that the regional government acts most often only in a supportive role, as it does not have the knowledge that can be used for innovation activities in firms (EXP4).

6.7 The value of knowledge spillover

Based on interview findings, this chapter was able to draw three key characteristics related to the value of KS to regions. First, KS is positive for innovation. Even though there is research indicating that KS may not be of interest to policy makers, or innovative companies, because it facilitates knowledge to leak to third parties who did not invest their resources or spend money to create it (as suggested by OECD, 2018 and Döring and Schnellenbach, 2006). The current research, however, is aligned with most previous research, which postulates that KS supports regional innovation (for example Stuetzer, Audretsch, Obschonka, Gosling, Rentfrow, and Potter, 2018; McCann, Ortega-Argilés, 2016).

Secondly, even though the current research identified fifteen channels of KS, the five channels that are of particular importance for KS and innovation are (1) Specialisation; (2) Diversification; (3) Networking; (4) Competition between firms; and (5) Hiring skilled labour. The consideration of these five key channels of KS, capable of contributing to regional innovation, reinforces the positive value of KS and contradicts previous research as it commonly tackles one (as demonstrated by Beaudry and Schiffauerova, 2009) or a few channels (see for example Halpern and Muraközy, 2007; Görg and Greenaway, 2004; Harabi, 1997; Levin, Klevorick, Nelson, Winter, Gilbert and Griliches, 1987) that do not reflect all the possibilities for KS to happen at the regional level. Thirdly, two determinants of KS were identified during this research, namely trust and learning. These determinants are important for KS and regional innovation outcomes because they are the aspects that can hinder or facilitate the effect of channels of KS. Thus, trust can facilitate innovative organisations to interact more openly with surrounding firms and knowledge is transmitted in the process. Learning facilitates knowledge to be transferred as the recipient needs to learn how to apply it and, whenever possible, convert it into innovation. Therefore, trust and learning demonstrate the positive value of KS as such determinants can support firms to obtain indirect knowledge that can be used for innovation.

6.8 Chapter summary

This Chapter presented the views of regional stakeholders and KSIexperts, people who are involved with Knowledge Spillover (KS) propagation and regional innovation, as regards the importance of the five channels of KS that yielded the highest scores of importance in the survey conducted for this research (see Chapter 5, An empirical analysis on channels and patterns of KS). The importance of these five channels of KS and also how they propagate KS in regions were explained by interviewees. In addition, the interview findings contribute to meeting Research Objective 5, which is to determine whether KS is region specific or generic. Based on KSIexperts, the process of KS is different across regions as, for example, some regions have government agencies that actively promote research cooperation between HEIs and firms whilst other regions may not even have HEIs active in research on innovation. Moreover, some regions have firms that constantly look for networking and R&D cooperation opportunities, whilst other regions may have firms that are just striving to survive by themselves. Thus, the findings suggest that, even though the most important channels of KS propagate KS in the same way, it depends on certain regional conditions for these channels to exist in the first place.

The views of key informants greatly contributed to the discussion on how KS happens because they explained how channels of KS can generate KS between firms and other organisations, such as universities, research centres and regional government agencies. Therefore, the interview findings directly support this research to meet its aim, to explain the process of KS at the regional level. In addition, the interview findings also identified that the process of KS may be different across regions because some regions have better frameworks for innovation than others, which can increase the chances for knowledge spillover between firms.

The next chapter, Chapter 7, The Knowledge Spillover (KS) Process And The Propagation Of KS In Regions, discusses all findings and meets the overall aim of this research, i.e. explaining the process of KS.

.

Chapter 7
The Knowledge Spillover (KS) Process And The Propagation Of KS In Regions

Chapter 7 The Knowledge Spillover (KS) Process And The Propagation Of KS In Regions

7.1 Introduction

Previous research has focused on explaining knowledge spillover (KS) as a resultant of the impact of either two channels of KS, namely Specialisation and Diversification (as demonstrated by Beaudry and Schiffauerova, 2009) or as a few channels (see for example Halpern and Muraközy, 2007; Harabi, 1997; Levin *et al.*, 1987) that can reflect how KS happens only to a certain extent and in specific contexts. Moreover, the literature on KS has traditionally provided a substantial amount of studies employing quantitative approaches aiming to measure KS outputs, often derived from a knowledge production function (Cerver-Romero, Ferreira and Fernandes, 2018; Qiu, Liu and Gao, 2017; Agarwal, Audretsch and Sarkar, 2010; Audretsch and Lehman, 2005; Romer, 1990; Arrow, 1962; Griliches 1979). However, this current research is unique in that it provides a more in-depth and comprehensive approach on the process of KS, at the regional level, than previous studies by relying on a mixed methods design. Qualitative techniques, consisting of twenty-four interviews with regional stakeholders and Experts on KS and Innovation (KSIexperts), were employed in order to explain quantitative findings. The quantitative findings were derived from a survey administered in four regions namely South East Ireland, North East Brazil, Bucharest-Ilfov Romania and Castilla-La Mancha Spain; and provided evidence of the importance of fifteen channels of KS to ICT and manufacturing firms, which are expected to reflect all the possibilities for KS to happen at the regional level.

Previous studies investigating KS empirically through qualitative techniques are scarce. Following an extensive literature review, only a few examples were found. However, these studies lack the reach and depth of analysis that is necessary to explain how KS happens at the regional level and how it contributes to innovation outcomes. Examples of such studies can be found in Ko and Liu (2015) and Pickernell, Senyard, Clifton, Kay and Keast (2007). Ko and Liu (2015), for example, interviewed representatives of registered charities in the U.K. only and explained how KS happens in third sector organisations and how proactive organisations from the third sector can benefit from KS. Thus, Ko and Liu's (2015) study differs from the research this thesis because it did not consider innovation in the analysis and the approach used did not include regional stakeholders, other than third sector organisations. Moreover, based on interviews with stakeholders from industry, academia and government, Pickernell et al.

(2007) explored KS by evaluating the capabilities of knowledge users and the effectiveness of knowledge transfer.in the biotechnology industry sector only. in Australia, They found evidence of KS from firms and universities and also that there are a number of different firms' governance modes at work simultaneously. However, Pickernell et al.'s qualitative approach is narrowed down to a specific geographical location and a specific industry sector. Therefore, the research from this thesis contributes to the body of knowledge on KS by adopting a qualitative approach to further explain quantitative findings and provide an understanding of how KS happens in regions and how it influences innovation outcomes based on a broad range of channels, contexts (the regions surveyed), and perspectives, i.e. firms, regional stakeholders and KSIexperts. Such a broad and in-depth investigation better represents regions, compared to previous studies that focused in just qualitative techniques, because it is focused on broader contexts and geographical locations.

This Chapter discusses the findings from the current research. Thus, in order to explain the process of KS, it was considered necessary to meet five research objectives, as follows (see Table 7.1).

Research question	How does the process of KS happen at the regional level?
Aim of the research	To explain the process of KS at the regional level
Objectives	1 To determine the most and least important channels of KS 2 To distinguish the importance attributed to channels of KS between firm size 3 To determine the regional differences as regards channels and patterns of KS 4 To determine the differences between sectors with different technological intensity as regards channels and patterns of KS 5 To understand whether KS is region specific or generic

Table 7.1 Research aim and objectives (Source: Author)Research aim and objectives (Source: Author)

In performing the research and addressing the objectives five major findings emerged from the process (see Table 7.2).

#	Major findings
1	Regardless of region, firm size or technology intensity, the five most important channels of KS are the same
2	Large firms attribute more importance to KS than smaller firms
3	Knowledge spillover is region-specific
4	Specialisation and diversification of industries are interrelated
5	Patents and reverse engineering are interrelated, but not perceived by respondents as an important pattern of KS

Table 7.2 Major findings in this research (Source: Author)

These major findings are presented and discussed in Sections 7.2 to 7.5. These are then followed by an explanation of the process of KS at the regional level (research aim) (Section

7.6) and also by a proposal on how KS can be propagated (Section 7.7). The last Section (Section 7.8) presents the chapter summary.

7.2 Regardless of region, firm size or technology intensity, the five most important channels of KS are the same

Because the regions that were part of the empirical investigation presented different levels of innovation performance (Hollanders, Es-Sadki and Kanerva, 2016; and IBGE, 2016), and based on the belief that their innovation performance was motivated by KS (Stuetzer *et al.*, 2018; McCann and Ortega-Argilés, 2016; Romer, 1990), this research expected that there would be more differences than similarities in the way that firms attribute importance to channels of KS in regional, firm size, and technology intensity contexts. Consequently, this research was designed to establish the differences, with regards to KS, in these three contexts (as stated in research objectives 2 to 4 in Table 7.1). However, the findings were surprising in the sense that they revealed that there are more similarities than differences between regions, between firm sizes, and between technology intensity categories. As regards the five most important channels of KS, those which yielded the five highest scores of importance, these similarities were consistent in all iterations to favour Specialisation, Networking, Competition, Hiring skilled labour, and Diversification over the other channels. The channels of KS that yielded the five highest scores of importance derived from the survey were identified as critical by most KSIexperts (EXP1, EXP2, EXP4, EXP5, EXP6, EXP8, EXP9) because they are of decisive importance for generating KS and supporting a region to create innovation.

These findings are interesting because they contribute to the dualistic debate found in the literature on KS that has been ongoing for decades, which is whether it is KS from Specialisation or Diversification that is conducive to innovation (examples of studies addressing this debate: Farhauer and Kröll, 2012; Beaudry and Schiffauerova, 2009; Van der Panne, 2004; and Glaeser, Kallal, Scheinkman and Shleifer, 1991). The impact of the Specialisation/Diversification debate in the literature is demonstrated by Beaudry and Schiffauerova (2009), who reviewed 67 papers that provide empirical evidence either confirming or rejecting Specialisation and Diversification of industries as channels of KS. Beaudry and Schiffauerova (2009) concluded that research should go beyond the Specialisation/Diversification debate in order to identify the other channels through which KS happens. This is in line with the current research, as findings suggest that another three channels

are also of key importance for KS at the regional level and should be included in this debate, namely Networking, Competition, and Hiring skilled labour.

Glaeser *et al.* (1991), the seminal authors on the Specialisation/Diversification debate, is the second most cited paper in the literature on KS according to a recent study on trends in KS research (Cerver-Romero, Ferreira and Fernandes, 2018), which shows that this debate is still very relevant. By addressing the dichotomy between Specialisation and Diversification based on the context of US cities, Glaeser *et al.* (1991) found that KS occurs because of Diversification as it encourages employment growth: 'the evidence suggests that important knowledge spillovers might occur between rather than within industries' (Glaeser *et al.*, 1991, p. 1126). Thus, Glaeser *et al.* (1991), consistent with the current research, identified KS effects from Diversification. What differs greatly from this research, however, is that Glaeser *et al.* (1991) was unable to find KS effects from Specialisation. The survey findings in this research suggested that Specialisation can generate KS to firms from different regions, sizes and categories of technology intensity; and interview findings explained the reasons as, for example, Specialisation creates an environment amid firms that helps them to solve problems that are common in the industry sector (IREHEI3; BRAGOV1).

However, examples of studies supporting Specialisation as a relevant channel of KS are as abundant as those that support Diversification. For example, Van der Panne (2004), addressed this debate and reached opposite conclusions to those from Glaeser *et al.* (1991). Based on a Dutch context, Van der Panne (2004) identified that Specialisation influences regional innovation because of more pronounced R&D outcomes and concluded: 'a regional specialisation towards a particular industry tends to increase regional innovativeness in that industry. This suggests that intra- rather than inter-industry knowledge spillovers positively affect regional innovativeness' (Van der Panne, 2004, p. 595). Thus, opposite to Glaeser *et al.* (1991) and also the current research, Van der Panne (2004) disregarded Diversification from generating KS. Diversification was considered in this research among the channels of KS that yielded the five highest scores of importance and also that 'Diversification brings different competences to the region that complement each other and may lead to more meaningful innovations' (BRAGOV1). Thus, as a matter of fact, the current research can support neither of these two studies because their findings suggest that one channel of KS, i.e. either Specialisation or Diversification of industries, happens at the expense of the other.

Previous studies addressing more than two channels of KS, such as the current research, are limited in numbers. Halpern and Muraközy (2007), Görg and Greenaway (2003), Harabi (1997) and Levin, Klevorick, Nelson, Winter, Gilbert and Griliches (1987), are examples of studies that explain the happening of KS through groups of channels and, consequently, adopt a more systemic view on the process of KS. Thus, these studies are discussed in this research in relation to its findings. Halpern and Muraközy (2007) considered five channels of KS (FDI, imitation, acquisition of human capital, competition and vertical spillover) in order to examine the impact of KS through Foreign Direct Investment (FDI) in Hungary. Based on a sample of 24,000 firms, of which 25% comprised of foreign-owned firms and was heavily biased towards large firms, Halpern and Muraközy (2007) identified that FDI (represented by foreign firms) generates KS to domestic-owned firms located in the same region because of the influence of the other four channels. However, having identified that FDI was consistently one of the channels of KS that yielded the three lowest scores of importance for ICT and manufacturing firms in four regions from different countries, the current research cannot corroborate Halpern and Muraközy's findings that consider FDI as an effective channel of KS, which suggests that the spillover effects identified by these authors may be specific to Hungary. Moreover, in the current research, out of the 429 firms surveyed (those that informed the number of employees), 35 (8.1%) were of large and 148 (34.5%) of small size, thus as the sample of firms investigated was biased towards small firms, this may suggest that if a region comprises mostly of large and foreign-owned firms, the process of KS is more influenced by FDI. However, this is not the case of the regions in most countries and therefore may not be representative.

Moreover, Görg and Greenaway (2003) reviewed the literature in order to identify channels of KS that can influence FDI to generate KS and found four of them, namely imitation, competition, human capital and exports. However, findings of the current research could not suggest any evidence that these channels can influence FDI to generate KS. The only channels of KS that can do so are Specialisation and Diversification as, according to IREIND1, BRAIND2 and BRAHEI1, concentrations of firms from both the same and different industry sectors attract multinational firms to their region because they need to be close to other firms and people that can support them with their activities, for example, suppliers, outsourcing firms and skilled labour (IREIND1, BRAIND2, BRAHEI1). However, such relationship identified by Görg and Greenaway (2003) may exist only in regions with a significant number of foreign-owned firms, which is not the case of the four regions investigated by this research, but is likely to be the case of regions in Hungary, as indicated by Halpern and Muraközy (2007).

Harabi (1997), in line with the current research, aimed at investigating the effectiveness of seven channels of KS for Swiss manufacturing firms. The seven channels of KS identified were: (i) Licensing of the technology; (ii) Patent disclosures; (iii) Publications and open technical meetings; (iv) Informal conversations with employees of the innovative firms; (v) Hiring skilled labour; (vi) Reverse engineering; and (vii) R&D. There are two major similarities between Harabi (1997) and the current research. The first is that Harabi considers a broad number of channels of KS, which is more representative than a number of other studies, such as Halpern and Muraközy (2007), Görg and Greenaway (2003) and those that address the Specialisation/Diversification debate. The second major similarity is that Harabi was interested in identifying the patterns of KS derived from these channels through Exploratory Factor Analysis (EFA), which was the same reason for the current research to also employ EFA. However, this research differs from Harabi (1997) also for two major reasons. First, it employs a broader number of channels of KS (fifteen) in regions from four different countries, which is likely to be more representative than focusing on fewer channels and on the context of a specific country. Second and most importantly, Harabi complemented EFA findings by employing a second multivariate technique, cluster analysis, in order to assure that the patterns of KS were significant. The current research complemented the quantitative findings (including EFA findings) by employing a different approach, qualitative in nature, in order to explain the quantitative findings and also to explain how KS happens at the regional level. Thus, as most previous studies on KS, Harabi (1997) refers to quantitative techniques in order to meet the objective of the research and the results are relationships with no additional explanations. By employing qualitative techniques, i.e. interviews with regional stakeholders and KSIexperts, this research differs from Harabi (1997) by providing the reasons for relationships between variables, that is, it explains how the channels that yielded the highest scores of importance generate KS and innovation to regions, which cannot be done solely with quantitative approaches.

