UNIVERSITY OF DEUSTO-DEUSTO BUSINESS SCHOOL

Doctoral Programme in Business Competitiveness and Economic Development

Doctoral dissertation

THE IMPACT OF BUSINESS INNOVATION MODES ON INNOVATION PERFORMANCE: THE CASE OF BELARUS

Natalja Apanasovich

Supervisors:

Prof. Dr. Mario Davide Parrilli

Dr. Henar Alcalde

2014

ACKNOWLEDGEMENTS

First of all, I would like to deeply thank my supervisor, Prof. Dr. MD Parrilli who has not only provided me with invaluable guidance in my research process but has continuously supported my academic endeavors. His wide knowledge on the subject of innovation has benefited me greatly. I am also grateful to my second supervisor Dr. Henar Alcalde for her advice, support, feedback on my work and easy-going co-operation.

I would like to thank Prof. Majocchi and Prof. Rampa for the invitation to stay at the University of Pavia for three months and WEBB program for financial support of my stay. This visit helped me to reach a significant progress driven by the intensive collaboration and interaction with the excellent group of researchers from the Department of economics. I also thank to Prof. Stefano Denicolai and Prof. Roberto Fontana for our fruitful discussions and for their insightful comments as external reviewers of this dissertation. I would like to express my gratitude to Prof. Aitziber Elola from the University of Deusto for the review of the final version of dissertation,

I would like to express my thanks to conference participants and, in particular, to Prof. Jorge Niosi and Prof. Cristina Chaminade for the precious comments received at the Globelics 13 conference in Ankara. I am grateful to research committee of Globelics 13 for awarding my paper titled “Influence of research, technology and HR management drivers of SMEs innovation: case of Belarus” as the second best PhD paper. I would like to thank Prof. James Karlsen for the useful comments made at Regional Innovation Policy 8th conference in San Sebastian.

My sincere gratitude also goes to Erasmus Mundus, which supported me with a scholarship during the first year of my study at the University of Deusto, and School of

Business and Management of Technology of BSU, which supported my further study at PhD program. I would like to thank Belstat (Belarusian Statistical Committee) for providing me with statistical data. Assistance provided by personnel of the library of Deusto is greatly appreciated. I am also in debt to my friends and university colleagues who encouraged me during the whole process.

I owe my greatest appreciation and deepest gratitude to my family, my husband Rodion, my parents Tamara and Vladimir and my sister Tatyana, for their unconditional inspiration, help and care. It is impossible to describe their support in words. It is to them that this thesis is dedicated.

To my husband, parents and sister

Natalja Apanasovich

June 18, 2014

ABSTRACT

For many firms, the question is not about whether or not to innovate but about how to increase the degree of novelty of their innovations in order to improve their competitiveness and economic performance and reach access to new markets. This thesis contributes to advance knowledge on business modes of innovation employed by SMEs (small and medium enterprises) and their role in firm's innovation performance in different country contexts and, in particular, in the context of economies in transition. It focuses on a current debate on learning modes employed by the firms and their impact on firms' innovation performance. We conducted the first empirical analysis on the case of Belarus.

The results of a grounded meta-analysis have revealed that firms in different country contexts, which combine the STI (science, technology and innovation) and DUI (doing, using and interacting) modes of innovation are more likely to innovate. We have conducted the first study of the effect of STI/DUI modes on innovation performance of SMEs in the new context of economies in transition. We have enriched the methodology of measuring the DUI mode by adding new indicators to capture "doing" and "using" drivers. Moreover, it has been estimated which of the modes, the STI or DUI is more effective in generating innovation. In addition, we study the influence of STI and DUI not only on product but also on organizational innovation. The results of regression analyses have provided the evidence of how the STI and DUI modes influence these two types of innovation. Thus, Belarusian SMEs combining the STI and the DUI modes are more likely to generate product innovation. However, SMEs that rely on the DUI mode alone are more likely to generate product innovation than those that rely on the STI mode alone. With respect to organizational innovations, we have found out that the STI mode does not relate to this type of innovation to a significant

extent. In contrast to product innovation, firms combining the STI and DUI modes of innovation are not more effective in generating organizational innovation than firms relying on the DUI mode alone.

While conducting these analyses, we have faced difficulties in estimating the extent to which SMEs rely on the STI or DUI modes, and what drivers were crucial in this combination. The STI and DUI modes of innovation were not able to show how SMEs could mix different drivers of innovation or what the composition of innovation drivers was in the combination of the STI and DUI mode of innovation. Therefore, we have explored how different drivers of innovation can be successfully reconciled within a firm. For this purpose, we have introduced a new research instrument that enables us to determine the business innovation profiles and modes – the RTH (Research, Technology and Human Resource Management) model of innovation. This model involves three drivers: Research (R), Technology (T) and HRM (H). The novelty of this study is that it goes beyond the analysis of 'modes of innovation' introduced by Jensen, et al. (2007) and proposes an 'innovation profile' as a detailed description of an innovative firm. Firms with similar innovation profiles have been grouped into clusters which have been identified as 'modes of innovation'. Thus, we have revealed 17 innovation profiles, which we have grouped in the three modes of innovation by means of cluster analysis. Firms that belong to a mode (cluster) that is characterized by low level of the 'R' and high levels of the 'T' and above the average level of the 'H' driver report the highest innovation output among the revealed modes. Firms in this cluster are characterized as 'creative organizations' and are able to produce new-to-international-market products and services.

Keywords: innovation, STI and DUI, modes of innovation, transition economy, Belarus.

JEL codes: O31, O32

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter 1. Introduction

Chapter 1. Introduction

It is widely accepted that innovation plays a crucial role in a modern rapidly changing economy, enabling firms to grow and gain competitive advantages. Globalization has resulted in wide access to information and new markets for firms and led to greater international competition. In such conditions, the low-road type of competition by keeping prices down is no longer effective. However, firms can improve the processes of production and thus make it possible to develop a new range of products, and new organizational practices, while interacting with partners can help to generate and absorb new knowledge that can be used to develop other innovations. Thus, in a time of advanced technologies and greater flows of information, a firm's ability to innovate is more and more viewed as a central driver of its competitiveness and sustainability. In the modern economy the innovative performance of firms depends on a variety of factors among which there are the decisions of numerous stakeholders and policy makers. In order to develop policies that support innovation appropriately, it is essential to understand critical aspects of the innovation process such as innovation activities other than R&D, the interactions among actors and knowledge absorption, which are discussed in this thesis,.

Academic analysis of business innovation has a long tradition of research (Schumpeter, 1942; Nelson & Winter, 1982; Dosi, et al., 1988; Lundvall, 1992). Two relevant streams of the literature identify the sources of business innovation. The first stream stresses the importance of science and technology-based drivers and considers investments in R&D, infrastructure and human capital as the key inputs to innovation (Griliches, 1979; Cohen & Levinthal, 1989; Romer, 1994). The second stream accentuates non-scientific innovation drivers and places emphasis on practice and specialization in production (Arrow, 1962), learning by using technologies (Rosenberg, 1982), interactions and informal relationships that facilitate the exchange of knowledge (Lundvall, 1992). Jensen et al. (2007) have successfully bridged the gap between these research streams by introducing the debate on science and technology-based innovation (STI) versus the innovation mode based on learning-by-doing, by-using and by-interacting (DUI). The STI mode emphasizes the use of research and development (R&D) expenditure, patenting, the level of scientifically educated human capital and innovation infrastructure (e.g. R&D institutions and universities) as the crucial factors of the development of innovation. This mode relies mainly on scientific knowledge, further develops explicit, global know-why and know-what types of knowledge (Jensen et al. 2007). The second mode accentuates non-scientific innovation drivers and places emphasis on practice and specialization in production (Arrow, 1962), product customization (Rosenberg, 1982), interactions and network (Lundvall, 1992), which are synthesized in the acronym of DUI. The learning process takes place through DUI interaction within the supply-chain, mainly between customers, producers, suppliers, and competitors. The DUI mode of innovation relies mainly on tacit and context-based knowledge that is often generated from trial-and-error processes and intra and inter-firm problem-solving developed by both individuals and teams. Since the study was published in 2007, the attention of international researchers has been paid to the debate on the most effective mode of business innovation. Most in-country analyses focus on countries that operate in market economies: Denmark (Jensen, et al., 2007), Norway and Sweden (Aslesen, et al., 2012; Isaksen & Karlsen, 2012a; Isaksen & Nilsson, 2013), Portugal (Nunes, et al., 2013), Spain (Parrilli & Elola, 2012) and Canada (Amara, et al., 2008). Most studies (though not all) have shown that firms which combine the STI and DUI modes of innovation, are more capable of producing innovation than those relying on STI or DUI modes alone. However, there are no studies yet that analyze the effect of STI and DUI innovation modes in the context of countries in transition. These countries whose economy is shifting from a centrally planned economy to free market) are characterized by the lack of financial capital, innovation management experience and state-of-the-art technology (Rees & Miazhevich, 2009; Fink, et al., 2009). However, on the positive side, these countries have a high level of educated human capital in comparison with Western Europe (Aidis, et al., 2008). For our analysis, we selected Belarus as a representative of post-soviet countries in transition as it shows the above-mentioned features quite clearly.

1.1 Research questions

The thesis analyzes the modes of innovation in different types of economies and, in particular, in the context of economies in transition and proposes a new RTH model to identify innovation profiles and modes of innovation. The three chapters of this thesis focus on business modes of SME innovation.

International researchers have paid attention to the ongoing contention on business modes of innovation. To identify which mode is the most effective in generating innovation, it is very important to determine the core characteristics and indicators of each mode. Therefore, we try to answer following research question:

RQ1. What are the core characteristics of the STI and DUI modes of innovation?

In order to empirically assess the STI and DUI modes of innovation there is a need to identify clear indicators. We would like to stress that there is a diversity and a lack of standard indicators, especially for the DUI mode. This situation can cause difficulties in assessing this mode. Thus, the following research question arises:

RQ2. What are the most adequate indicators of STI and DUI modes of innovation?

Jensen et al. (2007) and other authors (Aslesen, et al., 2012) show that the combination of the STI mode of innovation with the DUI mode is strongly correlated with innovation output. However, on the basis of empirical evidence from Spain, Parrilli and Elola (2012) show that the product innovation is, in fact, more sensitive to the STI drivers than to the DUI drivers. Therefore, a new question arises:

RQ3. What are the characteristics of the most effective mode of innovation in different country contexts?