Levin *et al.* (1987) considered seven channels of KS (which would be the same ones later used by Harabi (1997)) to survey 650 manufacturing firms in the US in order to demonstrate the effectiveness of alternative methods of learning. The approach adopted by Levin *et al.* (1987) differs to the current research for analysing channels of KS based on their effectiveness for firms' products and processes, suggesting that channels of KS have different impacts on product and process innovation. The current research analyses channels of KS based on their importance for firms' business, which can cover technological aspects (product and process),

and non-technological aspects, such as marketing and organisational, that can also contribute to innovation (see details in Section 4.4.2 Phase 2: Quantitative approach, in Chapter 4, Conceptual and methodological frameworks). Thus, the consequences of Levin *et al.* (1987) in addressing the importance of a channel for products and processes is that the results reflected the impact of this channel of KS on technological innovation, whilst the consequences of this research, by addressing the importance of a channel of KS for the firm's business, is that the results suggest the importance of a channel of KS on business innovation. This is relevant because, in the context of policy-making, both technological and non-technological innovations can increase regional economic development and, therefore, should be considered.

Therefore, based on the discussions presented in this Section, previous research seeking to explain how KS happens most commonly concentrate on one source, i.e. the Specialisation/Diversification debate (Farhauer and Kröll, 2012; Beaudry and Schiffauerova, 2009; Van der Panne, 2004; and Glaeser *et al.*, 1991). However, the few studies that investigated a group of channels of KS, neither consider Specialisation nor Diversification (Halpern and Muraközy, 2007; Görg and Greenaway, 2003; Harabi, 1997; and Levin *et al.*, 1987). The current research, by considering five critical channels of KS, namely Specialisation, Networking, Competition, Hiring skilled labour, and Diversification differs from previous studies by including other channels in this debate.

7.3 Large firms attribute more importance to knowledge spillover than smaller firms

It is a general belief that small firms, because of their limited size and structure, are more flexible and agile than their larger counterparts, which enable them to comply faster with new and different opportunities. Previous research on KS also suggests that the process by which KS happens in a region tends to be more beneficial to small, rather than large firms (Iammarino and McCann, 2010; McCann and Mudambi, 2005; Van der Panne, 2004; and Feldman, 1996). Van der Panne (2004), for example, by surveying 398 innovative firms in the Netherlands, identified that location and geographical proximity to innovative firms and organisations are more important to smaller rather than larger firms because they benefit more from KS. Small firms typically 'rely on firm-external knowledge more than do large firms, since the resources needed for maintaining the knowledge base are typically beyond the means of small firms' (Van der Panne, 2004, p. 601). The survey administered for the current research, however, identified that large firms attribute more importance, than micro and small firms, to the three channels of KS that enable geographical proximity to innovative firms and organisations,

namely Specialisation, Diversification and University research. Thus, these findings oppose Van der Panne's (2004) because they suggest that, although geographical proximity is important to small firms, large firms benefit more from geographical proximity because of the higher importance they attribute to the interactions with different types of firms and universities in the same region.

Moreover, based on the transactions costs approach, which explains that KS favours firms concentrated in a region as long as there is an assessment of the relative importance of knowledge inflows and outflows (McCann and Mudambi, 2005), the industrial complex model proposes that in regions with both large and small firms, KS happens at the expense of large firms (Iammarino and McCann, 2010). This is because large firms, which are constantly creating knowledge for innovation, involuntarily generate knowledge flows to the region because of interactions with other firms, and this knowledge becomes available and can be used by small firms in order to innovate. Therefore, KS is costly to large firms and makes them lose competitive advantage to competitors (Iammarino and McCann, 2010).

However, the findings in this research show that large firms attribute more importance to channels of KS than smaller firms, especially if compared to micro firms. Thus, these findings suggest that large firms benefit more from KS than smaller firms, which contradicts the industrial complex model (Iammarino and McCann, 2010, McCann and Mudambi, 2005). One reason for this assertion is due to the necessity that large firms have to constantly interact with other organisations, which leads them to benefit from KS effects. For example, large firms need to interact with small firms for outsourcing (BRAHEI1, ROMIND1), universities for research collaboration (ROMHEI1), government agencies for funding on innovation (BRAHEI1) and even individuals as they constantly seek to hire skilled employees (SPAIND1).

The differences by which small and large firms benefit from KS are also explored by Feldman (1994) in a study conducted in the US seeking to identify the degree to which small firm innovation is related to KS. Thus, in line with previous studies (Iammarino and McCann, 2010; McCann and Mudambi, 2005; and Van der Panne 2004), and contrary to this research, Feldman's (1994) findings suggest that 'small firm innovation appears to benefit from the presence of external institutions and resources. Although large firm innovative activity benefits from the presence of knowledge resources, location appears to be especially beneficial to small firm innovative activity' (Feldman, 1994, p. 363). In addition, Feldman's (1996) findings

contrast with this research because of the KS effects regarding university research, which are greater for small than they are for large firms: 'small firms appear able to generate innovative outputs while undertaking negligible amounts of investment in R&D by capturing spillovers from university research. Large firms are more adept at exploiting knowledge created in their own laboratories, while smaller firms exhibit a comparative advantage at exploiting spill-overs from university laboratories (Feldman, 1996, p. 370). Based on the survey findings of the current research that were obtained in relation to university research, which indicated that the score of importance for micro (3.39) and small firms (3.34) are lower than for large firms (3.57), evidence suggests the contrary, i.e. that large firms attribute more importance to university research than micro and small firms. However, there is evidence that confirms Feldman's (1996) assertion that large firms are more adept at exploiting knowledge created in their own laboratories, as large firms surveyed (3.57) attributed more importance to R&D than both micro (3.36) and small firms (3.49).

Therefore, contrary to the general belief that small firms are more flexible and agile than larger firms, which enable them to comply faster with opportunities, this research proposes that large firms benefit more from KS than small and especially micro firms. This assertion also contradicts previous studies that identified that small firms benefit more from KS than large firms (Iammarino and McCann, 2010; McCann and Mudambi, 2005; Van der Panne, 2004; and Feldman, 1994).

7.4 Knowledge spillover is region-specific

The quantitative findings of this research identified consistency in the way firms attribute importance to channels of KS and the manner by which these channels are interrelated across regions and industry sectors, suggesting that KS might be a generic process. However, the majority of KSIexperts interviewed considered KS as region-specific (EXP1, EXP2, EXP3, EXP4, EXP6, EXP7, EXP8, EXP9). EXP3 explained that 'knowledge spillovers operate via different channels, such as labour, spin-offs, company linkages and so forth. So the specific characteristics of the region: few or many companies, few or many networks, industrial, sectoral and organisational structure; will have implications for the process of knowledge spillover'. These findings provide three reasons why KS differs between regions, which confirms previous studies, such as Ortiz (2013), Cooke and Laurentis (2010), Iammarino and McCann (2010) and McCann and Mudambi (2005). However, what is different about the current research compared to these previous studies is the emphasis on the similarities in the

process of KS, which are important in order to reach an explanation of this regional phenomenon.

The first reason why KS is region specific is that regions with different industry sectors have different KS processes due to the influence of sectoral proximity, i.e. proximity that happens between firms from the same industry sector. For example, through an investigation of networks of collaboration in high-tech clusters from three industry sectors, Cooke and De Laurentis (2010) identified KS effects that are derived from sectoral proximity. They found that interactions between high-tech firms from the same industry sector evolve to networking and cooperation, and that the result of these interactions generate better innovation outcomes than the results of the interactions between high-tech firms from different industry sectors. Consequently, a region that has a cluster of firms in sectoral proximity perform better on innovation than regions that have a cluster with firms from different industry sectors. The current research is in line with Cooke and Laurentis (2010) because it identified that interactions between firms in sectoral proximity are more important for KS to happen than interactions between firms from different industry sectors, even though the latter is also of decisive importance.

The second reason why KS is region specific is because regions do not always rely on the same type of organisations that can support innovation processes. Ortiz (2013), for example, based on the context of innovation systems in Germany, Spain and the United Kingdom, explored the differences by which Regional Innovation Systems (RIS) can benefit from knowledge transfer that happens between firms and innovative organisations and found that regional organisational configurations can influence knowledge transfer outcomes. Consistent with Ortiz (2013), most KSIexperts interviewed in this research explained that regions have different KS outcomes depending on the existence of key organisations, such as are HEIs, government agencies and innovative firms (EXP1, EXP2, EXP3, EXP4, EXP5, EXP8).

The third reason are the differences in the level of trust between firms. According to the social network model of clusters (McCann and Mudambi, 2005; and Iammarino and McCann, 2010), when the level of trust between firms in the same region is high, their knowledge interactions are more prone to facilitate R&D collaboration and KS. By identifying that high-levels of trust between firms in the same region are more likely to generate KS (ROMIND1, EXP4, EXP5, EXP6, EXP9), this research's findings support the social network model of clusters (McCann

and Mudambi, 2005; and Iammarino and McCann, 2010). Trust, according to ROMIND1, is a key aspect for firms that are constantly networking to engage in R&D cooperation.

Identifying that KS is region specific was another major finding of this research because, in order to explain the process of KS at the regional level (*research aim*), it is relevant to understand the aspects that influence the differences in this process. However, interview findings also suggest that the role of the channels of KS that obtained the five highest scores of importance, derived from this research survey, is critical for generating KS across regions and industry sectors. This also suggests that there are generic aspects in the process of KS. These findings are relevant because they contribute to previous research discussed in this Section that provided the reasons why KS happens differently between regions (as exemplified by Ortiz, 2013; Cooke and Laurentis, 2010; Iammarino and McCann, 2010; and McCann and Mudambi, 2005), by providing empirical evidence of generic aspects in the process of KS. As observed by EXP5, 'the process is roughly the same but it is facilitated or complicated depending on specific interactions at the regional level'.

7.5 Specialisation and diversification of industries are interrelated

The finding that Specialisation and Diversification of industries are interrelated significantly substantiates the previous discussion in this Chapter regarding the '*mutually exclusive*' Specialisation/Diversification debate (see Section 7.2, Regardless of region, firm size or technology intensity, the five most important channels of KS are the same). This is because it provides empirical evidence implying that when Specialisation increases importance in a region so does Diversification, and vice versa, which further disagrees with previous studies already discussed that contend that either one of these channels happens at the expense of the other (Farhauer and Kröll, 2012; Beaudry and Schiffauerova, 2009; Van der Panne, 2004; and Glaeser, Kallal, Scheinkman and Shleifer, 1991).

Moreover, by identifying that Specialisation, Diversification and Networking are interrelated, this research reveals a core pattern of KS comprising of three out of five channels of KS that were identified as critical for KS by most KSIexperts (EXP1, EXP2, EXP4, EXP5, EXP6, EXP8, EXP9), which was interpreted as being the region's industrial setting. This pattern introduces a third element to the debate between Specialisation and Diversification, whose interpretation was suggested by IREHEI2, IREHEI3, BRAGOV1 and SPAGOV1, in which firms from the same and different industry sectors frequently network in the interest of solving

a common problem, such as those of a research, industry or market nature whereby these knowledge interactions can generate KS to the firms that surround them. The interrelationship between Specialisation, Diversification and Networking represents a key aspect of KS at the regional level that can be considered, as proposed by Park (2001), as a basis for regional innovation strategies.

By examining the major strategies for developing RIS adopted in Korea, Park (2001) provided a set of strategies for different policy issues that are expected to increase regional innovation performance and competitiveness according to the particularities of a RIS. Park said, 'major policy issues and related strategies for regional innovation and competitiveness can be regarded as common issues required for the successful development of RIS. Taking these basic policy issues into account, each region can develop their own region-specific RIS, with appropriate consideration of distinctive regional characteristics' (Park, 2001, p. 29). Moreover, with the objective of promoting region-specific clustering, policy-making should focus its strategy on the specialisation of the existing industry by focusing on providing professional services and networking opportunities between firms along the value-added chain and between firms and universities (Park, 2001). Thus, Park (2001) is in favour of a limited Diversification in order to provide support to the process of regional Specialisation, by which the networking between firms from different industry sectors that are related to the main industry sector whereby the region is specialised is key for both Specialisation and Diversification to generate KS. Survey findings from the current research uphold Park (2001) by pointing out that even though Diversification was identified as a very important channel of KS, Specialisation was consistently even more important than Diversification. Moreover, interview findings explained why Specialisation is more important than Diversification for KS and innovation to happen. According to IREHEI2, IREHEI3, BRAGOV1, SPAGOV1 it is because firms from the same industry sector tend to interact more because they have more common problems and goals and that these interactions lead to R&D cooperation and innovation more often (BRAGOV1). Thus, the current research agrees that, if policy-making focuses on Specialisation, limited Diversification and Networking KS and innovation are likely to happen at the regional level.

Therefore, Park's (2001) findings are relevant for the current research because they provide a plausible explanation for the interrelation between Specialisation, Diversification and Networking that was interpreted, in the current research, as the core pattern of KS for the industrial setting. However, previous studies that are dedicated to understanding how channels

of KS combine together in order to generate KS through patterns are rare. Literature reviewed for this research identified that previous research has not fully explored the relationship between channels and patterns of KS as this was identified only in one study (see Harabi, 1997). However, contrary to this research, Harabi did not consider Specialisation or Diversification as channels of KS. Harabi identified patterns of KS from the Swiss context based on seven channels of KS. The current research, on the other hand, identified core patterns of KS based on fifteen channels of KS, which were tested in four regions from four different countries. Thus, the patterns yielded by this research are believed to better represent the relationships between channels of KS that can happen in a region because they consider the reality of different regional contexts and a vast number of KS that are expected to reflect all the possibilities for KS to happen. Moreover, the core pattern of the industrial setting, which supports the interrelationship between Specialisation, Diversification and Networking is the most important among the five identified because it comprises of three critical channels of KS.

7.6 Patents and Reverse Engineering are interrelated, but not perceived by responden as an important pattern of KS

The core pattern of KS of industrial secrecy, representing the interrelationship between Patent disclosures and Reverse Engineering, was highly consistent across regions and categories of technology intensity. However, identifying that there is a strong intercorrelation between these two channels of KS, does not necessarily imply that this pattern is important to generate KS at the regional level. Patent disclosures and Reverse engineering were highly consistent in every iteration performed by the quantitative analysis as the least important channel of KS for ICT and manufacturing firms (see Section 5.8 Core patterns of KS in Chapter 5, An empirical analysis on channels and patterns of knowledge spillover). Therefore, this research considers this pattern as not important because it represents the interrelationship of the two least important channels of KS among the fifteen that were tested in the survey, thus they are not expected to propagate KS, as strongly as the other 13 channels, at the regional level. Or perhaps, KS effects from this pattern (Patents and Reverse engineering) may be specific to only some regions that were not considered by this research. These findings contradict previous studies that propose Reverse engineering (Halpern and Muraközy, 2007; Harabi, 1997; Levin *et al.*, 1987) and Patent disclosures (Harabi, 1997; Levin, Klevorick, Nelson and Winter, 1987) as effective channels of KS.

However, Reverse engineering was considered a highly effective channel of KS, especially between firms from the same industry sector, in the context of Hungarian manufacturing firms (Halpern and Muraközy, 2007). In the context of Swiss manufacturing firms, Reverse engineering was also considered a highly effective channel of KS, mainly for product innovations (Harabi, 1997). For US manufacturing firms, however, Reverse engineering is a moderately effective channel of KS (Levin *et al.*, 1987). Whereas these previous studies were focused on single regions, the current research provides a broader context because the findings are based on four regions from four different countries. Therefore, these findings disagree with previous studies by consistently suggesting that Reverse engineering is a much less common channel of KS that consistently obtained the second lowest score of importance (see Section 5.7 Most and least important channels of KS in Chapter 5, An empirical analysis on channels and patterns of knowledge spillover).

Patent disclosures, on the other hand, was generally not regarded as effective as Reverse engineering by previous studies comparing the impacts of different channels of KS. For example, even though Patent disclosures were not an effective channel of KS for most industry sectors in Switzerland, it was moderately effective in some, such as chemicals, machinery and metal processing (Harabi, 1997). In the US context, manufacturing firms considered Patent disclosures as a moderately effective channel of KS for both product and process innovations (Levin *et al.*, 1987). Thus, previous research identified that Patent disclosures is moderately important for generating KS in particular regions or industry sectors. The current research, however, provided empirical evidence that contradicts these previous studies by indicating that Patent disclosures as is a channel of KS that consistently yielded the three lowest scores of importance

7.7 The process of KS at the regional level

Even though knowledge flows leave trails that cannot be seen (OECD, 2018, Krugman, 1991), this research shows that they can be identified. The explanation of the process of KS at the regional level is the result of the analysis based on the findings of this research which follows the trail of unintentional knowledge flows, i.e. KS at the regional level, that starts from the geographical proximity of firms and key organisations and culminates with regional innovation. This Section explains how this trail of unintentional knowledge flows, much like a domino effect, leads the way towards regional innovation by creating many opportunities for firms to interact with other firms and key organisations and thereby benefit from the knowledge

flows that are available in their region. The process of KS at the regional level is represented in Figure 7.1.

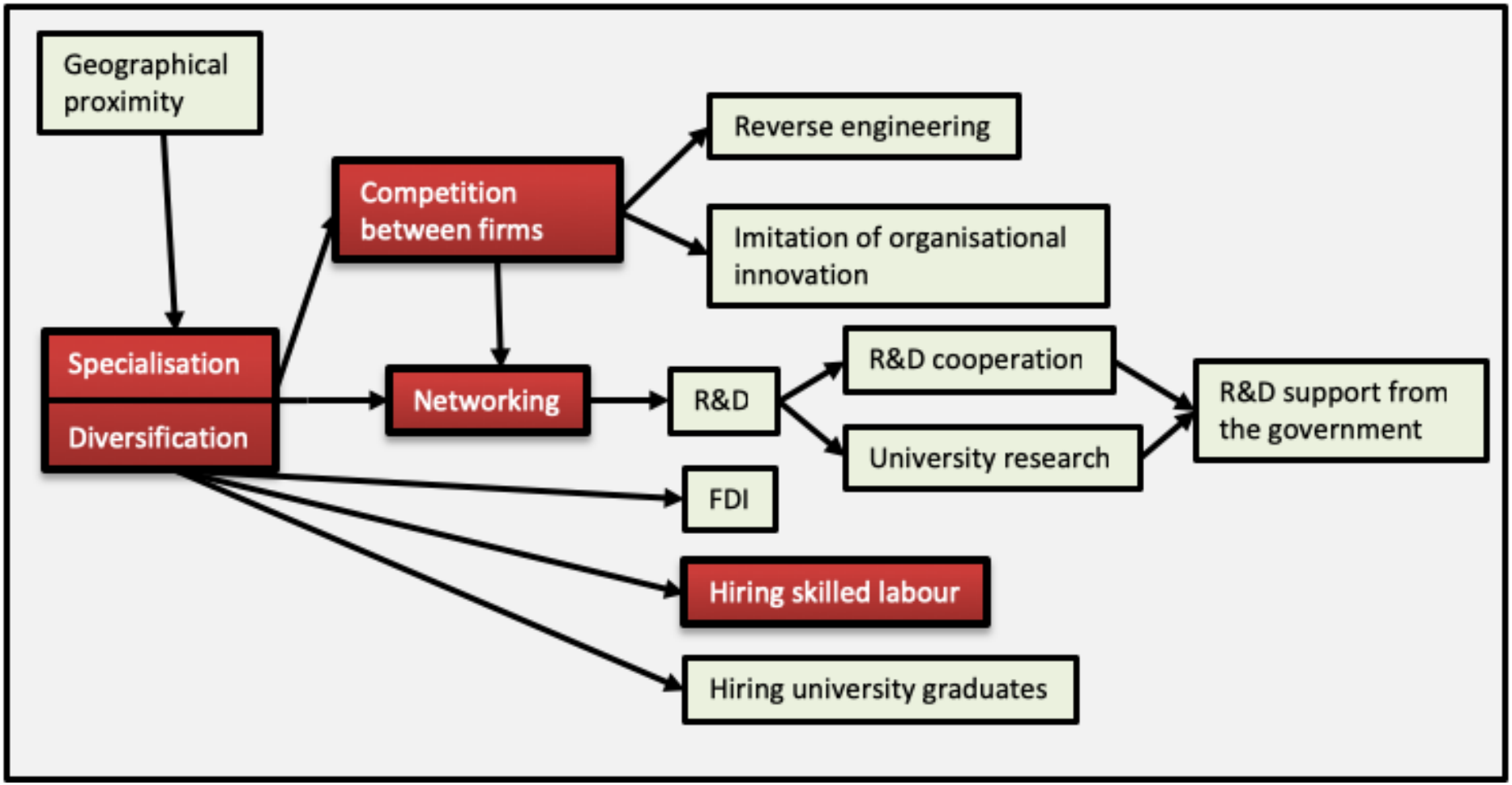

Figure 7.1 The process of KS at the regional level (Source: Author)

The framework in Figure 7.1 is based on the capacity of channels, especially the critical ones (highlighted in red), to generate KS to firms located in the same region. These channels also have a knock-on effect that contribute further to firms to benefit from knowledge that is available in the region due to innovation activities. This framework indicates which channels of KS have an impact on others and how these relationships unfold. For example, the process of KS at the regional level starts with geographical proximity of firms and other organisations (HEIs, government agencies and innovative firms) because it enables constant opportunities for knowledge interactions in both formal and informal contexts between people who work in these organisations. Thus, If these organisations are in place and interact with firms in the region, the interactions are likely to be fruitful and lead to innovation outcomes for firms involved directly and indirectly (IREIND1, BRAGOV1, ROMIND1, SPAHEI1, EXP2).

Over time, the number of firms increases and they become concentrated in the region. Concentration of firms from the same (specialisation) and different industry sectors (diversification) is important for KS to happen because the knowledge interactions become considerably more frequent (IREHEI1, IREHEI2, IREIND1, BRAIND1). In addition, when firms are close to each other and knowledge interactions become more frequent, relationships are created which lead to networking (IREHEI2, IREHEI3, ROMIND1, EXP7). Moreover, when the number of firms in the region increases, firms tend to create and join industry representative bodies to pursue their common interests. These institutions often promote events that offer opportunities for firms to engage in networking and learn from each other (IREHEI2). Competition is intensified when firms are concentrated in a region because geographical proximity enables firms to identify the innovation activities of their competitors, which forces them to become involved with innovation activities as well (BRAGOV1, SPAIND1, EXP7). Thus, two results of competition are (i) the copying of innovative products through reverse engineering and also (ii) the imitation of organisational innovation (EXP9).

Networking, in turn, enables firms to become aware of innovation opportunities and their potential which leads firms to conduct R&D (BRAIND1, BRAIND2, ROMIND1). When firms conduct R&D, they acquire knowledge and experience on innovation activities, which enable them to engage in research cooperation with other firms (IREHEI2, IREIND1, ROMIND1) and also with universities (IREHEI3, SPAHEI1, BRAHEI1). Once it is visible that the capabilities of the industry can contribute to regional development, there is support from the government for these firms (BRAIND2).

Moreover, the concentrations of firms also attracts FDI to the region because multinational firms need to be closer to other firms in order to, for example, identify suppliers and outsourcing as well as talents (IREIND1, BRAIND2, BRAHEI1). A concentrations of firms also attracts skilled labour to the region because there are more employment opportunities, facilitating the skilled labour to choose where to work (IREHEI2, IREHEI3, IREIND1, SPAGOV1). Also, these firms hire university graduates because they have learnt up-to-date skills that can be applied to their businesses (IREHEI3, IREIND1, SPAGOV1).

The process of KS described in this Section is supported by fourteen channels. One of the fifteen channels of KS originally identified by this research, Patent disclosure, was not considered because it was consistently attributed as not being important by the firms surveyed and was not mentioned as part of KS processes by key informants during the interviews. Thus, these fourteen channels are considered in this Section because they were identified, either by the quantitative or the qualitative approach undertaken by this research, as relevant for KS and innovation.

Thus, the findings of the current research indicate that KS can help firms to become more innovative, which is in line with the literature on KS (see for example: Stuetzer, Audretsch, Obschonka, Gosling, Rentfrow, and Potter, 2018; McCann, Ortega-Argilés, 2016; Romer, 1990). However, it was also identified that in the fourth edition of the Oslo manual (OECD, 2018), which is a reference for OECD countries to conceptualise and measure innovation outputs, an undermining view on KS effects that 'unintentional knowledge flows can result in unwanted transmission of information to competitors. Some types of flows can be illegal, such as knowledge obtained through industrial espionage. Firms cannot prevent knowledge contained in patents from flowing to competitors, but they can obtain damages for the misuse of knowledge protected by IP rights' (OECD, 2018, p. 131). This undermining view disagrees with most of the literature on KS and also with findings of the current research. It is also troublesome because, the way the Oslo Manual Conceptualises KS may be the way that policy makers see it as 'the fast adoption and diffusion of the manual's proposals, both within and beyond the OECD and the EU, are a clear indication of the value of this initiative; in fact, innovation surveys covering more than 80 countries have been carried out thus far' (OECD, 2018, p. 3). The approach adopted by this research suggests that KS can positively influence regional innovation performance and therefore should be considered in policies on innovation.

7.8 Knowledge spillover propagation

Based on an analysis on the process of KS and on the core patterns of KS, this research proposes a framework to explain how KS can be propagated at the regional level (Figure 7.2).

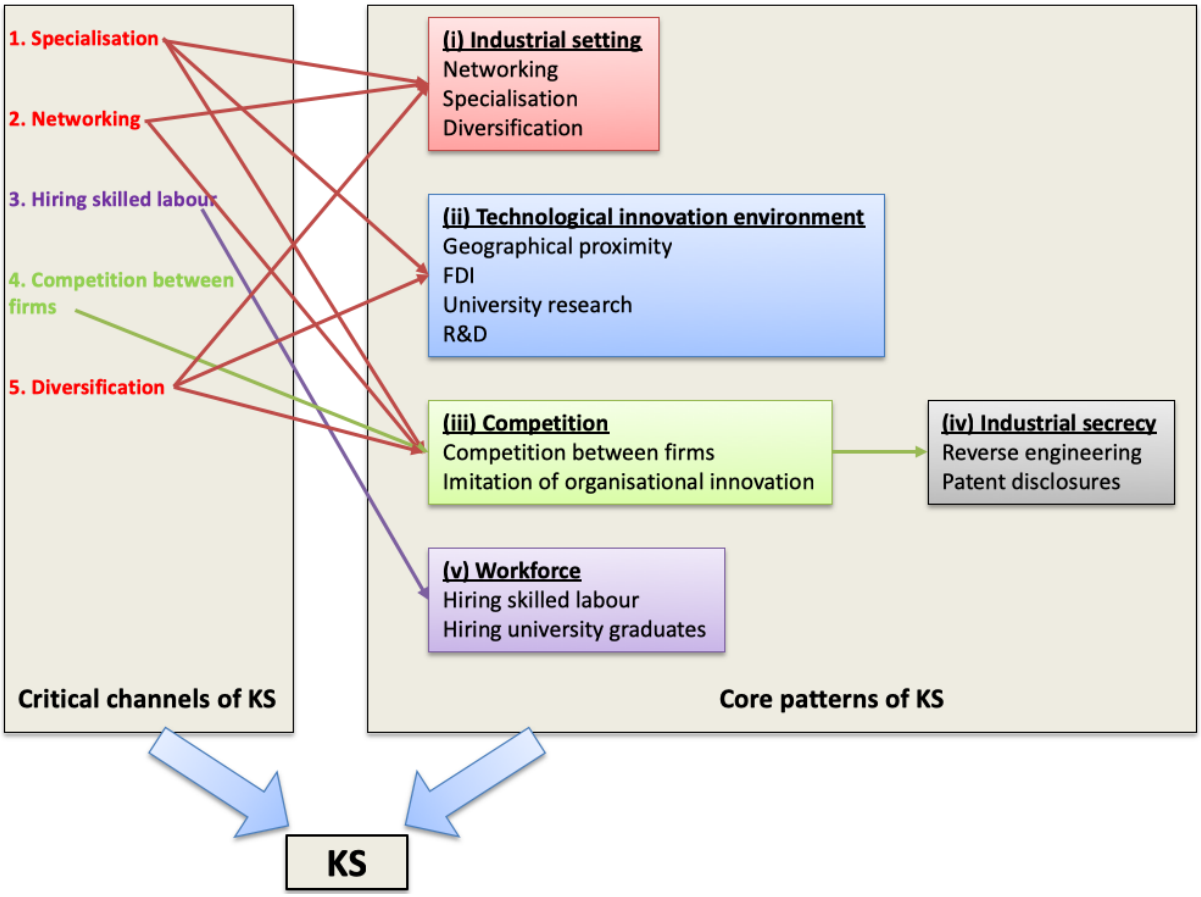

Figure 7.2 Knowledge Spillover propagation (Source: Author)

In the framework for KS propagation (Figure 7.2), the key aspects that enable KS to be propagated within the region are the five **critical channels of KS** (which are Specialisation, Networking, Hiring skilled labour, Competition between firms and Diversification), and the five **core patterns of KS,** which are (i) Industrial setting, (ii) Technological innovation environment, (iii) Competition, (iv) Industrial secrecy and (v) Workforce. The five critical channels of KS are of decisive importance for generating KS and supporting a region to create innovation and, therefore, play a key role within the pattern that relate to them by creating a knock-on effect on the other channels that are part of their pattern. This framework proposes that when policy makers support conditions for the most important channels to generate KS, they are actually contributing for KS to be propagated through the patterns that they are interrelated, which include other channels of KS as well. Thus, this framework enables policy makers to target specific patterns of KS according to the specificities of their region by focusing

on the channels of KS that are relevant to them. So, for example, as per Figure 7.2, increasing conditions for the three channels specialisation, diversification and networking to propagate KS will also lead to an increase in the capacity of the industrial setting of the region (first core pattern of KS). Moreover, specialisation, diversification and/or networking also influence the capacity of R&D, competition, hiring skilled labour and hiring university graduates to propagate KS through their own patterns (second, third and fifth core patterns of KS, namely Technological innovation environment, Competition and Industrial setting).

The same process happens when competition between firms and hiring skilled labour are considered by policies in order to propagate KS. They propagate KS through their patterns of KS which are, respectively, Competition and Workforce (third and fifth patterns of KS). The critical channels of KS do not have a direct impact on industrial secrecy (fifth core pattern of KS), which is an effect of the pattern of Competition. KS in the Technological innovation environment (second pattern of KS) is propagated through Specialisation and Diversification.