In this thesis, we analyze the innovation performance of small and medium enterprises (SMEs). Inasmuch as SMEs are critical for a dynamic market economy, innovative SMEs are an important policy target for many governments. SMEs are commonly recognized as nimbler than larger enterprises, thus can easily explore new types of activities (Rammer, et al., 2009). These enterprises are often regarded as a driving force for innovation (Ibid). The 20 million European SMEs or 99,8% of all enterprises play an important role in the European economy (EU, 2013). The SME sector as a whole delivers 57.6% of the GDP and represents 66.5% of all European jobs (Ibid). In countries in transition, the contribution of the SME sector to GDP is rather low: 22% – in Belarus, 20% – in Russia, 19% – Kazahstan and 16% – in Ukraine (IPM, 2013). These countries are usually dominated by large companies where most R&D potential is concentrated (Djarova, 2011). These companies represent the core of the Belarusian economy and exports. The national innovation system of Belarus is highly dependent on a relatively small number of industries and large enterprises (Djarova, 2011). However, to be effective the national production system has to include a multiplicity of flexible and nimble enterprises, i.e. the SMEs sector. SMEs ensure important complementarities to the innovative activities of large firms, for example, Belarusian High Technologies Park. For this reason, it is crucial for Belarus to develop these kinds of innovative SMEs. The majority of empirical cross-country studies on modes of innovation mainly focus on countries that operate in the market economy. There is a lack of studies that demonstrate the way SMEs innovate in the new context of economies in transition. Therefore, we decided to analyze the innovative performance of Belarusian SMEs. An answer to the next research question helps to fill this gap:

RQ4. What is the most effective mode of innovation for SMEs in economies in transition?

The studies on STI/DUI modes of innovation do not show how SMEs can mix different drivers of innovation in different innovation modes and, in particular, what proportion of these drivers can be more effective. These premises lead us to following research question:

RQ5. What is the most effective combination of drivers to generate SME innovation?

We conducted a deep literature review and meta-analysis based on a grounded theory approach to answer the first three research questions. The grounded meta-analysis (Strauss & Corbin, 1994; Hossler & Scalese-Love, 1989) enables us to combine both quantitative and qualitative studies and extract comparable categories from the studies performed on STI/DUI modes of innovation. To answer the fourth research question a regression analysis is applied. However, the results of this analysis open a new research focus that is reflected in the fifth research question, which is answered by conducting an in-depth analysis of local firms representing the ICT sector (in Minsk and its region). Cluster analysis and ordinal regression analysis are applied in this case.

1.2 Contribution of the thesis

This thesis contributes to the theoretical and empirical understanding of the role of business modes in the generation and development of innovation in different country contexts and, in particular, in the context of economies in transition. First, the literature review provides a complete overview of STI/DUI modes of innovation from both theoretical and practical perspectives. Second, through a grounded meta-analysis, we provide a comprehensive comparative review of these studies and highlight several issues that may help researchers to study this phenomenon. More in depth, we reveal a lack of studies on innovation modes in countries in transition.

Third, we conduct a pioneering study in which we analyze the effect of these business innovation modes on innovation performance of SMEs in the new context of economies in transition.

Fourth, we enrich the methodology of measuring the DUI mode by adding new indicators that capture learning-by-doing, by-using and by-interacting type of drivers. Vis-a-vis other studies in the field that measure only the interaction driver, our new indicators help to assess the DUI mode more precisely. In addition, we estimate which of the modes is more effective in generating innovation.

Fifth, we study the influence of the STI and DUI modes not only on product but also on organizational innovation, which has not been studied yet in the context of business modes.

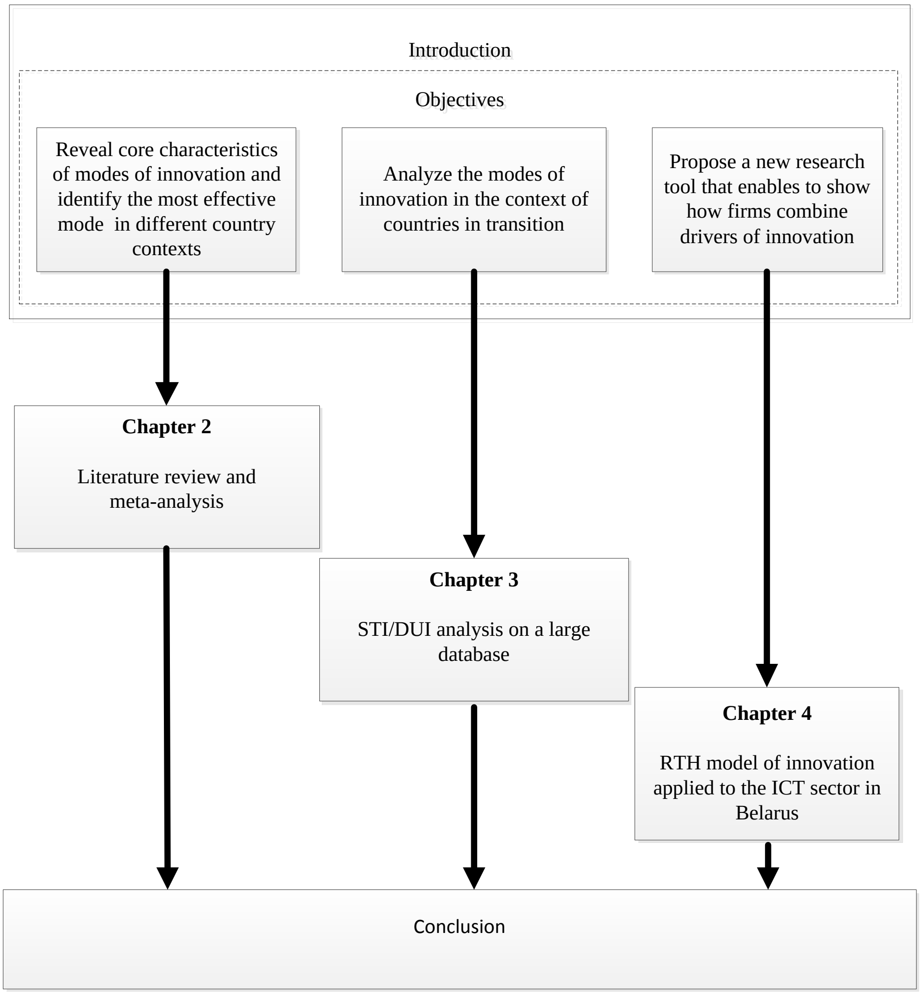
Finally and most importantly, this thesis has contributed to the literature on the drivers and modes of innovation in firms by proposing a new "tool" to determine the relevant profiles and modes of business innovation – the RTH model of innovation. We introduce a new model of innovation because the STI/DUI modes are not able to show how SMEs (and firms more in general) can mix the different drivers of innovation and what the most effective proportion of these drivers. This model implies three drivers, which are the Research (R), Technology (T) and Human Resource Management (H). The literature is relatively inconclusive on how to connect the 'R', 'T' and 'H' drivers in one mode of innovation. In this regard, we attempt to fill this gap. The novelty of this study is that it goes beyond the analysis of modes of innovation and proposes the archetype of ‘innovation profiles’ as a means to identify the most innovative firms.

1.3 Research process, objectives and structure of the thesis

The overall objectives of this thesis include the analysis of existing studies on STI/DUI modes of innovation as a means to reveal the most effective mode. The first step towards achieving this goal is to look at what has already been done in this area. Therefore, we conduct a literature review and grounded meta-analysis to provide a complete understanding of business modes of innovation and their impact on firm’s innovation performance in different country contexts. Afterwards, we carried out an analysis to study the effect of the STI and DUI modes on the innovation performance of Belarusian SMEs. Since we faced technical and methodological difficulties in estimating the extent to which SMEs rely on STI or DUI modes (e.g. how to separate ‘S’ (science) and ‘T’ (technology) drivers), and which drivers are crucial in this combination, we have undertaken our own survey to capture relevant data and present our new research instrument. This instrument – the RTH model – enables us to characterize the modes of innovation in detail.

The thesis is divided in five parts consisting of the introduction, 3 chapters and a conclusion that help to achieve the study objectives as outlined in the Figure 1.1.

Figure 1.1. Thesis structure and objectives



Source: own elaboration

In chapter 2 we review the literature on the evolution of the major innovation theories that preconditioned the emergence of the concept of STI and DUI modes of innovation. The theories of innovation have constantly developed and evolved: from a linear model of innovation, to interactive models and up to the current theories that recognize innovation and knowledge as the main factors of competitiveness (Rodríguez-Pose & Crescenzi, 2008). This study is also designated as grounded meta-analysis of the literature on the STI and DUI modes of innovation. This study provides a meta-analytical review of research purposes and methodologies, and investigates the existing inconsistencies across the various findings of relevant qualitative and quantitative studies implemented from 2007 to 2013. The majority of these studies aim at investigating the modes of learning and innovation with the objective of identifying the most effective mode. Firms in different country contexts, which combine the STI and DUI forms of learning, are found more likely to innovate. Chapter 3 is devoted to the analysis of the effect of three critical business innovation modes: STI and DUI and the combination of these two (STI+DUI). To our knowledge, this is the first study analyzing the effect of business innovation modes on innovation performance of SMEs in the context of economies in transition. In addition, we study the influence of STI and DUI not only on product but also on organizational innovation, which is "non-technological" type of innovation that may require different types of drivers of innovation. With regard to other studies in the field, we enrich the methodology of measuring the DUI mode by adding new indicators such as preliminary marketing and technological preparation for production, which measure learning-by-doing and learning-by-using drivers that were not measured in previous studies. In Chapter 4, we discuss the role of 'business innovation modes' in SME innovation performance and propose a new model to determine different 'innovation profiles' and modes of innovation – the RTH (Research, Technology and Human Resource Management) model of innovation. This model is based on three drivers of innovation: R (Research), T (Technology) and H (Human Resource Management). The literature is relatively silent on how to separate research and technological drivers; as they are usually proxies by the same types of indicators within the STI mode (Jensen, et al., 2007; Parrilli & Elola, 2012). One of the main reasons why we decided to separate the 'R' from 'T' driver is that in Belarusian context there are two main ways that firms adopt to innovate. First, as in many catching-up economies, technological innovation in Belarus is, to a large extent, connected to the purchase and installation of new machinery and the effective use of new equipment (Palacín & Radosevic, 2011) (the 'T' driver). Second, Belarusian enterprises can benefit from R&D results conducted by themselves, public institutions or large enterprises (the 'R' driver). We differentiate between the 'R', 'T' and 'H' drivers of innovation, distinguish firms dominated by different innovation profiles and classify them into modes of innovation. The novelty of this study is that it goes beyond the analysis of modes of innovation and proposes the concept of 'innovation profile' as a more specific identification marker of the innovative firms. This implies particular combinations in the adoption of the different drivers. Firms with similar innovation profiles are grouped into clusters, which are defined as modes of innovation, which may be similar to the STI, DUI and STI+DUI modes, but not identical. The interrelation between profiles and modes enables the identification of the most effective innovation mode together with the strength of the drivers that characterize it. Finally, in the last section we summarize the conclusions and implications derived from this doctoral investigation, outlines implications and delineates future research lines.

Chapter 2. Review of modes of innovation: a grounded meta-analysis

Chapter 2. Review of modes of innovation: a grounded meta-analysis

2.1 Introduction

The idea that innovation is crucial for economic development dates back over 200 years. The division of labor across firms was thought to increase competitiveness and extend markets (Smith, 1776). This led to a reorganization of the labor process in pursuit of new and more competitive strategies of production, such as flexible or agile manufacturing, value-added manufacturing, agile manufacturing, mass customization (Duguay, et al., 1997). In order to understand current innovation processes (1) and models (2), it is important to be familiar with the evolution of innovation theories. The necessity of innovation in business performance and competitiveness is widely discussed in economic literature. Schumpeter (1934) presented the introduction of innovations in the market as the key process of economic change. In a linear interpretative model (one in which the introduction of some inputs automatically generates a specific output), innovation is considered as a driver (or input) of economic growth (Lederman & Saenz, 2005; Rodríguez-Pose & Crescenzi, 2008; González-Pernía, et al., 2012b). However, the linear model is harshly criticized because of its incapacity to take into account the mutual feedbacks that intercourse between different agents of the innovation process (scientists, designers, and sellers). On these bases, Kline and Rosenberg (1986), introduced a chain-linked model which considers innovation as a complex process and includes feedback loops between different agents and stages (design, production, marketing and distribution activities) of the innovation process. This reflection opens the way to a world of innovation-oriented activities that implies more complex interactions within and across firms and between these and various institutional agents.

Such reflection led the way to the foundation of a new research paradigm linked to the development of national innovation systems (NIS) (see Freeman, 1987, Lundvall, 1992 and Nelson, 1993). According to the NIS approach, the open interaction with different types of agents is one of the main factors of innovation because firms rarely innovate on the grounds of their intramural knowledge capability alone, but increasingly rely on external sources of knowledge and research to accelerate internal innovation processes and the market uptake of innovations once these are produced (Howells, et al., 2012). The "learning economy" is a stage of the socio-economic progress of developed countries, in which knowledge is a main resource, while learning is the most important process of integration of new knowledge and competences (Lundvall & Johnson, 1994; Freeman, 1995; Edquist, 1997) that enhance the capacity of firms to produce innovations. There is a great variety of firms in the market. In order to analyze such variety in a more systematic form there is a need for establishing taxonomies or, in other words, groups of firms according to specific and reasonable criteria. The analysis of 'the knowledge-based firm' requires taxonomies that focus on their knowledge base. Lorenz and Lundvall (2007) argue that current types of taxonomies, which distinguish between firms operating on the basis of analytic and synthetic knowledge (Asheim & Coenen, 2005), or on the basis of high and low-technology are problematic. During times of dramatic changes in technologies and production, such distinctions tend to become blurred. Jensen et al. (2007) introduced a taxonomy, which distinguishes between the STI and DUI modes of innovation. The first mode emphasizes the scientific and technology-based nature of innovation. The second mode is based on experience and interactive practice. The third mode is a combination of the former two modes. The seminal study of Jensen et al. (2007) bridges the gap between the linear approach to innovation and the systems, which entails interactions and practice.

This chapter provides a grounded meta-analysis of the existing studies on the STI and DUI modes of innovation. A major purpose of this type of analysis is to provide a comprehensive comparative analysis of studies on business modes of innovation, and to inform researchers, policy makers and practitioners about the state-of-the-art and future research directions in their area of interest. This analysis encompasses 16 studies on the STI/DUI-modes of innovation published from 2007 to 2013. We synthesize the research purposes, methodologies and results of the studies that help to identify trends and patterns in this research field.

This chapter is structured as follows. In section 2.2, we review the evolution of the major innovation theories that preconditioned the STI and DUI modes of innovation. In section 2.3, we review the literature on STI/DUI modes of innovation and provide a comparative discussion of these modes and studies. Section 2.4 describes the methodology of grounded meta-analysis together with the selected variables and data as well as their coding procedure. Then, in section 2.5, we discuss the findings of the grounded meta-analysis. In the final section 2.6, the study and findings are summarized and discussed together with the relevant implications for researchers, policy makers, and managers. In addition, we point out the limitations and issues that should receive attention and delineate future research lines.

2.2 Evolution of the major innovation theories

2.2.1 Early models of innovation

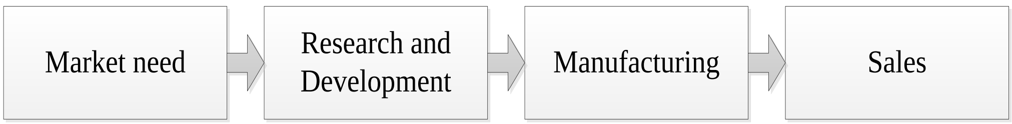
The early model of innovation that contributed to the understanding of the role of science and technology within the economy is a linear model (Bush, 1945; Maclaurin, 1953; Godin, 2006). Technology-push and market-pull models are considered as two alternative types of the linear model (Rothwell, 1994). According to the technology-push model, scientific activity and technological capacities are the main drivers of innovation. Figure 2.1 demonstrates that the innovation process starts from scientific discovery; it is followed by design, technological application, engineering activities, and it is completed by marketing and sales. Thus, the R&D activity is the key driver.

Figure 2.1. Technology push model

Source: Rothwell (1994)

The technology-push model was dominant in the 1950s and 1960s. It was practiced particularly in the automobile and steel industry and in new industries such as aviation and electronics, which grew by leaps and bounds. Thus, a number of innovations were produced in automobile manufacturing, which became the largest industry. However, in the 1960s, the significant role of the market in promoting the business innovation process was stressed (Godin, 2006). Market demand for new products can also spur the start of research and development activities. To meet market demand in conditions of rising competition, firms started to diversify their product portfolio. In market-pull (or demand-pull) model (Figure 2.2), customer needs were interpreted as the driving factor of innovations and the origin of ideas for conducting R&D activities (Rothwell, 1994). According to this model, innovation activities are under the influence of variations in demand, prices and profits.

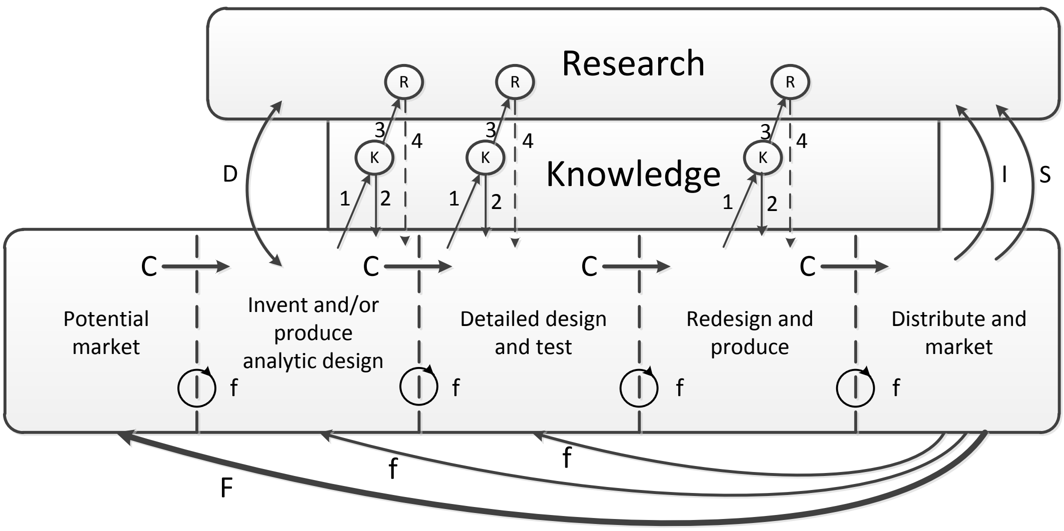
Figure 2.2. Market-pull model



Source: Rothwell (1994)

In general, the linear model of innovation was criticized because of its oversimplification. Firstly, it considers R&D as a main source of innovation and, secondly, it ignores the importance of feedbacks in the innovation process (OECD, 1992; Rosenberg, 1994). This model ignores the importance of feedbacks not only within intra-firm product development processes, but also in relation with customers and sales agents, which are essential agents in harnessing the business competitive position and in formulating appropriate business strategies (Kleine, 1985; Kline & Rosenberg, 1986). The limitations of the linear model in generating relevant innovations gave rise to alternative interaction-based innovation models. One of them, called a *chain linked* model (see Figure 2.3), was introduced by Kline and Rosenberg (1986). In compliance with this model, innovation is understood as a complex process that starts in the market (market exchanges), which activates complementary design, production, marketing and distribution activities. Each step implies a feedback, which shows the interactions that occur between the different agents of the innovation process. There is a connection between existing knowledge and new knowledge, which is created through research activities. According to the chain-linked model, if a firm faces a technical problem, firstly, it has to raise internal stored knowledge, and only in case of failure, it leads to conduct one's own scientific research and development activities.

Figure 2.3. Chain-linked model showing flow paths of information and cooperation.



Symbols on arrows: C - central chain of innovation; f - feedback loops; F - particular important feedback.

K-R: Links through knowledge to research and return paths. If problem solved at node K, link 3 to R not activated. Return from research (link 4) is problematic-therefore dashed line.