The framework for KS propagation is proposed as a policy tool that aims to provide innovative knowledge to multiple firms at a regional level. It is relevant because it enables policy makers, through KS, to induce innovation in firms that are not directly involved with innovation activities but benefit from these activities anyway. However, this framework has not yet been further investigated or tested. Such an undertaking can be a task for future research on KS propagation.

7.9 Chapter summary

This chapter discussed the key findings of this research in the context of the literature on KS and innovation. The discussions of research findings enabled this research to explain the process of KS at the regional level (*research aim*) and also to propose a framework for KS propagation that can be used as a tool for policy-making. The discussion suggests that, since previous literature has not fully explained the process of KS at the regional level (as presented in Section 7.1, Introduction), policy makers most likely do not have the means to entirely understand its potential for innovation and, as a result, are not considering it in policies on innovation.

This research served the purpose of addressing this gap in policy-making by explaining the process of KS at the regional level and identifying how it leads to innovation. Therefore, the implications of this research are not only theoretical because they also provide a perspective

that should be considered by policy makers who are concerned with solving the imbalances of regional innovation in their countries.

.

Chapter 8
Conclusion, Major Contributions, Limitations and Recommendations

Chapter 8 Conclusion, Major Contributions, Limitations and Recommendations

8.1 Introduction

In order to answer the research question, '*How does the process of knowledge spillover (KS) happen at the regional level?*', a mixed-methods design was devised in which a quantitative approach tested the importance of channels of KS with firms from different regions and technological backgrounds, and a qualitative approach explained and complemented these findings. Thus, initially, the importance of channels of KS, proposed by previous research as relevant for generating KS, was tested in a survey administered to 7,292 ICT and manufacturing firms (with a response rate of 6.02%) from four regions, namely South East Ireland, North East Brazil, Bucharest-Ilfov Romania, and Castilla-La Mancha Spain. The scores of importance were analysed through quantitative techniques such as descriptive statistics, One-way Analysis of Variance (ANOVA) and Exploratory Factor Analysis (EFA) and were based on firm size, region and category of technology intensity.

The survey findings, suggesting strong consistency in the way firms attribute importance to channels of KS and how these channels interrelate, were further analysed and explained based on interviews with fifteen regional stakeholders, from the same four regions surveyed, and nine experts on KS and innovation. Interview findings significantly contributed to answer the research question because they were key to elucidate relevant aspects related to the process of KS, such as suggesting that, even though KS is region specific, there are five channels, namely Specialisation, Networking, Competition, Hiring skilled labour, and Diversification that are critical for generating KS and innovation across regions and categories of technology intensity.

The findings of this research led to theoretical and practical contributions, which are presented in the next Section. The following two Sections present, respectively, the limitations of this research and suggestions for future studies. The final Section summarises this Chapter and concludes the this Thesis.

8.2 Major contributions of the research

A major contribution of this research is to provide an in-depth and comprehensive explanation of the process of KS at the regional level and how it contributes to innovation, which substantiates the body of knowledge on KS because most of previous studies explained KS as

a resultant of one (see for example Farhauer and Kröll, 2012; Beaudry and Schiffauerova, 2009; Van der Panne, 2004; and Glaeser, Kallal, Scheinkman and Shleifer, 1991), or a few channels (see for example Halpern and Muraközy, 2007; Harabi, 1997; Levin *et al.*, 1987) that cannot reflect all possibilities for KS to happen at the regional level. There are only a few studies explaining KS using qualitative approaches, however, they are restricted to specific contexts, such as Ko and Liu (2015) and Pickernell, Senyard, Clifton, Kay and Keast (2007). For example, Ko and Liu (2015) explained how KS happens between third sector organisations through registered charities in the UK; and Pickernell et al. (2007) explained how KS happens through R&D interactions within the biotechnology industry sector in Australia. The research for this thesis differs from these previous studies because it adopted a broader approach, by which KS is explained through a wide array of channels and based on different contexts, i.e. the four regions whereby firms were surveyed and regional stakeholders were interviewed. Such explanation culminates with a framework considering the importance of fourteen channels in generating KS and innovation to firms located in the same region and in having a knock-on effect on other channels that further contribute for these outcomes. Thus, this research substantially contributes to the literature by explaining KS through a broad number of channels. Using a broad number of channels to investigate KS has not been performed before by previous research. Such an investigation is expected to reflect all the possibilities for KS to happen at the regional level. The research contribution of understanding the process of KS based on such a broad approach can also be extended to policy-making as, given that previous literature has not fully explained how KS happens, policy makers cannot access the means to entirely understand its potential for innovation. Consequently they are not likely therefore to consider KS propagation in policies on innovation.

By demonstrating that the channels of KS are interrelated, the five core patterns of KS provide additional reasons sustaining that a broader approach reflecting all the possibilities for KS to happen at the regional level is relevant to the body of knowledge on KS. Each of these patterns represent a different underlying mechanism through which KS can be propagated and, for this reason, they can be used as a pertinent policy instruments for KS and innovation at the regional level, as is proposed by this research. However, the most important of these patterns for KS propagation is the *Industrial setting* because it comprises of Specialisation, Diversification and Networking, which are three out of the five critical channels of KS. On the other hand, the least important of these patterns is the *Industrial secrecy*, because it comprises of Patent disclosures

and Reverse engineering, which were consistently considered by the firms surveyed as the least important channels of KS.

Proposing a framework for KS propagation is an unprecedented contribution to the field of research on KS, innovation and policy-making because the extensive literature review did not identify any single study focused on revealing the elements that are necessary to purposefully trigger KS within regions and, consequently, contribute to innovation outcomes. KS is commonly a possible result of policy efforts towards innovation that cannot be controlled (such as suggested by OECD, 2018; and Park, 2001). The framework for KS propagation contributes especially for policy-making because it can be used as a tool to provide innovative knowledge to multiple firms at a regional level by focusing on specific patterns of KS according to the specificities of the region. However, as it was beyond the objectives of this research, the framework for KS propagation was not empirically tested and, consequently, depends on future studies to be validated and applied.

Identifying five critical channels for KS and innovation, namely Specialisation, Networking, Competition, Hiring skilled labour, and Diversification, confronts a '*mutually exclusive*' debate within the KS theory by which KS and innovation are either derived by Specialisation or Diversification (examples of studies addressing this debate: Farhauer and Kröll, 2012; Beaudry and Schiffauerova, 2009; Van der Panne, 2004; and Glaeser, Kallal, Scheinkman and Shleifer, 1991). The current research proposes that neither happens at the expense of the other and, in fact, not only are both critical in generating KS, but they are also critical for Networking, Competition and Hiring skilled labour. The implications of identifying five critical channels of KS for policy-making is that it provides a broader spectrum of the key sources by which KS happens that can be considered based on the particularities of the target-region.

Contrary to a general belief that small firms, because of their limited size and structure, are more flexible and agile than their larger counterparts, which enable them to comply faster with new and different opportunities; and specifically in contrast with previous research on KS that poses that small firms benefit more of KS than firms of larger size (Iammarino and McCann, 2010; McCann and Mudambi, 2005; Van der Panne, 2004; and Feldman, 1994), this current research provides empirical findings suggesting the contrary, that large firms actually benefit more from KS than smaller firms do, especially if compared to micro firms. Moreover, if considering KS from university research, previous research has found that KS effects from university research are greater for small rather than for large firms (Feldman, 1996). This

thesis, however, cannot corroborate Feldman's (1996) finding as its empirical findings also suggest the contrary, that large firms attribute more importance to university research than micro and small firms. From a policy perspective. the knowledge that large firms benefit more from KS is important because policy-making needs to provide a means by which this difference can be alleviated, as micro firms are usually the ones that do not have the resources required for innovation activities and, as a consequence, are more dependent on external knowledge than large firms.

This research explored whether KS is a region-specific or a generic process and, in line with the literature on KS (Ortiz, 2013; Cooke and Laurentis, 2010; Iammarino and McCann, 2010; and McCann and Mudambi, 2005), found that KS is region specific and based on peculiarities, such as levels of trust, learning capacity and the value given to KS. However, this research greatly differs from these previous studies in that it focused on the similarities of the process, rather than the differences, and, as a result, found that the critical channels of KS and the core patterns are consistent across regions and categories of technology intensity. These findings were indispensable for this research to answer its question, as the critical channels are an essential part of the framework by which the process of KS is explained, and also of the framework for KS propagation, as both the critical channels and the core patterns are key aspects of the framework.

In addition, this research contributes to the literature on KS by proposing an unique mixed methods design whereby the role of the qualitative approach is prominent to answer the research question, which demands an explanation of the phenomenon of KS. Thus, this research, inductive in nature and based on a qualitative approach, drastically contrasts with previous studies in the field of KS, which are comprised almost exclusively of quantitative approaches employed to measure KS outputs, often derived from a knowledge production function (see for example Cerver-Romero, Ferreira and Fernandes, 2018; Qiu, Liu and Gao, 2017; Agarwal, Audretsch and Sarkar, 2010; Audretsch and Lehman, 2005; Romer, 1990; Arrow, 1962; Griliches 1979). Previous studies employing qualitative approaches to explain KS are very limited in numbers and specific to particular contexts (for example Ko and Liu, 2015; Pickernell, et al., 2007) and do not provide an explanation as to how KS happens and can support innovation at the regional level. The mixed methods design employed by this research is also of practical relevance because it can be replicated by future studies concerned with understanding how KS happens in different regions and contexts.

8.3 Research limitations

Explaining an intricate regional phenomenon such as KS entails that this research has its limitations such as the following:

1. This research developed a framework to explain how KS happens in regions based on a survey with ICT and manufacturing firms and also based on interviews with regional stakeholders and KSIexperts. Even though this framework provides an in-depth understanding of the research question, the amount it actually reflects the process of KS at the regional level is not determined. This issue relates to sample size as the sample of firms used to generate quantitative findings was not representative, i.e. it was not large enough in order to statistically represent the population under investigation, which implies that the findings of this research do not accurately reflect the perspectives of firms in the regions surveyed and may be biased towards the sample. Moreover, even though this research is based on a sample of firms from 23 industry sectors, the number of firms is not equally distributed by industry sector and biased mainly towards software (27.33%) and machinery (12.98%), implying that the generalisations that are made in this research about ICT and manufacturing firms are also biased towards these two industry sectors.
2. Since a qualitative approach was key to explain quantitative findings, another limitation of the framework to explain the process of KS refers to two inherent weaknesses of qualitative approaches, which relates to the fact that the knowledge generated may be too specific and not generalisable to other people or settings and also that the results are often more influenced by the researcher's personal biases and idiosyncrasies (Johnson and Onwuegbuzie, 2004). Thus, this framework may have been biased by the specificities of the regions in which the interviewees were based. Also, even though all measures were taken in order to perform impartial analyses, the researcher's own experiences and meanings may have influenced the framework.
3. Other multivariate techniques could have been employed with the quantitative data in order to add more details to the analysis performed. The choice for EFA was due to its capacity to provide interrelationships between channels of KS and reveal patterns through which KS can happen, and therefore could greatly contribute to explain the process of KS. However, multiple regression analysis could identify relationships between the critical channels of KS and the others; and Structural Equation Modelling

(SEM) could confirm the relationships between channels of KS identified in this research.

4. The framework by which KS is explained depends on the geographical proximity of firms and key organisations, namely HEIs, government agencies and innovative firms. These organisations were identified as necessary in a region in order for specific channels to generate KS. This research has not explored how KS happens in regions where these key organisations are not available, which would be relevant because an understanding of KS processes in such regions could contribute to the capacity of their governments to provide effective policies on innovation.
5. Because of the positive influence on regional performance, this research investigated KS based on the benefits for policy-making. An aggregate analysis of firms representing regions and categories of technology intensity provided the means to understand KS in regions and also to propose a broader viewpoint on this regional phenomenon by which policy makers can address imbalances of innovation performance between regions. However, It would have been an addition to this research to consider KS from a business perspective because it would explain how firms could become more innovative if they were aware of the KS opportunities. Thus, KS could be explored as part of their strategic planning in order to benefit from the knowledge that is available in their external environment.

8.4 Future studies

This research provided an in-depth explanation of the process of KS at the regional level, thus due to the complexity of the investigation that was conducted, by which diverse aspects such as regions, categories of technology intensity and firm size were taken into consideration to unveil the critical channels, the core patterns of KS and two frameworks detailing how KS happens and can be propagated, it is natural to expect that further research can be carried out in order to complement findings or adopt a different perspective in this process. Thus, based on the aspects that were not considered by this research, but that are related to the complexities of a regional phenomenon such as KS, this Section proposes four opportunities for future studies to continue exploring this field.

Firstly, the framework by which the process of KS is explained suggests a number of dependence relationships between channels due to the knock-on effect by which some channels of KS have on others. Thus, Structural Equation Modelling (SEM) would be a pertinent

multivariate technique that could test simultaneously the significance of these dependence relationships. Therefore, providing statistical significance of such relationships could have an impact on the field of research on KS, traditionally quantitative, because it would identify whether a quantitative approach could reach the same results as its qualitative counterpart, such as the one adopted by this research.

Secondly, employing multiple regression analysis could enable future studies to approach KS from a business perspective and devise a management tool by which entrepreneurs and managers could make strategic decisions in order to benefit the most from KS. This is because multiple regression analysis, a technique commonly used for modelling firm performance, would explain how the critical channels of KS (individually used as dependent variables), could also influence a firm to benefit from other channels of KS and, as a consequence, multiply opportunities to gain from the innovative knowledge that is available in the region.

Thirdly, the framework by which KS is explained in this research does not consider regions without key organisations, namely HEIs, government agencies and innovative firms. These organisations are key in this framework because they are responsible for providing innovative knowledge that is available in the region. Thus, it would be relevant to conduct a study explaining how KS happens in regions where these key organisations are not available and also to test whether geographical proximity would play a crucial role for KS to happen in these regions.

Finally, the mixed methods design devised for this research could be replicated in a comparative study between regions with great innovation performance and regions where innovation performance is very low, in order to identify differences by which KS happens in a highly-innovative and in a highly-non-innovative context. Such a study could also depict the differences by which KS happens for small and large firms in both contexts in order to propose the regional nuances that need to be considered by policy-making in different contexts for KS to happen.

8.5 Chapter summary

This Chapter concluded this Thesis. It showed that the research question ‘How does the process of knowledge spillover (KS) happen at the regional level?’ was answered through a unprecedented research design in the literature on KS relying on quantitative and qualitative approaches. Moreover, it was also presented in this Chapter that this research provided

theoretical contributions to the body of knowledge on KS as well as practical contributions, most notably related to policy-making. Also relevant in this Chapter was depicting the limitations of the research as well as suggestions for future research.

Bibliography

Bibliography

Abernathy, W. J., and Utterback, J. M. (1978) 'Patterns of industrial innovation', *Technology review*, *80*(7), pp. 40-47.

Acs, Z. J., Audretsch, D. B., and Feldman, M. P. (1994) 'R & D spillovers and recipient firm size', *The Review of Economics and Statistics*, Vol. 76, No. 2, pp. 336-340.

Acs, Z. J., Audretsch, D. B., Lehmann, E. E., and Licht, G. (2016) 'National systems of innovation', *The Journal of Technology Transfer*, Vol. 42, No. 5, pp. 997-1008.

Adams, J. D., and Jaffe, A. B. (1996) 'Bounding the effects of R&D: An investigation using matched establishment-firm data', *National Bureau of Economic Research Working Papers*, No. 5544.

Agarwal, R., Audretsch, D., and Sarkar, M. B. (2010) 'Knowledge spillovers and strategic entrepreneurship', *Strategic Entrepreneurship Journal*, Vol. 4, No. 4, pp. 271-283.