D: Direct link to and from research from problems in invention and design.

I: Support of scientific research by instruments, machines, tools, and procedures of technology.

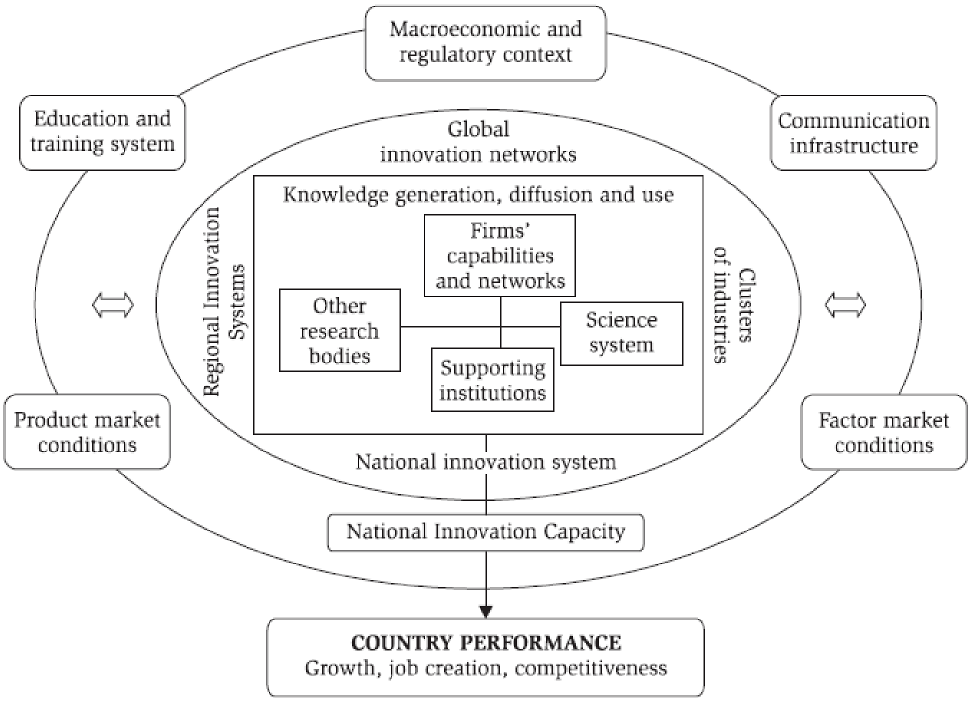
S: Support of research in sciences underlying product area to gain information directly and by monitoring outside work. The information obtained may apply anywhere along the chain.

Source: Kline and Rosenberg (1986).

2.2.2 The ‘national innovation system’ approach

In economics, the discipline in which this work is framed, the complex approach to innovation initiated by interactive models was broadened by the new paradigm of national innovation system (NIS) introduced in the 1990s (Freeman, 1987; Lundvall, 1992; Nelson, 1993). The NIS approach has a systemic view of innovation that goes beyond the interactive model. It states that the interaction with external organizations promotes the generation of innovation. According to the NIS approach, innovation is mainly the result of various long-term types of relationships and flows of technology and information between business, public organizations and institutions in a country (Edquist, 2005; Patel & Pavitt, 1994; Freeman, 1987). This comprehensive view on innovation dynamics has resulted in a growing interest of international scholars and policy makers in the concept of national innovation system (OECD, 1992; Lundvall, et al., 2002; Edquist, 2005). The NIS points out the crucial role of firms, research organizations, other institutions (e.g. universities), and the forms and intensity of their interactions. The complexity of actors in innovation processes (firms, public and private research organizations, and government and other public institutions) and linkages and interactions is presented in the following diagram (Figure 2.4). These actors are influenced by a variety of factors that are country specific, for example: the financial system, regulatory frameworks, the level of education and skills and labor relations (OECD, 1999).

Figure 2.4. Actors and linkages in the national innovation systems



Source: OECD (1999)

2.2.3 The "learning economy"

The existing knowledge and information base changes with tremendous speed and becomes obsolete quicker than in the era of mass production. The current stage of socio-economic development of many efficiency-driven countries and all innovation-driven countries (Sala-i-Martin & Schwab, 2011), which is characterized by rapid changes and transformations driven by new technologies and market globalization, has been defined as the "learning economy" (Lundvall & Johnson, 1994; Freeman, 1995; Edquist, 1997).

Individuals, firms and other organizations have to acquire new competences in order to withstand intense competition. In these times of change and innovation, the knowledge and learning capabilities of individuals and organizations become more and more important. Thus, in the "learning economy" knowledge is a key resource and learning is the most important process to renew the competitive advantage of firms and territories (Lundvall & Johnson, 1994; Freeman, 1995; Edquist, 1997; Lundvall, 1992). Hence, firms engage in organizational learning. "Learning organizations" or companies that facilitate the learning of their members are a central element of knowledge management (Lundvall & Johnson, 1994; Yeo, 2005). Organizational knowledge management should be focused on the stimulation of internal and external linkages to engage in networking, informal relationships and organizational collaborations, which lead to effective learning and innovation (Von Hippel, 1988; Lundvall, 1992), rather than merely controlling the processes of knowledge creation (Lundvall, 2006).

The process of shifting to a "learning economy" is quite challenging. The endogenous growth theory (Romer, 1986; Romer, 1994) and subsequent research on economic growth demonstrated the crucial role of knowledge, technology, and innovation in socio-economic development (Bilbao-Osorio & Rodriguez-Pose, 2004; González-Pernía, et al., 2012b). In this context, the individual and business ability to 'forget' old routines and to generate new knowledge and competences is crucial to promote the competitiveness of firms, regions and countries (Wong, et al., 2005; Sterlacchini, 2008). One specific example of current fast-track change is the fact that half the skills acquired by IT specialists during their education become obsolete swiftly (Lundvall, 2006). This process demands changes in organizational structures. For example, organizations with a strong hierarchy become inefficient because of the rigid process of vertical communication (top-down), which is characterized by a long chain of knowledge exchange (Acs, et al., 2009). Thus, innovative ideas can be underestimated and missed in each management level. Moreover, employees are not encouraged to collaborate and share information, which they have obtained directly from customers, suppliers, and partners. Many old organizations in traditional industries such as iron and steel manufacturing (e.g. U.S. Steel and Bethlehem Steel) are structured along vertical hierarchies. In contrast, the flexible structure of learning organizations and their decentralized decision-making process supports their ability to innovate (Cosh, et al., 2012; Lam, 2005). Firms with such decentralized organizational structures tend to support competence building through learning-by-doing and learning-by-interacting. For example, Saturn Corporation, a subsidiary of General Motors, has been structured as a horizontal organization to learn and to adapt state-of-the-art business practices in order to be competitive in the market. Many firms in high-tech sectors (e.g. Google, IBM) tend to establish self-governing work teams to provide more ways to involve the employees in the exchange of knowledge and the generation of innovation.

2.2.4 Antecedents of the study on the business modes of innovation

The origin of economic value is created at the firm-level. On this basis, we can argue that different organizations and their business interrelations are key aspects in both the working of NISs and learning economies. Due to the role that innovative organizations play in the socio-economic development of regions and countries, the innovation capability and performance of individual organizations deserve the attention of academics and policy-makers all around the world (Amara, et al., 2008; Audretsch, 2003). This entails the establishment of a meaningful research stream that focuses on the business modes of innovation (Jensen, et al., 2007; Chen, et al., 2011; Aslesen, et al., 2012; Isaksen & Nilsson, 2013, among others).

The literature identifies two main approaches that consider different sources of innovation. The first approach is based on the linear model of innovation and stresses that innovation is the result of R&D activities. According to this approach, the main inputs that help to generate innovation are investment in R&D and scientific human capital (Griliches, 1979; Cohen & Levinthal, 1989,Romer, 1994). The second approach accentuates interactions across the organization and between companies that promote generation, exchange and the spreading of knowledge for innovation (Lundvall, 1992). A number of authors tried to bridge the gap between these two research streams. On the one hand, there is a linear or science-based approach to innovation. On the other, there are institutional-interactive approaches, which emphasize the assimilation of external knowledge and ideas as a key element in the innovation process. Von Hippel (1976) studied user-supplier relationships in the production of scientific instruments. This scholar found out that the majority of innovations were created with the help of users who stimulated a significant increase in functional utility. Von Hippel (1976) concluded that user-supplier relationships play an important role in innovation processes by promoting the successful commercialization of innovative products and by providing feedback from customers; and by creating an inexhaustible source of innovative ideas. Von Hippel (1986) introduced the lead user method to identify lead users and to explore the valuable insights they can offer with reference to their needs. This author defined lead users as those users whose “present strong needs will become general in a marketplace months or years in the future” (Von Hippel, 1986).

However, to take advantage of cooperation, communication and networking, companies must develop the capacity to absorb new knowledge from outside. This capacity strongly conditions the quality of knowledge transfer and the probability of benefiting from the acquired knowledge. Thus, a new concept of absorptive capacity of the firm, which refers to their ability to "recognize the value of new information, assimilate it, and apply it to commercial ends”, was introduced by Cohen and Levinthal (1990, p. 128). This definition captures the different stages of the inter-organizational learning process (Lane & Lubatkin, 1998). The concept of knowledge, its gathering, assimilation and repository, generation and commercialization received more and more attention in the literature and was suggested to play a vital role in the whole innovation process (Cohen & Levinthal, 1990; Nonaka, 1991; Lane & Lubatkin, 1998; Van Den

Bosch, et al., 1999). Cohen and Levinthal (1990) suggest that the firm's absorptive capacity tends to develop cumulatively. This implies that its current development promotes its future accumulation. The absorptive capacity depends to a significant extent on its prior related repository, which includes scientific knowledge, basic skills and common language. "The cumulativeness of absorptive capacity and its effect on expectations suggests an extreme case of path dependence in which once a firm stops investing in its absorptive capacity in a quickly moving field/industry, it will not be able to assimilate and exploit new information in that field/industry, regardless of the value of that information" (Cohen & Levinthal, 1990, p. 136). Therefore, the characteristic of absorptive capacity implies that it is path or history-dependent and is built on prior investments in the absorptive capacity of its members. Cohen and Levinthal (1989) showed that firm's investments in R&D have a positive direct impact on its absorptive capacity or, in a nutshell, the more a firm invests in R&D activities, the more it will be able to absorb new external information. Therefore, in order to promote absorptive capacity firms have to invest in R&D instead of simply purchasing innovative products. A business ability to absorb and utilize external knowledge is critical to develop its innovation potential, because the stock of ideas and business solutions generated within organizations is always limited. The importance of external knowledge sources, interactions and networks in the innovation process was stressed in the literature (von Hippel, 1988; Nonaka, 1991; Lundvall, 1992).