Akcigit, U., Hanley, D. and Serrano-Velaverde, N. (2013) 'Back to Basics: Basic Research Spillovers, Innovation Policy and Growth', *National Bureau of Economic Research Working Papers*, No. 19473.

Akram, K., Siddiqui, S. H., Nawaz, M. A., Ghauri, T. A., and Cheema, A. K. H. (2011) 'Role of knowledge management to bring innovation: an integrated approach', *International Bulletin of Business Administration*, No. 11, pp. 121-134.

Albalate, D., and Fageda, X. (2016) 'High-technology, employment and transportation: evidence from the European regions', *Regional Studies*, Vol. 50, No. 9, pp. 1564-1578.

Albino, V., Garavelli, A. C., and Schiuma, G. (1998) 'Knowledge transfer and inter-firm relationships in industrial districts: the role of the leader firm', *Technovation*, Vol. 19, No. 1, pp. 53-63.

Andersson, T., Serger. S.S., Sörvik, J., Hansson, E.W. (2004) *The cluster policies whitebook*. Malmö: IKED.

ANPEI (2009) *Guia prático de apoio à inovação*. Brasília: SETEC/MCTI.

Anselin, L., Varga, A., and Acs, Z. (1997) ‘Local geographic spillovers between university research and high technology innovations’, *Journal of urban economics*, 42(3), pp. 422-448.

Anselin, L., Varga, A., and Acs, Z. (2000) ‘Geographical spillovers and university research: a spatial econometric perspective’, *Growth and Change,* Vol. 31, No. 4, pp. 501-515.

Antonelli, C. (2010) ‘Pecuniary externalities and the localized generation of technological knowledge’, in Boschma. R. and Martin, R. (eds) *The Handbook of Evolutionary Economic Geography*. Cheltenham: Edward Elgar Publishing, pp. 162-181.

Araújo, B.C. (2012) ‘Políticas de apoio à inovação no Brasil: uma análise de sua evolução recente', *Instituto de Pesquisa Econômica Aplicada*, Texto para discussão 1759.

Araújo, L., Silva, S., and Teixeira, A. (2013) ‘Knowledge spillovers and economic performance of firms located in depressed areas: does geographical proximity matter?’ *FEP Working Papers,* No. 488, pp. 185-208.

Archibugi, D. (2001) ‘Pavitt’s taxonomy sixteen years on: a review article’, *Economics of Innovation and New Technology,* Vol. 10, No. 5, pp. 415–425.

Arrow, K. J. (1962) The economic implications of learning by doing. *The Review of Economic Studies*, Vol. 29, No. 3, pp. 155-173.

Arrow, K. J. (1985) ‘Informational structure of the firm’, *The American Economic Review,* Vol. 75, No. 2, pp. 303-307.

Asheim, B.T. and Gertler, M.S. (2007) ‘The geography of innovation: regional innovation systems’, in Nelson, R.R. and Mowery, D.C., and Fagerberg, J. (eds) *The Oxford Handbook of Innovation*. Boston: Oxford University Press, pp. 291-317.

Audretsch, B. (1998) ‘Agglomeration and the location of innovative activity’, *Oxford Review of Economic Policy,* Vol. 14, No. 2, pp. 18-29.

Audretsch, D.B., and Aldridge, T.T. (2009) ‘Knowledge spillovers, entrepreneurship and regional development’, in Capello, R. and Nijkamp, P. (eds) *Handbook of Regional Growth and Development Theories*. Cheltenham: Edward Elgar Publishing, pp. 201-210.

Audretsch, D.B., and Feldman, M.P. (1996) 'R&D spillovers and the geography of innovation and production', *The American Economic Review*, Vol. 86, No. 3, pp. 630-640.

Audretsch, D.B., and Feldman, M.P. (2004) 'Knowledge spillovers and the geography of innovation' in Nijkamp, P. (ed) *Handbook of Regional and Urban Economics*. Amsterdam: Elsevier North Holland, Vol. 4, pp. 2713-2739.

Audretsch D. B., Keilbach and Lehmann (2006) *Entrepreneurship and economic growth*. Oxford: Oxford University Press.

Audretsch, D. B., and Lehmann, E. E. (2005) 'Does the knowledge spillover theory of entrepreneurship hold for regions?' *Research Policy*, Vol. 34, No. 8, pp. 1191-1202.

Audretsch, D. B., and Mahmood, T. (1994) 'Firm selection and industry evolution: the post-entry performance of new firms'. *Journal of Evolutionary Economics*, Vol. 4, No. 3, pp. 243-260.

Ayer, A. J. (Ed.) (1959) *Logical positivism* (Vol. 2). London: Simon and Schuster.

Babakus, E., and Mangold, W. G. (1992) 'Adapting the SERVQUAL scale to hospital services: an empirical investigation', *Health Services Research*, Vol. 26, No. 6, pp. 767.

Babbie, E. R. (1973) *Survey research methods*. Belmont: Wadsworth.

Baranson, J., and Roark, R. (1985) 'Trends in North-South transfer of high technology', in Rosenberg, N., and Frischtak (eds) *International technology transfer: Concepts, measures, and comparisons*. New York: Praeger, pp. 24-52.

Barnier, M., Stahl, G., Lluna, D., Bachtler, J., and Ziegler, A. (2003) 'EU cohesion policy: challenges and responses', *Intereconomics*, Vol. 38, No. 6, pp. 292-295.

Basile, R., Pittiglio, R., and Reganati, F. (2017) 'Do agglomeration externalities affect firm survival?', *Regional Studies*, Vol. 51, No. 4, 548-562.

Bedi, H. S. (2019) 'Innovativeness, business performance and environmental uncertainty: a multivariate configuration', *International Journal of Business Innovation and Research*, Vol. 18, No. 3, pp. 328-345.

Bhaskar, R. (1978) *A realist theory of science*. Sussex: Harvester.

Bhattacherjee, A. (2012) *Social science research: Principles, methods, and practices*. Tampa: Scholar Commons.

Beaudry, C., and Schiffauerova, A. (2009) 'Who's right, Marshall or Jacobs? The localization versus urbanization debate', *Research Policy*, Vol. 38, No. 2, pp. 318-337.

Blakeley, N., Lewis, G., and Mills, D. (2005) 'The economics of knowledge: what makes ideas special for economic growth?' *Policies perspectives paper*, New Zealand Treasury. Available at: <URL> https://treasury.govt.nz/publications/ppp/economics-knowledge-what-makes-ideas-special-economic-growth-pp-05-05-html (Accessed: 27 May 2016).

Bolisani, E., and Bratianu, C. (2018) 'The elusive definition of knowledge' in Bolisani, E. and Bratianu, C. (2018) *Emergent knowledge strategies: Strategic thinking in knowledge management*. Cham: Springer International Publishing, pp. 1-22.

Boschma, R., Coenen, L., Frenken, K., and Truffer, B. (2017) 'Towards a theory of regional diversification: combining insights from Evolutionary Economic Geography and Transition Studies', *Regional Studies*, Vol. 51, No. 1, pp. 31-45.

Boschma, R. and Frenken, K. (2010) 'The Spatial Evolution of Innovation Networks: A Proximity Perspective' in Boschma. R. and Martin, R. (eds) *The Handbook of Evolutionary Economic Geography*. Cheltenham: Edward Elgar Publishing, pp. 120-135.

Braczyc, H.J, Cooke, P. and Heidenreich, M. (1998) *Regional Innovation Systems: The Role of Governances in a Globalized World*. London: UCL Press.

Branstetter, L. (2006) 'Is foreign direct investment a channel of knowledge spillovers? Evidence from Japan's FDI in the United States', *Journal of International Economics*, Vol. 68, No. 2, pp. 325-344.

Breschi, S., and Lissoni, F. (2001) 'Knowledge spillovers and local innovation systems: a critical survey', *Industrial and corporate change*, Vol. 10, No. 4, pp. 975-1005.

Breschi, S., and Lissoni, F. (2003) 'Mobility and Social Networks: Localised Knowledge Spillovers Revisited', *CESPRI Working Paper*, no. 142.

Breschi, S., Lissoni, F., and Montobbio, F. (2007) 'The scientific productivity of academic inventors: New evidence from Italian data', *Economics of Innovation and New Technology* Vol. 16, No. 2, pp. 101–118.

Broekel, T., Brenner, T., and Buerger, M. (2015) 'An investigation of the relation between cooperation intensity and the innovative success of German regions', *Spatial Economic Analysis*, Vol. 10, No. 1, pp. 52-78.

Buesa, M., Heijs, J., and Baumert, T. (2010) 'The determinants of regional innovation in Europe: A combined factorial and regression knowledge production function approach', *Research Policy*, Vol. 39, No. 6, pp. 722-735.

Caiazza, R., Belitski, M., and Audretsch, D. B. (2019) 'From latent to emergent entrepreneurship: the knowledge spillover construction circle', *The Journal of Technology Transfer*, pp. 1-11.

Cainelli, G., Montresor, S., and Marzetti, G. V. (2014) 'Spatial agglomeration and firm exit: a spatial dynamic analysis for Italian provinces', *Small Business Economics*, Vol. 43, No. 1, pp. 213-228.

Caniëls, M. C. (2000) *Knowledge spillovers and economic growth: regional growth differentials across Europe*. Cheltenhem: Edward Elgar Publishing.

Cantisani, A. (2006) 'Technological innovation processes revisited', *Technovation*, Vol. 26, No. 11, pp. 1294-1301.

Carreira, C., and Lopes, L. (2018) 'Regional knowledge spillovers: a firm-based analysis of non-linear effects', Regional Studies, Vol. 52, No. 7, pp. 948-958.

Cassiman, B., and Veugelers, R. (2002) 'R&D cooperation and spillovers: some empirical evidence from Belgium', *The American Economic Review*, Vol. 92, No. 4, pp. 1169-1184.

Castellacci, F. (2007) 'Evolutionary and new growth theories. Are they converging?' *Journal of Economic Surveys*, Vol. 21, No. 3, pp. 585-627.

Cerver-Romero, E., Ferreira, J. J., and Fernandes, C. (2018) 'A scientometric analysis of knowledge spillover research', *The Journal of Technology Transfer*, pp. 1-26.

Chilisa, B., and Kawulich, B.B. (2012) *Doing Social Research, a Global Context*. London: McGraw Hill.

Christensen, C. (1997) *The innovator's dilemma: when new technologies cause great firms to fail*. Boston: Harvard Business Review Press.

Christensen, C. M., Raynor, M. E., and McDonald, R. (2015) 'What is disruptive innovation?' *Harvard Business Review,* Vol. 93, No. 12, pp. 44-53.

Cirera, X. and Maloney, W.F. (2017) *The innovation paradox: developing-country capabilities and the unrealised promise of technological catch*. Washington: World bank Group.

Cohen, W. M., and Levinthal, D. A. (1990) 'Absorptive capacity: a new perspective on learning and innovation', *Administrative Science Quarterly*, Vol. 35, pp. 128-152.

Cooke, P. (2002) *Knowledge economies: Clusters, learning and cooperative advantage*. London: Routledge.

Cooke, P., Asheim, B., Boschma, R., Martin, R., Schwartz, D., and Tödtling, F. (2011) 'Introduction', in Cooke, P., Asheim, B., Boschma, R., Martin, R., Schwartz, D., and Tödtling, F. (eds) *The Handbook of Regional Innovation & Growth*. Cheltenham: Edward Elgar.

Cooke, P., Boekholt, P., Schall, N., and Schienstock, G. (1996) 'Regional innovation systems: concepts, analysis and typology', *EU-RESTPOR Conference on Global Comparison of Regional RTD and Innovation Strategies for Development and Cohesion,* Brussels, pp. 19-21.

Cooke, P., and De Laurentis, C. (2010) 'Evolutionary economic geography: regional systems of innovation and high-tech clusters', in Boschma, R., and Martin, R. (eds) *The Handbook of Evolutionary Economic Geography*. Cheltenham: Edward Elgar Publishing, pp. 239-257.

Cooke, P., Uranga, M. G., and Etxebarria, G. (1997) 'Regional innovation systems: Institutional and organisational dimensions', *Research Policy*, Vol. 26, No. 4-5, pp. 475-491.

Cooper, D.R., and Schindler, P.S. (1998) Business research methods, 6th ed., London: Irwin McGraw-Hill.

Collis, J., and Hussey, R. (2003) *Business research: a practical guide for undergraduate and postgraduate students*, 2nd Edn., Hampshire: Palgrave McMillan.

Cowan, R., David, P. A., and Foray, D. (2000) 'The explicit economics of knowledge codification and tacitness', *Industrial and Corporate Change*, Vol. 9, No. 2, pp. 211-253.

Cozzi, G., and Galli, S. (2014) 'Sequential R&D and blocking patents in the dynamics of growth', *Journal of Economic Growth*, Vol. 19, No. 2, pp. 183-219.

Creswell. J.W. (2013) *Qualitative Inquiry and Research Design: Choosing among Five Approaches*, 3rd Edn., London: Sage.

Cuadrado-Roura and Maroto (2016) 'Unbalanced regional resilience to the economic crisis in Spain: a tale of specialisation and productivity', *Cambridge Journal of Regions, Economy and Society*, Vol. 9, No. 1, pp. 153-178.

Danermark, B., Ekstrom, M., and Jakobsen, L. (2005) *Explaining society: Critical realism in the social sciences*. London: Routledge.

Delgado-Márquez, B. L., Hurtado-Torres, N. E., Pedauga, L. E., and Cordón-Pozo, E. (2018) 'A network view of innovation performance for multinational corporation subsidiaries', *Regional Studies*, Vol. 52, No. 1, pp. 47-67.

Derudder, B. and Taylor, P. J. (2018) 'Central flow theory: comparative connectivities in the world-city network', *Regional Studies*, Vol. 52, No. 8, pp. 1029-1040.

Dierkes, M., Antal, A. B., Child, J., and Nonaka, I. (Eds.) (2003) *Handbook of organizational learning and knowledge*. Oxford: Oxford University Press.

Dierkes, M. (2001) 'Visions, Technology, and Organizational Knowledge', in De la Mothe, J., and Foray, D. (eds) *Knowledge management in the innovation process*. Boston: Springer, pp. 9-42.

Doloreux, D. (2003) 'Regional innovation systems in the periphery: the case of the Beauce in Québec (Canada)', *International Journal of Innovation Management, 7*(01), pp. 67-94.

Doloreux, D., and Parto, S. (2005) 'Regional innovation systems: Current discourse and unresolved issues', *Technology in society*, Vol. 27, No. 2, pp. 133-153.

Donmoyer, R. (2008) 'Generalizability', in Given, L.M. (ed) *Sage Encyclopedia of Qualitative Research Methods*. Thousand Oaks: Sage publications, pp. 714-719.

Döring, T., and Schnellenbach, J. (2006) ‘What do we know about geographical knowledge spillovers and regional growth?: A survey of the literature’, *Regional Studies*, *40*(03), pp. 375-395.

Dosi, G. and Nelson, R.R. (1994) ‘An introduction to evolutionary theories in economics’, *Journal of Evolutionary Economics*, Vol. 4, pp. 153-172.

Dosi, G. (1982) ‘Technological paradigms and technological trajectories: a suggested interpretation of the determinants and directions of technical change’, *Research Policy*, Vol. 11, No. 3, pp. 147-162.

Dosi, G. (1988) ‘Sources, procedures, and microeconomic effects of innovation’, *Journal of Economic Literature*, Vol. 26, pp. 1120-1171.

Drucker, P. F. (1988) *The Frontiers of Management: Where Tomorrow's Decisions are being Shaped Today*. New York: Truman Talley Books.

Dunning, J. H. (2002) *Regions, globalization, and the knowledge-based economy*. Oxford: Oxford University Press.

Easterby-Smith, M., Thorpe, R., and Lowe, A. (1991) *Management research: an introduction*. London: Sage.

Ebben, J.J.. Johnson, A.C. (2005) ‘Efficiency, flexibility, or both? Evidence linking strategy to performance in small firms’, *Strategic Management Journal*, Vol. 26, No. 13, pp. 1249-1259.

European Central Bank (2017) *Five things you need to know about the Maastricht Treaty*, Available at: <URL> https://www.ecb.europa.eu/explainers/tell-me-more/html/25_years_maastricht.en.html (Accessed: 13 July 2018).

European Commission – EC (2007) *FP7 in brief: how to get involved in the EU 7th Framework Programme for Research*. Brussels: Publications Office. Available at: <URL> https://ec.europa.eu/research/fp7/pdf/fp7-inbrief_en.pdf (Accessed: 22 Jan 2016).

European Commission (2010) *Europe 2020: a strategy for smart, sustainable and inclusive growth*. Brussels, 3.3.2010. Brussels: Publications Office. Available at: <URL> http://ec.europa.eu/eu2020/pdf/COMPLET%20EN%20BARROSO%20%20%20007%20-%20Europe%202020%20-%20EN%20version.pdf (Accessed: 25 Dec 2015).

European Commission - EC (2015) *Europe 2020 targets: statistics and indicators at EU level*. Available at: <URL> https://ec.europa.eu/info/business-economy-euro/economic-and-fiscal-policy-coordination/eu-economic-governance-monitoring-prevention-correction/european-semester/framework/drafteurope-2020-strategy/europe-2020-targets-statistics-and-indicators-eu-level_en (Accessed: 20 July 2018).

European Commission (2015) *Regions in the European Union: nomenclature of territorial units for statistics NUTS 2013/EU-28.* Brussels: Publications Office.

European Union – EU (2017) *The history of the European Union*. Available at: <URL> https://europa.eu/european-union/about-eu/history_en#1945_-_1959 (Accessed 12 July 2018).

European Union (2017) *The European Union: what it is and what it does*, Brussels: Publications Office.

Edquist, C. (2010) 'Systems of innovation perspectives and challenges', *African Journal of Science, Technology, Innovation and Development*, Vol. 2, No. 3, pp. 14-45.

Edquist, C., and Chaminade, C. (2006) 'Industrial policy from a systems-of-innovation perspective', *European Investment Bank Papers (AIB)*, Vol. 11, No. 1-2, pp. 108-132.

Edquist, C., and Johnson, B. (1997) *Systems of Innovation: Technologies, Institutions and Organizations*. London and Washington: Pinter/Cassel Academic.

Elvekrok, I., Veflen, N., Nilsen, E.R., and Gausdal, A.H. (2018) 'Firm innovation benefits from regional triple-helix networks', *Regional Studies*, Vol. 52, No. 9, pp. 1214-1224.

Fagerberg, J. (2003) 'Schumpeter and the revival of evolutionary economics: an appraisal of the literature', *Journal of evolutionary economics*, Vol. 13, No. 2, pp. 125-159.

Fagerberg, J. (2007) 'Innovation: a guide to the literature', in Fagerberg, J., Mowery, D.C., and Nelson, R.R. (eds) *The Oxford handbook of innovation*. Oxford: Oxford University Press, pp. 1-26.

Fagerberg, J., and Verspagen, B. (2009) 'Innovation studies: The emerging structure of a new scientific field', *Research policy*, Vol. 38, No. 2, pp. 218-233.

Faggian. A. and McCann, P. (2009) 'Human Capital and Regional Development', in Capello, R., and Nijkamp P. (eds) *Handbook of Regional Growth and Development Theories*. Cheltenham: Edward Elgar Publishing, pp. 133-151.

Fallah, M.H., and Ibrahim, S. (2004) 'Knowledge spillover and innovation in technological clusters', *Proceedings of International Conference on Management of Technology (IAMOT) 2004 Conference,* pp. 1-16, Washington, DC.

Farhauer, O., and Kröll, A. (2012) 'Diversified specialisation - going one step beyond regional economics' specialisation-diversification concept, *Jahrbuch für Regionalwissenschaft,* Vol. 32, No. 1, pp. 63-84.

Feldman, M.P. (1995) *The Geography of Innovation*. Boston: Kluwer Academic Publishers.

Feldman, M.P. (1994) 'Knowledge complementarity and innovation', *Small business economics,* Vol. 6, No. 5, pp. 363-372.

Feldman, M.P. (2000) 'Location and innovation: the new economic geography of innovation, spillovers, and agglomeration', in Clark, G.L., Feldman, M.P., and Gertler, M.S. (eds) *The Oxford Handbook of Economic Geography*. Oxford: Oxford University Press, pp. 373-394.

Feldman, M. P., and Audretsch, D. B. (1999) 'Innovation in cities: science-based diversity, specialization and localized competition', *European Economic Review,* Vol. 43, No. 2, pp. 409-429.

Filippetti, A., and Archibugi, D. (2011) 'Innovation in times of crisis: national systems of innovation, structure, and demand', *Research Policy,* Vol. 40, No. 2, pp. 179-192.

Fischer, M.M. (1999) 'The innovation process and network activities of manufacturing firms', in Fischer, M.M., Suarez-Villa, L., Steiner, M. (eds) *Innovation, Networks and Localities*. Berlin: Springer, pp. 11-27.

Fischer, M. M., and Fröhlich, J. (2013) *Knowledge, Complexity and Innovation Systems*. Berlin: Springer-Verlag.

Fischer, M. M., and Nijkamp, P. (2009) 'Entrepreneurship and regional development', in Capello, R., and Nijkamp, P. (eds) *Handbook of Regional Growth and Development Theories*. Cheltenham: Edward Elgar Publishing.

Fitjar, R. D., and Rodríguez-Pose, A. (2016) *Purpose-built versus serendipitous innovation links: New survey evidence*. Available at: https://voxeu.org/article/marshall-was-wrong-nothing-air (Accessed: 23 October 2018).

Fitjar, R. D., and Rodríguez-Pose, A. (2017) 'Nothing is in the air', *Growth and Change*, Vol. 48, No. 1, pp. 22-39.

Fleetwood, S., and Ackroyd, S. (2004) *Critical realist applications in organisation and management studies*. Psychology Press.

Florida, R. (2002) 'The economic geography of talent', *Annals of the Association of American Geographers*, Vol. 92, No. 4, pp. 743-755.

Fons-Rosen, C., Kalemli-Ozcan, S., Sorensen, B. E., Villegas-Sanchez, C., and Volosovych, V. (2017) 'Foreign Investment and Domestic Productivity: Identifying knowledge spillovers and competition effects'. *Tinbergen Institute Discussion Paper*, No. 17-078/IV.

Forsman, H., and Temel, S. (2016) 'From a non-innovator to a high-innovation performer: networking as a driver', *Regional Studies*, Vol. 50, No. 7, pp. 1140-1153.

Freeman, C. (1995) 'The National System of Innovation in historical perspective', *Cambridge Journal of Economics*, Vol. 19, No. 1, pp. 5-24.

Freeman, C. (2007) 'A Schumpeterian renaissance?' *Science and Technology Policy Research*, Paper 102, pp. 130-41.

Freeman, C., and Soete, L. (2009) 'Developing science, technology and innovation indicators: what we can learn from the past', *Research Policy*, Vol. 38, No. 4, pp. 583-589.

Fritsch, M., and Franke, G. (2004) 'Innovation, regional knowledge spillovers and R&D cooperation, *Research Policy'*, Vol. 33, No. 2, pp. 245-255.

Gabel, M.J. (2014) *European Community*, Britannica. Available at: <URL> https://www.britannica.com/topic/European-Community-European-economic-association (Accessed: 11 July 2018).

Gilbert, M., and Cordey-Hayes, M. (1996) 'Understanding the process of knowledge transfer to achieve successful technological innovation', *Technovation*, Vol. 16, No. 6, pp. 301-312.

Gill, J., and Johnson, P. (2002) *Research Methods for Managers*. London: Sage Publishing, 3rd ed.

Given, L. M. (Ed.). (2008) *The Sage encyclopedia of qualitative research methods*. Thousand Oaks: Sage Publications.

Glaeser, E.L., Kallal, H.D., Scheinkman, J.A., and Shleifer, A. (1992) 'Growth in cities', *Journal of Political Economy*, Vol. 100, No. 6, pp. 1126-1152.

Goddard, J., and Kempton, L. (2011) *Connecting universities to regional growth: a practical guide*. Brussels: European Union Regional Policy (DG EAC, EC). Available at: <URL> https://ec.europa.eu/regional_policy/sources/docgener/presenta/universities2011/universities2011_en.pdf (Accessed: 15 Nov 2017).

Gogodze, J. (2016) 'Mechanisms and functions within a national innovation system', *Journal of Technology Management & Innovation*, Vol. 11, No. 4, pp. 12-21.

Görg, H., and Greenaway, D. (2004) 'Much ado about nothing? Do domestic firms really benefit from foreign direct investment?', *The World Bank Research Observer*, Vol. 19, No. 2, pp. 171-197.

Görg, H., and Strobl, E. (2005) 'Spillovers from foreign firms through worker mobility: An empirical investigation', *The Scandinavian Journal of Economics*, Vol. 107, No. 4, pp. 693-709.

Gorski, P. (2013) 'What is critical realism? And why should you care?', *Contemporary Sociology*, Vol. 42, No. 5, pp. 658-670.

Guba, E.G., and Lincoln, Y.S. (1989) 'Ethics: the failure of positivist science', *The Review of Higher Education*, Vol. 12, No. 3, pp. 221-240.

Gray, D. E. (2019) *Doing research in the real world*. Thousand Oaks: Sage Publications.

Griliches, Z. (1979) 'Issues in assessing the contribution of research and developments to productivity growth', *Bell Journal of Economics*, Vol. 10, No. 1, pp. 92-116.

Griliches, Z. (1990) 'Patent statistics as economic indicators: a survey', *Journal of Economic Literature*, Vol. 28, No 4, pp. 1661-1707.

Grillitsch, M., Schubert, T., and Srholec, M. (2019) ‘Knowledge base combinations and firm growth’, *Research Policy*, Vol. 48, No. 1, pp. 234-247.

Grizendi, E. (2011) *Manual de orientações gerais sobre inovação*. Brasilia: Ministério das Relações Exteriores.

Grossman, G., and Helpman, E. (2015) ‘Globalizations and growth’, American Economic Review: papers & Proceedings 2015, Vol. 105, No. 5, pp. 100-104.

Grossman, G., and Helpman, E. (1991) ‘Quality ladders in the theory of growth’, *The Review of Economic Studies*, Vol. 58, No. 1, pp. 43-61.

Hair, J.F., Anderson, R.E., Tatham, R.L., Black, W.C. (1998) *Multivariate Data Analysis*. New Jersey: Prentice Hall.

Hakánsson, H. and Snehota, I. (1995) *Developing relationships in business networks*. London: Routledge.

Halpern, L., and Muraközy, B. (2007) ‘Does distance matter in spillover?’ *Economics of Transition*, Vol. 15, No. 4, pp. 781-805.

Harabi, N. (1997) ‘Channels of R&D spillovers: an empirical investigation of Swiss firms’, *Technovation*, Vol. 17, No. 11-12, pp. 627-635.

Harrison, J., and Turok, I. (2017) ‘Universities, knowledge and regional development’, *Regional Studies*, Vol. 51, No. 7, pp. 977-981.

Haussen, T., and Uebelmesser, S. (2018) ‘Job changes and interregional migration of graduates’, *Regional Studies*, Vol. 52, No. 10, pp. 1346-1359.

Helpman, E. (1992) ‘Endogenous macroeconomic growth theory’, *European Economic Review*, Vol. 36, No. 2, pp. 237-267.

Helpman, E. (1998) *General purpose technologies and economic growth*. Cambridge: MIT press.

Hervás-Oliver, J. L., Albors-Garrigos, J., Estelles-Miguel, S., and Boronat-Moll, C. (2018) ‘Radical innovation in Marshallian industrial districts’, *Regional Studies*, Vol. 52, No. 10, pp. 338-349.

Hodgson, G. M. (1993) *Economics and evolution: bringing life back into economics*. Cambridge: University of Michigan Press.

Hollanders, H., Es-Sadki, N., Buligescu, B., Leon, L.R., Griniece, E. and Roman, L. (2014) *Regional Innovation Scoreboard 2017*. Brussels: Publication office.

Hollanders, H., Es-Sadki, N., and Kanerva, M. (2016) *European Innovation Scoreboard 2016: Methodology report.* Brussels: Publications Office.

Hollanders, H. and Es-Sadki, N. (2017) *Regional Innovation Scoreboard 2017*. Brussels: Publication office.

Hoshmand, L.T. (2003) 'Can lessons of history and logical analysis ensure progress in psychological science?', *Theory & Psychology*, Vol. 13, No. 1, pp. 39-44.

Howells, J. (1999) 'Regional systems of innovation?', in Archibugi, D., Howells, J., Michie, J. (eds) *Innovation Systems in a global economy*. Cambridge: Cambridge University Press, pp. 67-93.

Howells, J. R. (2002) 'Tacit knowledge, innovation and economic geography', *Urban Studies*, Vol. 39, No. 5-6, pp. 871-884.

Huber, G. P. (1991) 'Organizational learning: the contributing processes and the literatures', *Organization Science*, Vol. 2, No. 1, pp. 88-115.

Iammarino, S., and McCann, P. (2010) 'The relationship between multinational firms and innovative clusters', in Boschma, R., and Martin, R. (eds) *The Handbook of Evolutionary Economic Geography*. Cheltenham: Edward Elgar Publishing, pp. 182-204.

Iammarino, S., Piva, M., Vivarelli, M., and Von Tunzelmann, N. (2012) 'Technological capabilities and patterns of innovative cooperation of firms in the UK regions', *Regional Studies*, Vol. 46, No. 10, pp. 1283-1301.

Ibrahim, S. E., Fallah, M. H., and Reilly, R. R. (2008) 'Localized sources of knowledge and the effect of knowledge spillovers: an empirical study of inventors in the telecommunications industry', *Journal of Economic Geography*, Vol. 9, No. 3, pp. 405-431.

Illowsky, B., Dean, S. (2016) *Introductory Statistics*. Los Angeles: OpenStax.

Instituto Brasileiro de Geografia e Estatística - IBGE (2015) *Estatísticas de empreendedorismo 2014*. Rio de Janeiro: Instituto Brasileiro de Geografia e Estatística.

Instituto Brasileiro de Geografia e Estatística - IBGE (2016) *Pesquisa de inovação 2014*. Rio de Janeiro: Instituto Brasileiro de Geografia e Estatística.

Isaksen, A. (2001) 'Building regional innovation systems: is endogenous industrial development possible in the global economy?' *Canadian Journal of Regional Science*, Vol. 24, No. 1, pp. 101-120.

Jacobs, J. (1969) *The economy of cities.* New York: Random House.

Jaffe, A. B., Trajtenberg, M., and Henderson, R. (1993) 'Geographic localization of knowledge spillovers as evidenced by patent citations', *The Quarterly Journal of Economics*, Vol. 108, No. 3, pp. 577-598.

Jenkins, G.D., and Taber, T.D. (1977) 'A Monte Carlo study of factors affecting three indices of composite scale reliability', *Journal of Applied Psychology*, Vol. 62, No. 4, pp. 392.