The two aforementioned seminal concepts preconditioned to a new paradigm of open innovation proposed by Chesbrough (2003). He defined open innovation as the "use of purposive outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation” (Chesbrough, 2006, p. 2). In recent years, there has been growing interest in interactions and collaboration arrangements for innovation. Innovation is no longer a prerequisite of isolated firms and depends increasingly on collective action. Therefore, firms constantly cooperate with their users, suppliers, universities, and even competitors in pursuit of new knowledge, ideas, and business solutions.

Chesbrough’s (2003) ‘open innovation’ model suggests that firms are able to successfully innovate by gaining knowledge from a wider range of external sources. Thus, the process of searching and commercializing new ideas acquired from the external environment are a locus of innovation activity. If a firm relies only on its internal capacities, it will overlook a bulk of opportunities as some essential knowledge for generating innovation can be located externally. To summarize, in the current era of open innovation in which knowledge is widely distributed, companies should not only rely entirely on their internal capacities, own R&D activities, but should make efforts to thoroughly explore external sources looking for relevant knowledge and ideas. Laursen and Salter (2006) introduced concepts of *external breadth* and *depth* to describe a firm strategy for accessing knowledge from the external environment. The first concept of *external breadth* refers to the number of external partners firms rely upon in their innovative activities, while the concept of *external depth* describes the intensity of cooperation with these partners. Laursen and Salter (2006) find that the lack of business openness to its external environment may cause an organizational myopia or a situation in which managers may over emphasize the importance of internal sources and under emphasize external ones. These two concepts are widely used among scholars that analyze the impact of openness on the innovative performance of firms (Chen, et al., 2011) in order to identify the most effective combination of partners for innovation. To conclude, a variety of empirical studies have indicated that firms that are more open to external sources are more likely to have a higher level of innovation performance, due to the fact that some essential knowledge can only be found outside the firm (Chesbrough, 2003; Laursen & Salter, 2006). However, notwithstanding the great opportunities of openness, firms have to understand that collaborating with other organizations can be expensive due to increasing search costs, time consumption and, in addition, there is the potential danger of leakage of key technologies to competitors (Laursen & Salter, 2006). Moreover, it was empirically proved in the literature that increasing business collaboration practices improves the firm innovation performance up to an optimal number of partners, after which external relationships hinder such performance (Katila & Ahuja, 2002; Chesbrough, 2006; Chen, et al., 2011; Laursen & Salter, 2006). Thus, the efficiency of collaboration arrangements for innovation depends on the type of firms being considered (Tether, 2002) and on the type of external partners or business "orientation of openness" (Chen, et al., 2011), and its level of absorptive capacity (Cohen & Levinthal, 1989).

In conclusion, the firms use various strategies and approaches to pursue innovation. We certainly need classification tools or innovation taxonomies to analyze how different firms innovate and to determine the most effective innovative strategy. Examples of such taxonomies can be: sectoral Pavitt taxonomy (Pavitt, 1984), distinctions between firms or sectors based on synthetic and analytic knowledge (Asheim, et al., 2011) and distinctions between high and low-technological firms

(OECD). However, Lorenz and Lundvall (2007) argue that such taxonomies are problematic because they refer to a specific time frame. Thus, in the current era of dramatically changing environments and globalization such distinctions tend to become indistinct. The new classification by Jensen et al. (2007) that focuses on how firms combine different approaches to create knowledge and generate innovation is more appropriate for the rapid development pace of the modern economy. These authors bridged the gap between the research stream focused on a linear approach or internal R&D and the interactive approach by introducing the concept of modes of innovations. This seminal work identifies the theoretical framework of the STI and DUI modes of learning and innovation which our study is built upon. Advanced literature review and meta-analysis of studies on the STI and DUI modes of innovation are presented in the next sections.

2.3 Introducing the STI/DUI modes of innovation

The study conducted by Jensen and colleagues (2007) attracted the attention of international researchers and, in particular, led to the ongoing contention on the most effective mode of SMEs innovation Isaksen & Karlsen, 2010; Parrilli & Elola, 2012) (Jensen, et al., 2007; Isaksen & Karlsen, 2010; Parrilli & Elola, 2012).

The STI mode is focused on the use of research and development (R&D), patenting, information and communications technology (ICT) expenditures, and the level of scientifically educated human capital (Griliches, 1979; Cohen & Levinthal, 1989; Romer, 1994). This mode relies mainly on science-based knowledge and further develops explicit, global know-why and know-what type of knowledge (Jensen et al. 2007). Firms benefit in terms of innovation capability from a stronger connection to science that provides a platform for firms’ technological innovation and learning. Many of the innovation activities and research-based projects that characterize the STI mode of innovation take place in R&D departments, universities and research laboratories. The degree of innovation depends on the variety of interactions with research organizations and universities than with other firms (Jensen, et al., 2007; Amara, et al., 2008). The DUI mode of innovation emphasizes innovation based on learning-by-doing, by-using and by-interacting. The concept of learning-by-doing (Arrow, 1962) implies that a firm performs experiential learning and increases productivity and efficiency by getting more practice and repeating the same operations. Learning-by-using from user experience and demand in customizing a product that is supported by advanced technologies contributes to the increase in the productivity of machines and creates opportunities for experimentation and problem-solving on the shop floor (Wuyts, et al., 2004; Amara, et al., 2008). Innovation can also be a result of interactions, networks, informal relationships and organizational collaborations within and between organizations (Von Hippel, 1988; Lundvall, 1992; Gemünden, et al., 1996; Fu, et al., 2013). Closer cooperation with external partners provides access to information about technologies and markets (Ritter & Gemünden, 2004). At the level of a firm, the DUI mode can be characterized as decentralized, decision-making, softened hierarchies, eliminating strict boundaries between functions and intensive teamwork. This mode is defined as a user-driven mode that supports the development of new products and services in compliance with market needs (Isaksen & Nilsson, 2013).

Table 2.1 provides a brief synthesis of the modes of innovation, according to the following criteria: dominant knowledge typology, main external innovation partners, drivers of innovation, ways of learning, output of the innovation performance and knowledge transfer. Since the dominant knowledge base in the DUI mode of innovation is tacit (Jensen, et al., 2007), the knowledge acquisition and exploitation require frequent interactions with external business partners (Lundvall, 1988; Nonaka & Takeuchi, 1995), which can be facilitated by different kinds of proximities (Presutti, et al., 2011). DUI firms collaborate externally with customers, suppliers, distributors and competitors, while the main partners of STI firms are researchers, universities and research organizations. The STI mode prevails in research-oriented industries such as pharmaceuticals and chemicals, aeronautics, petroleum and nanotechnology. In contrast, the DUI mode dominates in more traditional industries, for example, traditional manufacturing. The STI mode aims at developing more radical innovations (product, process) (Jensen, et al., 2007). However, the DUI mode may also facilitates the generation of radical innovations (Lorenz, 2012), for example, when organizational innovation is involved (see chapter 3). The threat of knowledge leakage is higher in the STI mode of business innovation because of the use of codified knowledge, which is not sticky and can be more easily transferred to the recipients that count with a proper absorptive capacity (Sanchez, 2008; Chen, et al., 2011). Therefore, managers decide to patent some inventive products (Acs, et al., 2002) and in other occasions intentionally keep some knowledge in tacit form in order to prevent the flow of knowledge to competitors (Schulz & Jobe, 2001).

Sometimes firms apply the “pure” STI or “pure” DUI mode of innovation, in other occasions they tend to combine the two modes. Therefore, a third mode is a combination of the two modes. This mode combines different innovation drivers (science and technological drivers with learning-by-doing, using and interacting). Jensen et al. (2007) argue that firms combining the STI and DUI mode of learning and innovation are more likely to innovate than those using the STI or DUI alone. The ongoing contention on identifying the most effective mode of innovation has attracted the attention of international scholars (Aslesen, et al., 2012; Isaksen & Nilsson, 2013).

Table 2.1. Synthesis of modes of innovation

Criteria	**STI**	**DUI**	**STI+DUI**	**Literature**
Dominant knowledge typology	Explicit, scientific, codified, know-why and know-what	Tacit, synthetic, know-how and know-who	Explicit, scientific and tacit	(Jensen, et al., 2007; Sanchez, 2008; Chen, et al., 2011; Aslesen, et al., 2012; Isaksen & Nilsson, 2013; Isaksen & Karlsen, 2010; Parrilli & Elola, 2012)
Main external innovation partners	Cooperation between R&D institutions, universities and other research-intensive firms and R&D organizations	Internal and external cooperation (between customers, suppliers producers and competitors)	Cooperation between agents along the value chain, competitors and R&D organizations	
Drivers of innovation	Science and technology drivers: R&D, scientific human capital, research infrastructure and link to scientific partners	Practice, experimentation, specialization in production, product customization, interaction and networking	Mixed STI and DUI drivers	
Way of learning	In R&D projects, purchasing patents	In daily work and on-the-job training	In daily activities and R&D projects	
Output of the innovation performance; type of	New products, processes, patents, spin-offs; radical innovation	Process, organizational, product commercial innovation	Incremental and radical product and process innovation	

innovation				
Knowledge transfer and spillovers	Explicit knowledge may be moved easily and fast by information technologies. The danger of knowledge leakage is high because of use of codified knowledge that is not sticky	Knowledge transfer is costly and has limits in speed and reach. The lower probability of security leak due to the stickiness of the knowledge that has to be transferred.	Knowledge is shared in both ways: by information technologies and in tacit form	
Examples of industries	Pharmaceuticals and chemicals manufacturing, aeronautics, nanotechnology and energy	Machine-tools, cars, textiles, furniture	All types of industries	

Source: own elaboration

2.4 Grounded meta-analysis

To conduct our research, we were looking for a method that would allow us to synthesize both quantitative and qualitative inquiries and to compare studies on the bases of research purposes, methods and results. The *quantitative meta-analysis is* an application of different statistical methods to collect, combine, contrast and identify patterns among different studies that focus on the same topic. On the one hand, it enables one to extract and aggregate empirical findings from multiple quantitative studies and transform into a common measure (Rosenbusch, et al., 2011). With the help of statistical procedures, the results can be compared and evaluated (Stanley, 2001). This type of analysis provides research integration, comparison and generalizability of results and interpretations (Hunter & Schmidt, 2004). The use of quantitative techniques is appropriate when the aim of the analysis is to identify statistically justified relationships between variables and when there is a relevant amount of quantitative studies (Hossler & Scalese-Love, 1989). The limitation of this type of analysis is that it excludes qualitative information (Stall-Meadows & Hyle, 2010), which is important in our field of study. Qualitative meta-analysis using a grounded method (*grounded meta-analysis*) (Glaser & Strauss, 1967; Strauss & Corbin, 1994; Hossler & Scalese-Love, 1989) is a reasonable alternative as it enables one to combine both quantitative and qualitative studies, extract comparable categories from the studies and overcome the aforementioned limitations.