Johnson, B., and Christensen, L. (2008) *Educational research: Quantitative, qualitative, and mixed approaches*. London: Sage Publications.

Johnson, R.B., and Onwuegbuzie, A.J. (2004) 'Mixed methods research: a research paradigm whose time has come,, *Educational researcher*, Vol. 33, No. 7, pp. 14-26.

Jung, S., and Kwak, G. (2018) 'Firm Characteristics, Uncertainty and Research and Development (R&D) Investment: The Role of Size and Innovation Capacity', *Sustainability*, Vol. 10, No. 5, 1668.

Kamyab, S. H. (2014) 'The Entrepreneurship, Knowledge Spillover and Economic Growth. International', *Journal of Sustainable Development & World Policy*, No. 2, pp. 45-54.

Kant, I. (1795) *Perpetual peace: a philosophical essay*. London: S. Sonnenschein.

Kelly, M., and Hageman, A. (1999) 'Marshallian externalities in innovation', *Journal of Economic Growth*, Vol. 4, No. 1, pp. 39-54.

Ko, W. W., and Liu, G. (2015) 'Understanding the process of knowledge spillovers: learning to become social enterprises', *Strategic Entrepreneurship Journal*, Vol. 9, No. 3, pp. 263-285.

Kothari, C.R. (2004) *Research methodology: Methods and techniques*. New Delhi: New Age International.

Krugman, P. R. (1991) *Geography and Trade*. Cambridge: MIT press.

Krugman, P., Wells, R., and Graddy, K. (2008) *Economics, European Edition*. New York: Worth Publishers.

Kuhn, T.S. (1970) *The structure of scientific revolutions*. Chicago: University of Chicago press.

Kumar, R. (2011) *Research methodology: a step-by-step guide for beginners*, 3rd Edn., Sage: New Delhi.

Lambooy, J. G. (2002) 'Knowledge and urban economic development: an evolutionary perspective', *Urban Studies*, Vol. 39, No. 5-6, pp. 1019-1035.

Lazonick, W. (2007) 'The innovative firm', in Nelson, R.R., Mowery, D.C., and Fagerberg, J. *The Oxford handbook of innovation*. Oxford: Oxford University Press, pp. 29-55.

Lehmann, E. E., and Seitz, N. (2016) 'Freedom and innovation: a country and state level analysis', *The Journal of Technology Transfer*, Vol. 42, No. 5, pp. 1009-1029.

Leplat, J. (1990) 'Skills and tacit skills: a psychological perspective', *Applied Psychology*, Vol. 39, No. 2, pp. 143-154.

Levin, R. C., Klevorick, A. K., Nelson, R. R., Winter, S. G., Gilbert, R., and Griliches, Z. (1987) 'Appropriating the returns from industrial research and development', *Brookings Papers on Economic Activity*, Vol. 1987, No. 3, pp. 783-831.

Leyden, D. P., and Link, A. N. (2013) 'Knowledge spillovers, collective entrepreneurship, and economic growth: the role of universities', *Small Business Economics*, Vol. 41, No. 4, pp. 797-817.

Li, X. (2016) Exploring the spatial heterogeneity of entrepreneurship in Chinese manufacturing industries. *The Journal of Technology Transfer*, Vol. 42, No. 5, pp. 1077-1099.

Lundberg, J. (2017) 'Does academic research affect local growth? Empirical evidence based on Swedish data', *Regional Studies*, Vol. 51, No. 4, pp. 586-601.

Lundquist, K. J., and Trippl, M. (2013) 'Distance, proximity and types of cross-border innovation systems: A conceptual analysis', *Regional Studies*, Vol. 47, No. 3, pp. 450-460.

Lundvall, B. Å. (1985) *Product innovation and user-producer interaction*. Industrial Development Research Series, Vol. 31. Aalborg: Aalborg University Press.

Lundvall, B. Å. (1992) 'User-producer relationships, national systems of innovation and internationalisation', in Lundvall, B.A (1992) *National systems of innovation: towards a theory of innovation and interactive learning*. London: Anthem Press, pp. 45-67.

Lundvall, B. Å. (2006) 'Interactive learning, social capital and economic performance', In Kahin, B., and Foray, D. (eds) *Advancing Knowledge and the Knowledge Economy*. Cambridge: MIT Press.

Lundvall, B. Å. (2007) 'National innovation systems: analytical concept and development tool', *Industry and innovation*, Vol. 14, No. 1, pp. 95-119.

Lundvall, B. A., Dosi, G., and Freeman, C. (1988) 'Innovation as an interactive process: from user-producer interaction to the national system of innovation', in Dosi, G., Freeman, C., Nelson, R., Silverberg, G., Soete, L. (eds) *Technical Change and Economic Theory*. London: Pinter, pp. 349-369.

Lundvall, B. Å., and Johnson, B. (1994) 'The learning economy', in Lundvall, B. Å. (ed), *The Learning Economy and the Economics of Hope*. London: Anthem Press, pp. 107-129.

Mackenzie, N., and Knipe, S. (2006) 'Research dilemmas: Paradigms, methods and methodology', *Issues in Educational Research*, Vol. 16, No. 2, pp. 193-205.

Mahmood, I. P., and Rufin, C. (2005) 'Government's dilemma: The role of government in imitation and innovation', *Academy of Management Review*, Vol. 30, No. 2, pp. 338-360.

Malerba, F. (2002) 'Sectoral systems of innovation and production', *Research Policy*, Vol. 31, No. 2, pp. 247-264.

Manzella, G. P., Mendez, C. (2009) *The turning points of EU cohesion policy*. Available at: <URL> http://ec.europa.eu/regional_policy/archive/policy/future/pdf/8_manzella_finalformatted.pdf. (Accessed: 14 May 2016).

Marek, P., Titze, M., Fuhrmeister, C., and Blum, U. (2017) 'R&D collaborations and the role of proximity', *Regional Studies*, Vol. 51, No. 12, pp. 1761-1773.

Markides, C. (2006) 'Disruptive innovation: in need of better theory', *Journal of product innovation management*, Vol. 23, No. 1, pp. 19-25.

Marshall, A. (1890) *Principles of economics*. New York: Maxmillan.

Marshall, M.N. (1996) 'Sampling for qualitative research', *Family Practice*, Vol. 13, No. 6, pp. 522-526.

Marton-Williams, J. (1986) 'Questionnaire design', In Worcester, R., and Downham, J. (eds.) *Consumer market research handbook*. London: McGraw Hill, pp. 111-146.

Maxcy, S. J. (2003) 'Pragmatic threads in mixed methods research in the social sciences: the search for multiple modes of inquiry and the end of the philosophy of formalism', in Johnson, B., Turner, L.A. *Handbook of mixed methods in social and behavioral research*. Thousand Oaks: Sage Publications, pp. 51-89.

Maxwell, S. E., and Delaney, H. D. (2004) *Designing experiments and analyzing data: a model comparison perspective*. London: Routledge.

Mazzarol, T. (2003) 'A model of small business HR growth management', *International Journal of Entrepreneurial Behavior & Research*, Vol. 9, No. 1, pp. 27-49.

McCann, P., and Mudambi, R. (2005) 'Analytical differences in the economics of geography: the case of the multinational firm', *Environment and Planning*, Vol. 37, No. 10, pp. 1857-1876.

McCann, P., and Ortega-Argilés, R. (2016) Regional innovation, R&D and knowledge spillovers: the role played by geographical and non-geographical factors, in Shearmu, R., Carrincazeaux, C., and Doloreaux, D. (eds.) *Handbook on the Geographies of Innovation*, pp. 22-44.

Miguélez, E., and Moreno, R. (2013) 'Research networks and inventors' mobility as drivers of innovation: evidence from Europe', *Regional Studies*, Vol. 47, No. 10, pp. 1668-1685.

Miles, M., and Huberman, M. (1994) *Qualitative data analysis: an expanded sourcebook*. London: Sage Publications.

Montoro-Sánchez, A., Ortiz-de-Urbina-Criado, M., and Mora-Valentín, E. M. (2011) 'Effects of knowledge spillovers on innovation and collaboration in science and technology parks', *Journal of Knowledge Management*, Vol. 15, No. 6, pp. 948-970.

Morgan, D. L. (2007) 'Paradigms lost and pragmatism regained: Methodological implications of combining qualitative and quantitative methods', *Journal of mixed methods research*, Vol. 1, No. 1, pp. 48-76.

Nauwelaers, C., and Wintjes, R. (2003) 'Towards a new paradigm for innovation policy?', in Asheim, B., Isaksen, A., Nauwelaers, C., Tödtling, F. (eds) *Regional Innovation Policy for Small-Medium Enterprises*. Cheltenham: Edward Elgar, pp. 193-220.

Nelson, R.R. (1993) *National innovation systems: a comparative analysis*. Oxford: Oxford University Press.

Nelson, R.R. (1995) 'Recent evolutionary theorising about economic change', *Journal of Economic Literature*, Vol. 33, pp. 48-90.

Nelson, R.R. and Winter, S. (2002) 'Evolutionary theorizing in economics', *Journal of Economic perspectives*, Vol. 16, No. 2, pp.23-46.

Nelson, R.R. and Winter, S. (1982) *An evolutionary theory of economic change*. Cambridge: Harvard University Press.

Niwa, S. (2016) 'Patent claims and economic growth', *Economic Modelling*, Vol. 54, pp. 377-381.

Nonaka, I., Byosiere, P., Borucki, C. C., and Konno, N. (1994) 'Organizational knowledge creation theory: a first comprehensive test', *International Business Review*, Vol. 3, No. 4, pp. 337-351.

Nonaka, I., and Takeuchi, H. (1995) *The Knowledge-creating company: how Japanese companies create the dynamics of innovation*. Oxford: Oxford University Press.

Oerlemans, L., and Meeus, M. (2005) 'Do organizational and spatial proximity impact on firm performance?', *Regional studies*, Vol. 39, No. 1, pp. 89-104.

Oinas, P. (2000) 'The firm in local politics: Power, dependence, and coalitions', *Conference of the European Association of Evolutionary Political Economy*, Berlin, Germany, pp. 2-4.

Őnday, Ő. (2016) 'National and regional innovation systems, industrial policies and their impact on firm innovation strategies and performance: economic role of knowledge', *International Journal of Contemporary Applied Sciences*, Vol. 3, No. 2, pp. 1-35.

Oort, F., and Raspe, O. (2007) *Urban Heterogeneity in Knowledge-related Economic Growth*. Cheltenham: Edward Elgar Publishing.

Organisation for Economic Co-operation and Development – OECD (1996) *The Knowledge-based economy*. Paris: OECD Publishing.

Organisation for Economic Co-operation and Development – OECD (1997) *National Innovation Systems*. Paris: OECD Publishing.

Organisation for Economic Co-operation and Development – OECD (1997) *Oslo Manual: proposed guidelines for collecting and interpreting technological innovation data*, 2nd edition, Paris: OECD publishing.

Organisation for Economic Co-operation and Development – OECD (2002) *Frascati Manual: proposed standard practice for surveys on research and experimental development*. Paris: OECD Publishing.

Organisation for Economic Co-operation and Development – OECD (2005) *Oslo Manual: guidelines for collecting and interpreting innovation data*, 3rd Edn., Paris: OECD Publishing.

Organisation for Economic Co-operation and Development – OECD (2018) *Oslo Manual: guidelines for collecting and interpreting innovation data*, 4th Edn., Paris: OECD Publishing.

Organisation for Economic Co-operation and Development – OECD (2008) *OECD Benchmark Definition of Foreign Direct Investment*. Paris: OECD Publishing.

Organisation for Economic Co-operation and Development – OECD (2011) *Technology intensity definition: classification of manufacturing industries into categories based on R&D intensities – ISIC Rev. 3*. Available at: <URL> https://www.oecd.org/sti/inno/48350231.pdf (Accessed: 07 Feb 2017).

Organisation for Economic Co-operation and Development – OECD (2015) *Frascati manual 2015: Guidelines for collecting and reporting data on research and experimental development, the measurement of scientific, technological and innovation activities*. Paris: OECD Publishing.

Organisation for Economic Co-operation and Development – OECD (2016) 'Innovation matters and policy can do something about it', *STI in Focus*, Sept 2016. Available at: <URL> http://www.oecd.org/sti/Innovation-Matters.pdf (Accessed: 27 Mar 2018).

Organisation for Economic Co-operation and Development – OECD (2017) *OECD Science, Technology, and Industry Scoreboard 2017: the digital transformation*. Paris: OECD Publishing.

Organisation for Economic Co-operation and Development – OECD (2017) 'ICT and innovation', in *OECD Science, Technology, and Industry Scoreboard 2017: the digital transformation*. Paris: OECD Publishing.

Organisation for Economic Co-operation and Development – OECD (2018) *Members and partners*. Available at: <URL> http://www.oecd.org/about/membersandpartners/ (Accessed: 22 July 2018).

Ortiz, M. (2013) *Varieties of Innovation Systems: The Governance of Knowledge Transfer in Europe* (Vol. 3). Frankfurt: Campus Verlag.

Ouwersloot, H., and Rietveld, P. (2000) 'The Geography of R&D: Tobit analysis and a Bayesian approach to mapping R&D activities in the Netherlands', *Environment and Planning*, Vol. 32, No. 9, pp. 1673-1688.

Paci, R., and Usai, S. (2009) 'Knowledge flows across European regions', *The Annals of Regional Science*, No. 43, No. 3, pp. 669-690.

Park, S.O. (2001) 'Regional innovation strategies in the knowledge-based economy', *GeoJournal*, Vol. 53, No. 1, pp. 29-38.

Patel, P., and Pavitt, K. (1994) 'National innovation systems: why they are important, and how they might be measured and compared', *Economics of Innovation and New Technology*, Vol. 3, No. 1, pp. 77-95.

Patel, P., and Pavitt, K. (1997) 'The technological competencies of the world's largest firms: complex and path-dependent, but not much variety', *Research Policy*, Vol. 26, No. 2, pp. 141-156.

Pavitt, K. (1984) 'Sectoral patterns of technical change: towards a taxonomy and a theory', *Research Policy*, Vol. 13, No. 6, pp. 343-373.

Pavitt, K. (2007) 'Innovation processes', in Nelson, R.R., Mowery, D.C., and Fagerberg, J. *The Oxford Handbook of Innovation*. Oxford: Oxford University Press, pp. 86-114.

Pickernell, D., Senyard, J. M., Clifton, N., Kay, A., and Keast, R. L. (2007) 'Developing a framework for knowledge creation, dissemination and utilisation for SMEs: a case study of biotechnology', *RENT-Research in Enterprise and Small Business*, Cardiff, Wales,

Pratt, J. W. and Zeckhauser, R. J. (1985) *Principals and Agents: the Structure of Business*. Boston: Harvard Business School Press.

Polanyi, M. (1962) *Personal Knowledge: Towards a Post-Critical Philosophy*. Chicago: University of Chicago Press.

Polanyi, M. (1966) *The Tacit Dimension*. London: Routledge & Kegan Paul.

Popper, K.R. (1959) 'The propensity interpretation of probability', *The British journal for the philosophy of science*, Vol. 10, No. 37, pp. 25-42.

Porter, M.E. (1990) *The Competitive Advantage of Nations*. New York: Free Press.

Qian, H., and Acs, Z. J. (2013) 'An absorptive capacity theory of knowledge spillover entrepreneurship', *Small Business Economics*, No. 2, p.185-197.

Qiu, S., Liu, X., and Gao (2017) 'Do emerging countries prefer local knowledge or distant knowledge? Spillover effect of university collaborations on local firms', *Research Policy*, Vol. 46, No. 7, pp. 1299-1311.

Ramaciotti, L., Muscio, A., and Rizzo, U. (2017) 'The impact of hard and soft policy measures on new technology-based firms', *Regional Studies*, Vol. 51, No. 4, pp. 629-642.

Rammer, C., Czarnitzki, D., and Spielkamp, A. (2009) 'Innovation success of non-R&D-performers: substituting technology by management in SMEs', *Small Business Economics*, Vol. 33, No. 1, pp. 35-58.

Rank, L., Emediato, G. and Osorio, H.H.G. (2008) *Guia de Inovação*. Brasília: FINEP/MCT.

Ray, M. (2009) *Lisbon Treaty*. Britannica. Available at: <URL> https://www.britannica.com/event/Lisbon-Treaty (Accessed: 16 July 2018).

Reichardt, C. S., and Rallis, S. F. (1997) *The Qualitative-Quantitative Debate: new perspectives*, No. 61. San Francisco: Jossey-Bass.

Romer, P.M. (1989) 'Human capital and growth: theory and evidence', *National Bureau of Economic Research Working Paper Series*, No. 3173, pp. 251-286.

Romer, P. M. (1990) 'Endogenous technological change', *Journal of Political Economy*, Vol. 98, No. 5, pp. 71-102.

Roording, N., and de Vaal, A. (2010) 'Does horizontal FDI lead to more knowledge spillovers than vertical FDI', *NiCE Working Paper*, pp. 10-101.

Ruttan, V.W. (1997) 'Induced innovation, evolutionary theory and path dependence: sources of technical change', *The Economic Journal*, Vol. 107, No. 444, pp. 1520-1529.

Salunke, S., Weerawardena, J., and McColl-Kennedy, J. R. (2019) 'The central role of knowledge integration capability in service innovation-based competitive strategy', *Industrial Marketing Management*, Vol. 76, pp. 144-156.

Samuelson, P. and Nordhaus, W. (1998) *Economics*. Boston: McGraw-Hill.

Santarelli, E., and Tran, H.T. (2016) 'Young innovative companies: are they high performers in transition economies? Evidence for Vietnam', *The Journal of Technology Transfer*, pp. 1-25.

Sarkar, J. (1998) 'Technological diffusion: alternative theories and historical evidence', *Journal of Economic Surveys*, Vol. 12, No. 2, pp. 131-176.

Saunders, M., Lewis, P., and Thornhill, A. (2009) *Research methods for business students*. Harlow: Pearson education.

Saviotti, P.P., and Metcalfe, J.S. (eds) (2018) Evolutionary theories of economic and technological change, 3rd Edn., New York: Routledge.

Sawhney, M., Wolcott, R.C., and Arroniz, I. (2006) 'The 12 different ways for companies to innovate', *MIT Sloan Management Review*, Vol. 47, No. 3, pp. 75-81.

Schwandt, T. A. (2000) 'Three epistemological stances for qualitative inquiry: Interpretivism, hermeneutics, and social constructionism', in Denzin, N.K., and Lincoln, Y.S. *The Handbook of qualitative research*, 2nd Edn., London: Sage Publications, pp. 189-213.

Schumpeter, J.A. (1934) *The Theory of Economic Development: an Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle.* 1912, Reprint. Cambridge: Harvard University Press.

Schumpeter, J.A. (1939) *Business Cycles* (Vol. 1), New York: McGraw-Hill.

Shefer, D., and Frenkel, A. (1998) 'Local milieu and innovations: some empirical results', *The Annals of Regional Science*, Vol. 32, No. 1, pp. 185-200.

Shimaa, E., Ingham, H., and Read, R. (2018) 'Heterogeneous Sectoral Growth Effects of FDI in Egypt', *Lancaster University Working Paper*, Department of Economics, Lancaster.

Shujahat, M., Sousa, M. J., Hussain, S., Nawaz, F., Wang, M., and Umer, M. (2019) 'Translating the impact of knowledge management processes into knowledge-based innovation: The neglected and mediating role of knowledge-worker productivity', *Journal of Business Research*, Vol. 94, pp. 442-450.

Silverberg, G. (2002) 'The discrete charm of the bourgeoisie: quantum and continuous perspectives on innovation and growth', *Research Policy*, Vol. 31, No. 8, pp. 1275-1289.

Singh, Y.K. (2006) *Fundamental of research methodology and statistics*. New Delhi: New Age International Publishers.

Sloman, J. (2006) *Economics*. London: Pearson Publishing.

Smallbone, D., North, D., and Vickers, I. (2003) 'The role and characteristics of SMEs in innovation', in Asheim, B.T., Isaksen, A., Nauwelaers, C., and Tödtling, F. (eds) *Regional*

innovation policy for small-medium enterprises. Cheltenham: Edward Elgar Publishing, pp. 3-20.

Smeets, R., and De Vaal, A. (2006) 'Knowledge spillovers and FDI ownership', *NiCE Working Paper* 06-104.

Smith, J. K. (1983) 'Quantitative versus qualitative research: an attempt to clarify the issue', *Educational Researcher*, Vol. 12, No. 3, pp. 6-13.

Smith, K. (2000) 'Innovation as a systemic phenomenon: rethinking the role of policy', *Enterprise and Innovation Management Studies*, Vol. 1, No. 1, pp. 73-102.

Smolny, W. (2000) *Endogenous Innovations and Knowledge Spillovers*. Heidelberg: Physica-Verlag.

Snehota, I., and Hakánsson, H. (1995) *Developing relationships in business networks*. London: Routledge.

Soete, L.; Verspagen, B. and Weel, T. (2010) 'Systems of innovation', in Hall, B.H., and Rosenberg, N. (eds) *Handbook of the Economics of Innovation* (Vol. 2). Amsterdam: Elsevier, pp. 1159-1180.

Solow, R. (1956) 'A contribution to the theory of economic growth', *The Quarterly Journal of Economics*, Vol. 70, No. 1, pp. 65-94.

Solow, R. (1957) 'Technical change and the aggregate production function', *The Review of Economics and Statistics*, Vol. 39, No. 3, pp. 312-320.

Storper, M. (1997) *The regional world: territorial development in a global economy*. New York: Guilford Press.

Storper, M., and Venables, A. J. (2004) 'Buzz: face-to-face contact and the urban economy', *Journal of Economic Geography*, Vol. 4, No. 4, pp. 351-370.

Straubhaar, T. (2000) 'International mobility of the highly skilled: brain gain, brain drain or brain exchange', *HWWA Discussion Paper*, 88.

Stuetzer, M., Audretsch, D. B., Obschonka, M., Gosling, S. D., Rentfrow, P. J., and Potter, J. (2018) 'Entrepreneurship culture, knowledge spillovers and the growth of regions', *Regional Studies*, Vol. 52, No. 5, pp. 608-618.

SUDENE (2016) *Nordeste em Números 2015*. Recife: SUDENE.

Suriñach, J., Moreno, R., and Vayá, E. (2007) *Knowledge Externalities, Innovation Clusters and Regional Development*. Cornwall: Edward Elgar publishing.

Szulanski, G. (1996) 'Exploring internal stickiness: impediments to the transfer of best practice within the firm', *Strategic Management Journal*, Vol. 17, No. S2, pp. 27-43.

Tappeiner, G., Hauser, C., and Walde, J. (2008) 'Regional knowledge spillovers: fact or artifact?' *Research Policy*, Vol. 37, No. 5, pp. 861-874.

Tashakkori, A., and Teddlie, C. (1998) *Mixed methodology: combining qualitative and quantitative approaches* (Vol. 46). Thousand Oaks: Sage Publications.

Taylor, P.C., and Medina, M.N.D. (2013) 'Educational research paradigms: from positivism to multiparadigmatic', *The Journal of Meaning-Centered Education*, Vol. 1, No. 2, pp. 1-13.

Teichert, N. (2012) *Innovation in general purpose technologies: how knowledge gains when it is shared*. Karlsruhe: KIT Scientific Publishing.

Tödtling, F., and Trippl, M. (2005) 'One size fits all? Towards a differentiated regional innovation policy approach', *Research Policy*, Vol. 34, No. 8, pp. 1203-1219.

Trajtenberg, M. (2009) 'Innovation policy for development: an overview', in Foray, D. (ed) *The New Economics of Technology Policy*. Cheltenham: Edward Elgar, pp. 367-395.

Uyarra (2007) 'Key dilemmas of regional innovation policies', *Innovation*, Vol. 20, No. 3, pp. 243-261.

Van der Panne, G. (2004) 'Agglomeration externalities: Marshall versus Jacobs'. *Journal of Evolutionary Economics*, Vol. 14, No. 5, pp. 593-604.

Van Oort, F. (2002) 'Innovation and agglomeration economies in the Netherlands', *Tijdschrift voor Economische en Sociale Geografie*, Vol. 93, No. 3, pp. 344-360.

Verreynne, M. L., Williams, A. M., Ritchie, B. W., Gronum, S., and Betts, K. S. (2019) 'Innovation diversity and uncertainty in small and medium sized tourism firms', *Tourism Management*, Vol. 72, pp. 257-269.

Verspagen, B., and De Loo, I. (1999) 'Technology spillovers between sectors', *Technological Forecasting and Social Change*, Vol. 60, No. 3, pp. 215-235.

Wang, C., Madsen, J. B., and Steiner, B. (2017) 'Industry diversity, competition and firm relatedness: the impact on employment before and after the 2008 global financial crisis', *Regional Studies*, Vol. 51, No. 12, pp. 1801-1814.

Wang, Y., Ning, L., Li, J., and Prevezer, M. (2016) 'Foreign direct investment spillovers and the geography of innovation in Chinese regions: the role of regional industrial specialization and diversity', *Regional Studies*, Vol. 50, No. 5, pp. 805-822.

Watanabe, C., Kishioka, M., and Nagamatsu, A. (2004) 'Effect and limit of the government role in spurring technology spillover: a case of R&D consortia by the Japanese government', *Technovation*, Vol. 24, No. 5, pp. 403-420.

Xu, S. and Sam, A.G. (2018) 'Firm concentration and innovation: an empirical study in China', *2018 Agricultural & Applied Economics Association Annual Meeting*, Washington, D.C.

Yang, H., Phelps, C., and Steensma, H. K. (2010) 'Learning from what others have learned from you: the effects of knowledge spillovers on originating firms', *Academy of Management Journal*, Vol. 53, No. 2, pp. 371-389.

Zins, C. (2007) 'Conceptual approaches for defining data, information, and knowledge', *Journal of the Association for Information Science and Technology*, Vol. 58, No. 4, pp. 479-493.

Appendices

Appendix A Survey questionnaire

Dear sir / madam,

My name is Sergio Botelho Junior, and I kindly ask you for your collaboration with my PhD research by answering the following questionnaire. I am studying business and regional development at Waterford Institute of Technology (WIT), Ireland. The objective of my research is to understand regional innovation systems and the knowledge acquisition process of companies.

It will take less than five minutes to complete the questionnaire.

Your responses will be treated in the strictest of confidence. Especially your name, company name and contact details. You completing this survey will be a great contribution to my research.

Thank you for your collaboration.

Sergio.

1.Contact information

Respondent's name: _____

Company: _____

2. Position in company - mark with X:

Owner	
Director	
Manager	
Researcher	
Consultant	
Other (please specify)	

3. City / town: _____

Chemicals		Beverages	
Pharmaceuticals		Machinery	
Computers		Agriculture	
Software		Minerals	
Internet		Renewable energy	
Telecommunications		Fishery	
Plastic		Steel	
Food industry		Automotive	
If other, please specify:			

5. How important are these different aspects to your business? (Mark all items with X in the appropriate space)

	Not important	Slightly important	Moderately important	Important	Very important
Acquisition of knowledge through interacting with people from firms in the same industry sector as yours					
Acquisition of knowledge through interacting with people from firms in a different industry sector to yours					
Acquisition of knowledge as a result of networking					
Acquisition of knowledge through interacting with people from firms located in your firm's city/town or its vicinity					
Acquisition of knowledge through benefiting from R&D activities of other firms in your firm's city/town or its vicinity					
Acquisition of knowledge due to research undertaken in a university located in your firm's city/town or its vicinity					
Hiring students or graduates from a university located in your firm's city/town or its vicinity					
Hiring skilled employees with experience at firms located in your firm's city/town or its vicinity					
Acquiring knowledge due to the presence of a multinational company located in your firm's city/town or its vicinity					
Acquisition of knowledge though engaging in R&D cooperation with other firms					
Acquisition of knowledge through acquiring a product and reverse engineering it					
Acquisition of knowledge through patent disclosures					
Acquisition of knowledge through imitating an innovative style of management					
Acquisition of knowledge from competitors					
Acquisition of knowledge through government support of R&D in your business					

6.Which of the following are the <u>FIVE MOST IMPORTANT</u> aspects for your business?

(NOTE: Please choose ONLY FIVE of the options below. Leave all the rest blank.)

	Mark only 5
Acquisition of knowledge through interacting with people from firms in the same industry sector as yours	
Acquisition of knowledge through interacting with people from firms in a different industry sector to yours	
Acquisition of knowledge as a result of networking	
Acquisition of knowledge through interacting with people from firms located in your firm's city/town or its vicinity	
Acquisition of knowledge through benefiting from R&D activities of other firms in your firm's city/town or its vicinity	
Acquisition of knowledge due to research undertaken in a university located in your firm's city/town or its vicinity	
Hiring students or graduates from a university located in your firm's city/town or its vicinity	
Hiring skilled employees with experience at firms located in your firm's city/town or its vicinity	
Acquiring knowledge due to the presence of a multinational company located in your firm's city/town or its vicinity	
Acquisition of knowledge though engaging in R&D cooperation with other firms	
Acquisition of knowledge through acquiring a product and reverse engineering it	
Acquisition of knowledge through patent disclosures	
Acquisition of knowledge through imitating an innovative style of management	
Acquisition of knowledge from competitors	
Acquisition of knowledge through government support of R&D in your business	

7. What is the total number of employees in your company (approximate): _____

8. Out of the total number of employees, please indicate the approximate percentage of staff in each job position below:

	%
Directors	
Managers	
Research and Development (P&D)	
Technical staff	
Operatives	

Thank you for your participation

Sergio
sergio.botelhojunior@postgrad.wit.ie

Appendix B Regional stakeholders interview guide

1. In your opinion, how important is the concentration of firms from **the same industry sector** to your region?
    - Why is that important?
    - What does that do for your region?
        Probe: How is it achieved?

2. In your opinion, how important is the concentration of firms from **different industry sectors** to your region?
    - Why is that important?
    - What does that do for your region?
        Probe: How is it achieved?

3. In your opinion, how important is **networking** to your region?
    - Why is that important?
    - What does that do for your region?
        Probe: How is it achieved?

4. In your opinion, how important is **competition between companies** to your region?
    - Why is that important?
    - What does that do for your region?
        Probe: How is it achieved?

5. In your opinion, how important is **hiring skilled labour** to your region?
    - Why is that important?
    - What does that do for your region?
        Probe: How is it achieved?

Appendix C KSIexperts interview guide

1. In your opinion, is the concept of innovation interpreted in the same way across all regions? Or is it specific for each region? Please explain your response.

2. In your opinion, does the process of knowledge spillover happen in the same way in all regions? Or does it happen differently in each region? Please explain your response.

3. a) In your opinion, what are the determinants that cause knowledge spillover to happen?
   b) In your opinion, are these the same in all regions?

4. In your opinion, how important are the following for the process of knowledge spillover?

Aspect	Importance	Please explain your response
Universities / third level institutions		
Local and regional government		
Concentration of companies from the same industry sector		
Concentration of companies from different industry sectors		
Networking		
Competition		
Hiring skilled labour		