2.4.1 Methodology of grounded theory

We conducted meta-analysis based on the grounded theory approach. The specific methodology of grounded theory was discovered and developed by Glaser and Strauss, mostly through the analysis of interviews and observations (Glaser & Strauss, 1967; Strauss & Corbin, 1990; Corbin & Strauss, 1990). The grounded meta-analysis of published studies was firstly introduced by Hossler and Scalese-Love (1989) and then conducted and developed by other scholars (Ke, 2009; Wu, et al., 2012; Stall-Meadows & Hyle, 2010). This method was chosen because it enables us to synthesize the theory, explore methods and review empirical findings, and to formulate a complete image of this field of study (Hossler & Scalese-Love, 1989). Moreover, grounded meta-analysis enables us to combine both qualitative and quantitative studies that are essential for an exhaustive synthesis of the literature (Rahimi, et al., 2009; Stall-Meadows & Hyle, 2010; Timulak, 2009). The data have been extracted from 16 studies on the STI/DUI modes of innovation conducted in Europe, Asia and North America. This study aims to investigate the modes of innovation and their impacts on business innovation performance in different economic systems. To reach this goal, we review studies published since 2007 with the explicit focus on STI/DUI modes of innovation.

2.4.2 Data collection

To select appropriate studies for the analysis we have considered the following inclusion criteria: (i) content devoted to the STI/DUI mode of innovation, (ii) year of publication (2007-2013), (iii) English-language publications.

In order to identify relevant studies, a systematic search was carried out in the data pool consisting of electronic databases (e.g. EBSCO, Scopus, Emerald, Elsevier Science Direct). Special attention was paid to identify journals where the most influential articles were published. Then, manual searches were conducted among the selected journals issued. As there was lack of studies in peer-reviewed journals we also conducted a search through working papers series (e.g. Orkestra, Lund University), as well as in conference proceedings (e.g. International Schumpeter Society Conference), and dissertations (e.g. University of Lisbon). Additionally, we reviewed relevant works in their reference sections so as not to exclude any other meaningful study. Then, we tried to identify scholars who specialize in this field of research to conduct additional searches by authors' names. When we did not have an access to the full version of papers, we contacted the authors personally. As a result, our final sample comprised 16 studies on modes of innovation.

2.4.3 Data coding and analysis

We coded quantitative and qualitative information in compliance with the coding procedure set by Hossler and Scalese-Love (1989) which is widely used in the grounded meta-analysis (Ke, 2009; Wu, et al., 2012; Stall-Meadows & Hyle, 2010). While the coding of quantitative data requires beforehand logically deduced categories, the coding of qualitative data requires inductively identifying the categories after carefully reviewing the data (Hossler & Scalese-Love, 1989). The coding is the interpretive process, which enables constant comparison of data and revision of coding categories (Glaser & Strauss, 1967; Hossler & Scalese-Love, 1989; Strauss & Corbin, 1990; Stall-

Meadows, 1998). After a thorough perusal, we developed a coding matrix to delineate the studies by their research purposes, methods, sample sizes, types of firms, countries, indicators of modes of innovation and empirical findings. A summary of these studies is presented in Table 2.2.

Table 2.2. A summary of empirical studies reviewed

Study	Research purposes	Method	Sample size	Country	Findings
Jensen et al. (2007)	Investigate modes of learning and innovation and identify the most effective one	Quantitative (latent class analysis and logistic regression analysis)	692 firms	Denmark	Firms combining STI and DUI modes of learning and innovation are more likely to innovate than those emphasizing on STI or DUI alone.
Amara et al. (2008)	Investigate modes of learning and innovation and identify the most effective one	Quantitative (regression analysis)	639 firms	Canada	Learning by searching (investments in R&D, scientific trained personal, STI mode), learning by training, doing, using and interacting (DUI) impact positively on the degree of novelty of the innovation of established SMEs
Isaksen & Karlsen (2010)	Explore sources of firms' knowledge and types of collaboration	Qualitative (case study)	28 firms	Norway	University–industry cooperation takes place in both industries, but more easily achieved in the industry dominated by the STI mode of innovation

Chen & Guo (2010)	Investigate modes of learning and innovation and identify the most effective one	Quantitative	230 firms	China	Firms combining STI and DUI modes of innovation are more capable of producing product innovation
Guo et al. (2010)	Investigate modes of learning and innovation and identify the most effective one	Quantitative (complementary analysis draws on Jensen's et al. (2007) empirical data)	Jensen's et al. (2007) empirical data	China	Firms combining STI and DUI modes of innovation are more capable of producing product innovation
Trippl (2011)	Explore sources of firms' knowledge and types of collaboration	Qualitative (case studies and interviews)	10 firms	Austria	Within the DUI mode more conducive is collaboration with extra-regional agents, while within STI mode the collaboration with local partners.
Chen et al. (2011)	Explore sources of firms' knowledge and types of collaboration	Quantitative (regression analysis)	209 firms	China	Both the scope and depth of openness have a positive impact on innovative performance. In the STI mode it is crucial to combine technological linkages (universities and research institutes) and market relations (value

					chain partners). In the DUI-mode of innovation, firms profit from relationships with value chain partners and competitors as well as technology-related organizations.
Isaksen & Karlsen (2012a)	Investigate modes of learning and innovation and identify the most effective one	Qualitative (case study)	30 firms	Norway	CCI (STI+DUI) generates innovation and provides competitive strength
Isaksen & Karlsen (2012b)	Explore sources of firms' knowledge and types of collaboration	Qualitative (case study)	30 firms	Norway	DUI-firms are more regionally focused in their knowledge sourcing, while STI- and CCI (STI+DUI)-firms source more of their knowledge outside the region. Mobility of labor, local buzz and inter-organizational linkages are key regional knowledge sources.
Aslesen et al. (2012)	Investigate modes of learning and innovation and identify the most effective one	Qualitative (case study)	96 firms	Norway	The DUI technological mode (or STI+DUI) firms are globally competitive due to a strong regional technological base built upon broad collaboration and a mixed innovation strategy.

Parrilli & Elola (2012)	Investigate modes of learning and innovation and identify the most effective one	Quantitative	409 firms	Spain	Firms using the STI mode alone are more capable of generating substantial product innovations (new-to-market innovations)
Gonzalez-Pernia, et al. (2012a)	Investigate modes of learning and innovation and identify the most effective one	Quantitative (panel regression analysis)	8500 firms, 33789 observations	Spain	Firms using STI mode alone are more likely to innovate in products. Firms using DUI mode are more likely to innovate in processes
Isaksen & Nilsson (2013)	Investigate modes of learning and innovation and identify the most effective one	Qualitative	2 regions	Norway, Sweden	Firms combining STI and DUI modes of innovation are more likely to innovate in products
Nunes et al. (2013)	Investigate modes of learning and innovation and identify the most effective one	Quantitative (regression analysis and latent class models)	397 firms	Portugal	The most successful firms are those employing STI+DUI mode of innovation

Fitjar & Rodríguez-Pose, 2013	Explore sources of firms' knowledge and types of collaboration	Quantitative (regression analysis)	1406 firms	Norway	Both STI and DUI interaction matter for innovation. Within the DUI mode, collaboration with extra-regional agents is much more conducive to innovation than collaboration with local partners. Cooperation with competitors can harm firms’ innovative ability
Chapter 3 of the thesis	Investigate modes of learning and innovation and identify the most effective one	Quantitative (regression analysis)	489 firms	Belarus	Firms combining STI and DUI modes of innovation are more effective in generation product innovation. Firms using the DUI mode alone are more effective in generation organizational innovation

Source: own elaboration

2.5 Results of grounded meta-analysis

Grounded meta-analysis is more a deductive than inductive process and requires the investigator to start their analysis without clearly determined set of research questions or hypotheses (Hossler & Scalese-Love, 1989). Specifically our study addresses the following questions:

1. What are the major research purposes of studies on modes of innovation?
2. What are the major methodologies of studies on modes innovation?
3. What are the most appropriate indicators of the STI and DUI modes of innovation?
4. What is the most effective mode of innovation across countries?

2.5.1 Research question 1: Distribution of research purposes

We categorized each article into two groups according to its research purpose: (1) it investigates modes of learning and innovation and identifies the most effective one; (2) it explores the sources of firms' knowledge and the types of *interaction.* The most frequent research purpose is to investigate the modes of learning and innovation (71% of analyzed studies). For the rest of the articles the main purpose is to explore the sources of firms' knowledge and the types of interaction.

Research purpose 1. To explore STI-DUI types of interaction.

The studies pertaining to the first group according to their research purpose, explore diversity in interaction and knowledge sources of SMEs - relying on different modes of innovation. As we have already mentioned when introducing STI/DUI indicators that there are two types of firm interactions: *STI interaction (collaboration)* and *DUI interaction (collaboration). STI interaction* implies cooperation with universities, laboratories and other research organization. When we talk about the *DUI interaction* we consider the *external DUI interaction, i.e.* collaboration in innovation activities with customers, suppliers, distributors and competitors. Fitjar and Rodriguez-Pose (2013) investigate two types of firm interactions (STI/DUI) based on a sample of 1604 firms in Norwegian city-regions. By means of a logit regression analysis, they test the relationship between the STI and DUI modes separately with product and process innovation. Attention is also paid to the geographical location of partners. The results of regression analysis show that the collaboration within extra-regional agents is much more relevant for innovation in STI, DUI and STI+DUI firms, and that DUI collaboration outside the supply-chain (with competitors) can have a detrimental effect. Fitjar and Rodriguez-Pose (2013) have revealed that different types of partnerships are related to different types of innovation. From the partnerships linked to the STI mode of innovation, only interactions with universities (but not with research institutes and consultancies) are relatively strongly associated with radical product and process innovation. DUI cooperation with customers and suppliers is closely related to the innovative capacity of firms, while cooperation with competitors has a detrimental effect on innovation. Collaboration with suppliers has a strong positive impact on all types of innovation, especially on process innovation. Collaboration with customers is closely related to product innovation, however, does not significantly affect process innovation. The analysis conducted by Trippl (2011) is based on the case study of 10 firms in the Vienna food sector and 10 interviews with research organizations and industry experts. It was found that the DUI collaboration mainly takes place with extra-regional partners, while STI proved to be mainly regional. Different results were found by Isaksen and Karlsen (2012a). According to this study, firms relying on the STI mode source most of their knowledge outside the region, while firms relying on the DUI mode of innovation tend to focus their knowledge sourcing in the region. Isaksen and Karlsen (2010) show that universities often cooperate with industries and businesses dominated by the STI mode of innovation (e.g. biotechnology industry). However, cooperation between universities and industries dominated by the DUI mode of innovation also takes place, mostly in the form of education and training of personnel. The empirical analysis conducted by Chen, et al. (2011) illustrates that firms relying on the DUI mode benefit from relationships with value chain partners and competitors as well as with technology-related organizations. In addition, they found that firms relying on the STI mode profit from collaborations with universities and research institutes, as well as with value chain partners.

Research purpose 2. To identify the most effective mode of learning and innovation.

The most popular research purpose across the analyzed studies is to identify the most effective mode of innovation. In their pioneering study, Jensen et al. (2007) have shown that firms in Denmark that use mixed the STI and DUI modes of innovation are more innovative than the rest. In their study, the modes of innovation are tested using data from the 2001 Danish DISKO survey. On the sample of 692 firms, they perform a cluster analysis to identify groups of firms that practice different modes: low learning, STI, DUI and DUI+STI clusters. However, Fitjar and Rodriguez-Pose (2013, p. 2) consider that such division “implies a significant loss of information about STI and DUI modes of learning at the level of each firm” because of the strict assignment of the firm to one of these four categories. The innovation output in the article by Jensen et al. (2007) is measured in terms of product and service innovation. A classification of this variable is the following: no innovation, new-to-firm, new-to-national market and new-to-international market. The authors show that the combination of the STI mode of innovation and the DUI mode is strongly correlated with innovation output. Guo et al. (2010) conduct a complementary analysis based on empirical data extracted from a study conducted by Jensen et al. (2007). They point out that higher innovation performance can be achieved by combining the two modes.

Later, Chen and Guo (2010), Aslesen et al. (2012), Isaksen and Nilsson (2012), Isaksen and Karlsen (2012a), Nunes et al. (2013), Amara et al. (2008) and our study in chapter 3 confirmed totally or in part the results produced by Jensen et al. (2007). The study by Chen and Guo (2010) is based on the sample of 230 of Chinese manufacturing firms. According to the authors, firms combining the STI and DUI modes of innovation are more likely to innovate than those emphasizing the STI or DUI mode separately. Aslesen et al. (2012) analyze the dominant modes of learning and innovation based on a sample of 96 firms in the Agder region in Norway. This study corroborates the result obtained by Jensen et al. (2007); the combination of the two modes of innovation is the most effective business strategy. According to Aslesen et al. (2012), firms that use the STI+DUI mode of innovation respond differently to the challenges of globalization. For example, the DUI firms face a high risk of failure because of high competition from low-cost countries. The STI firms, in turn, face the threat of being relocated to another country if they do not ensure a strong competitive advantage to their international or national business groups. Nevertheless, firms that combine the STI and DUI mode of innovation are more likely to ensure higher competitiveness thanks to their strong regional technological base. On the sample of 639 technology manufacturing Canadian SMEs, Amara et al. (2008) tested the relationship between learning and novelty of innovation of the established SMEs by means of regression analysis. They deduced that learning by searching (investment in R&D, scientific trained personal, STI mode) and learning by training, doing, using and interacting (DUI) impact positively on the degree of novelty of innovation in SMEs. A recent our study in chapter 3 concludes that the SMEs that combine the STI and DUI modes of innovation are more likely to generate radical product innovation. However, in contrast to product innovation, firms combining two modes of innovation are not more effective in generating organizational innovation than firms relying on the DUI mode alone (Ibid). In contrast to the above mentioned studies, on the basis of empirical evidence from Spain, Parrilli and Elola (2012) show that the product innovation is, in fact, more sensitive to the STI drivers than to the DUI drivers. Three modes are tested on a sample of 409 Spanish SMEs in the Basque country (region in Spain) mostly belonging to medium-technology manufacturing and high-tech knowledge-intensive services industries. An ordinal regression analysis is performed to evaluate the impact of modes of innovation on product innovation. In their case, the combination of STI+DUI innovation modes does not add value (i.e. innovation output) to the adoption of the STI mode alone. In the study based on data from Spain, Gonzalez-Pernia et al. (2012) demonstrate that the combined effect of the STI+DUI mode does not seem to improve the effect on innovation output (i.e. product and process) vis-a-vis the separate effect of the STI and DUI modes. In contrast to the previous studies that are based on one time period, Gonzalez-Pernia et al. (2012) apply a multi-period approach by using large longitudinal data. In order to verify the relationships between the innovation drivers and their output, panel regression tests were conducted using 33,789 observations from 8,500 Spanish firms.

2.5.2 Research question 2: Distribution of research methodologies

Both quantitative and qualitative studies are essential for an exhaustive synthesis of the available literature. One of the main reasons why we conduct a grounded meta-analysis is because it enables us to combine both qualitative and quantitative studies that are essential for an exhaustive synthesis of the literature on modes of innovation. The greater part or 59 % of all analyzed studies are quantitative and 41% are qualitative.

We have classified the research purposes as: (1) investigate modes of learning and innovation and identify the most effective one, (2) explore sources of firms' knowledge and types of interaction. The majority of studies with purpose (№1) are qualitative (60%). However, studies with purpose (#2) are mostly quantitative (67%). In the majority of quantitative studies, regression analyses were conducted, while qualitative studies are almost completely based on case study methodology.

2.5.3 Research question 3: Indicators of the STI and DUI modes.

Researchers empirically assess different typologies of modes of innovation with the help of the indicators. There is a big diversity of indicators of the DUI mode, while indicators of the STI are more common. Notwithstanding the lack of standard indicators, we extracted 4 indicators that define the STI mode and 14 indicators that characterize the DUI mode of innovation (Table 2.3). We have not included exact measures of indicators because of the wide diversity of scales (Likert, binary, ordinal, interval and absolute values). The first group of STI indicators emphasizes that innovations are the result of science and R&D (Jensen et al., 2007; Parrilli and Elola, 2012) suggesting that investment in R&D and scientific human capital are considered as key innovation inputs. These indicators are more common in the analyzed studies, thus, have not evolved much since were introduced by Jensen et al. (2007). In this regard, the first indicator of the STI mode is the expenditure on R&D (mostly as a percentage of the annual turnover or in absolute terms). The next indicator is the number of R&D personnel. The third indicator assesses the level of *STI interaction*, i.e. cooperation with researchers attached to universities or research organizations.

Unlike the STI mode, the DUI mode stresses the practical and interactive nature of innovation. This mode of innovation stresses that the innovation is based on learning-by-doing, by-using and by-interacting (Arrow, 1962; Rosenberg, 1982; Lundvall, 1992; Jensen, et al., 2007). The indicators of the DUI mode are diverse and heterogeneous across the analyzed studies. Indicators introduced by Jensen et al. (2007) were capable of assessing only Interactive (I) aspects of the DUI mode. As the methodology of measuring the DUI mode evolved over time, new indicators were proposed. We have grouped the indicators in three groups on the bases of three aspects of the DUI mode: D (doing) and U (using) and I (interacting). In chapter 3 we firstly proposed the first two drivers such as preliminary marketing and technological preparation for production to assess “D” (doing) and “U” (using) aspects of the DUI mode. The other 12 indicators measure “I” (interactive) aspects or internal and external business relationships established by the firm. *Internal DUI interaction* works within a firm top-down and bottom-up (vertical communication) and between different company departments (horizontal communication) (Hinds & Kiesler, 1995). The indicators of DUI internal interaction are interdisciplinary workgroups, quality circles, systems for collecting proposals and autonomous groups. Some indicators (integration of function, softened demarcations) measure whether a firm has a flexible and decentralized organizational structure. The indicators assessing *external DUI interaction* show whether a firm collaborates in innovation activities with customers, suppliers and distributors, competitors and other organizations (Fitjar & Rodriguez-Pose, 2013; Fu, et al., 2013). All indicators are depicted in Table 2.3.

Table 2.3. Indicators of the STI and DUI modes of innovation

	Variables	**Description**	Literature
The STI mode			(Jensen, et al., 2007; Aslesen, et al., 2012; Chen & Guo, 2010; Gonzalez-Pernia, et al., 2012a) and our study in chapter 3
1	Expenditures on R&D	Expenditures on R&D (intramural, external) as share of total revenue	
2	Scientifically trained personnel	A firm employs scientifically trained personnel (master and PhD degree)	
3	Cooperation with researchers, technology centers, universities	If a firm cooperates with researches attached to universities or scientific institutes	
4	Level of research activities	Participation in academic conferences; publications in scientific journals; existence of scientific laboratories and department within the company	
The DUI mode			
	D (doing)		
1	Expenditures on marketing related to technological innovation	Indicates whether a firm reported expenditures on a preliminary study, market research, adaptation of the product in different markets and initial advertising	
	U (using)		
2	Expenditures on technological preparation for production	Indicates whether a firm reported expenditures on technological preparation for production including design and engineering of products	

	I (interacting) internal	
3	Interdisciplinary workgroups	To measure whether or not the firm makes use of the core high-performance work practices
4	Quality circles	
5	Systems for collecting proposals	
6	Autonomous groups, teamwork	
7	Integration of function	Whether a firm has flexible and decentralized organizational structure. Measurement of the extent to which functions are integrated and a measure of the extent to which demarcations are softened
8	Softened demarcations (decentralization)	
9	Education/training systems	Whether a firm's education/training systems take place
10	Communication policy that involves the whole organization	Communication works in both directions: top-down and bottom-up (vertical communication). Better communication and collaboration across different company departments is pursued (horizontal communication)
11	Collective Creativity	Team meetings are organized to search for and to discuss new ideas
12	Collective selection and management of innovative ideas	All members of the company use formal mechanisms and procedures to select and manage innovative ideas
	I (interacting) external	
13	Interaction and cooperation with customers, suppliers, competitors	If the firm interacts with customers and pilot-customers, suppliers, competitors, distributors

Source: own elaboration

2.5.4 Research question 4: The most effective mode of innovation

Via coding procedures (Hossler & Scalese-Love, 1989; Stall-Meadows & Hyle, 2010; Corbin & Strauss, 2007), we synthesize the data about the most effective business innovation mode that are presented in Table 2.4. Most in-country analyses focus on countries that operate in market economies: Denmark (Jensen, et al., 2007), Norway and Sweden (Aslesen, et al., 2012; Isaksen & Nilsson, 2013; Isaksen & Karlsen, Combined and complex mode of innovation in region cluster development: analysis of the light-weight material cluster in Raufoss, Norway, 2012a), Portugal (Nunes, et al., 2013), Canada (Amara, et al., 2008) and Spain (Parrilli & Elola, 2012). In contrast, only one that has appeared recently is based on firms' data from countries that operate in transition economies (here chapter 3).

We can observe that for almost all analyzed studies with the research purpose #2 (to investigate modes of learning and innovation and identify the most effective one), the STI+DUI mode is identified as the most effective one. Thus, firms in Denmark, Norway, Sweden, Portugal, and China perform more effectively through the combination of the STI and DUI modes of innovation. According to the analysis of SMEs in post-soviet countries in transition, firms combining the STI and DUI modes of innovation are more likely to generate product innovation (see chapter 3), while firms relying on DUI mode alone are more likely to generate organizational innovation. In contrast, Parrilli and Elola (2012) show that product innovation is more sensitive to STI drivers than to DUI drivers. The authors tested the modes of innovation on a sample of

Spanish SMEs (in the Basque region) that belong to medium-technology manufacturing and high-technology knowledge-intensive service industries situated in a region characterized by a high innovation capability (Parrilli & Elola, 2012; González-Pernía, et al., 2012b). On the bases of these different empirical data and studies, we conclude that, regardless of the country’s geographical and economic context, the most effective mode of innovation is the STI+DUI. However, some deviations can be observed in studies based on one or several regions or types of chosen industries (low- or high-technology manufacturing industries, high-tech or less knowledge-intensive services etc.).

Table 2.4. Most effective mode of innovation

Study	Country	Economy	The most effective mode
Jensen et al. (2007)	Denmark	Market, North Europe	STI+DUI
Aslesen et al. (2012) (2012), Isaksen & Karlsen (2012a), Isaksen & Nilsson (2013)	Norway, Sweden	Market, North Europe	STI+DUI
Nunes et al. (2013)	Portugal	Market, South Europe	STI+DUI
Parrilli & Elola (2012), Gonzalez-Pernia et al. (2012b)	Spain	Market, South Europe	STI (product innovation, DUI (process innovation
Amara et al. (2008)	Canada	Market, North America	STI+DUI
Chen & Guo (2010)	China	Emerging	STI+DUI
Study in chapter 3	Belarus	Transition, post-soviet	STI+DUI (product innovation), DUI (organizational innovation)

Source: own elaboration

2.6 Conclusion

This chapter contains the literature on the evolution of the major innovation theories and grounded meta-analysis of studies of STI/DUI modes of innovation. This meta-analytic approach gives the opportunity to analyze studies that focus on the same topic, but apply different methodological designs. Categories such as research purpose, methodology, indicators and findings have been extracted.

Considering the limited number of studies and because of the rather new theoretical framework of the STI/DUI modes (starting from 2007), we realize that our results should not be totally generalized. However, the results of our study highlight several issues that could help researchers to focus on studying the phenomenon, policy makers to promote programs that support the innovation mode of firms (industry) and help managers to foster effective innovation performance in their companies. This study is a relevant reference basis for future research on firm’s modes of innovation. The meta-analysis can be useful for young researchers as it provides a comprehensive analysis of the state-of-the-art in their area of interest. For further improvements we would like to highlight following issues.

First, the attention of international researchers has been paid to the ongoing debate on the most effective mode of SMEs innovation (Chen, et al., 2011; Aslesen, et al., 2012; Parrilli & Elola, 2012, Isaksen & Nilsson, 2013). The studies have shown that firms in Denmark and Norway, Sweden, Portugal, Canada and China and Belarus combining the STI and DUI modes of innovation are more likely to innovate than those relying on STI or DUI mode alone.

Secondly, researchers can face difficulties in assessing empirically different typologies of modes of innovation because of the large diversity and lack of standard indicators of the STI and DUI modes. The future research line could be to further identify reliable indicators, which are essential for high-quality empirical analyses.

The third issue relates to a possible problem of reverse causation (endogeneity) between the dependent variable and independent variables in quantitative studies. This problem concerns endogeneity and must be addressed by including in the model the value of explanatory variables with a lag (Bilbao-Osorio & Rodriguez-Pose, 2004; Audretsch & Keilbach, 2004) compared to the dependent variable for which data are available. Moreover, it can take several years until the R&D activities and interaction (Rosenberg, 1990) can start generating a cash flow and affect industrial productivity. The majority of studies use only data from a one-year period. Longitudinal data would be more relevant to verify such tendencies over a longer time span.

Finally, studies of modes of innovation do not show what the composition of innovation drivers is in the combination of the STI and DUI mode of innovation. In this regard, a good research line could focus on the analysis of how different drivers of innovation could be combined within the firm. We believe this would be another important contribution.

Chapter 3. The impact of business innovation modes on innovation performance: the case of Belarus

Chapter 3. The impact of business innovation modes on innovation performance: the case of Belarus

3.1 Introduction

The ability of SMEs to generate, develop and exploit their innovation is a precondition for their long term economic performance. This study stresses the importance of innovation based, on the one hand, on science and technology factors (Griliches, 1979; Romer, 1994; Greunz, 2005) and, on the other hand, on learning-by-doing, by-using and by-interacting (Rosenberg, 1982; Lundvall, 1992; Arrow, 1962).

Over the last twenty years, SMEs have been regarded as a driving force of innovation and economic performance due to their nimbleness and flexibility (Rammer, et al., 2009; UNECE, 2011; Audretsch, 2003). In this thesis, we analyze the innovation performance of SMEs and address the following research questions: Which drivers promote the innovation of SMEs? What is the most effective mode of SME innovation in the context of transition economies?

The debate on STI/DUI modes in SME innovation has attracted interest among international scholars. However, the majority of in-country analyses on the modes of innovation have mainly focused on developed countries that operate in market economies. The studies have shown that firms in Denmark (Jensen, et al., 2007), and Norway and Sweden (Isaksen and Nilsson, 2012, Aslesen et al., 2012) combining STI and DUI modes of learning and innovation are more likely to innovate than those relying on the STI or DUI mode alone. On the contrary, based on empirical evidence from Spain (Parrilli & Elola, 2012), it was argued that SME innovation is, in fact, more sensitive to STI than to DUI drivers. Only a few studies have been based on company data from countries that operate in emerging economies such as China (Chen & Guo, 2010; Chen, et al., 2011). However, studies that analyze the effect of modes of innovation performance of firms in the context of countries in transition are absent. The peculiarities of these countries are, on the negative side, the lack of financial capital, innovation management experience and state-of-the-art technology (Rees & Miazhevich, 2009; Fink, et al., 2009), while, on the positive side, these countries can count on a high level of educated human capital in comparison with Western Europe (Aidis, et al., 2008). These aspects may lead to the adoption of a peculiarly effective innovation mode that is representative of this kind of countries.

On this basis, we aim at analyzing the effect of three critical modes of innovation on innovation performance of SMEs in the context of economies in transition. With this purpose in mind, we enrich the methodology of measuring the DUI mode by adding new indicators that help to assess learning-by-doing, by-using drivers. Vis-a-vis other contributions in the field, we estimate which of the modes is more effective in generating innovation. We then study the influence of the STI and DUI modes not only on product but also on organizational innovation, which has not been studied in earlier researches on modes. For our empirical analysis, we selected Belarus as a representative of post-soviet countries in transition. In this study, we benefit from data of 489

Belarusian SMEs compiled by the National Statistical Committee of the Republic of Belarus (Belstat) that adopts a similar format to the community innovation survey (CIS).

We aim at contributing to the theoretical and empirical debate on the STI and DUI modes of innovation by generating hypotheses and results on the most effective mode of innovation. This chapter is structured as follows. In section 3.2 we provide the reference to the main streams of research that focus on adoption of STI and DUI modes of innovation. In section 3.3 we identify the focus of our study and hypotheses. In this section we make a presentation of transition economies and Belarus as representative of these types of economies. In sections 3.4 and 3.5 we describe the sample, present the selected methodology and the results of the statistical and econometric analysis. In the final section we summarize the study and discuss the findings and implications for SMEs and policy makers; moreover, we point out the limitations and issues that should receive attention in future investigations on business modes.

3.2 The STI/DUI modes of innovation

The STI mode emphasizes the importance of scientific human capital and innovation infrastructure (e.g. R&D institutions and universities). Human capital involves employees with a PhD in natural sciences or in construction engineering (Jensen et al., 2007) that are involved in innovation projects. A high level of scientific education across the employees increases their absorptive capacity and, consequently, improves the impact of R&D activities (Cohen & Levinthal, 1989). The main partners of STI firms are researchers, universities and research organizations (Isaksen & Karlsen, 2012b; Jensen, et al., 2007; Parrilli & Elola, 2012). The accumulation of knowledge through R&D activities forms a main source of increasing returns to production factors and is a fundamental component of endogenous growth (Greunz, 2005). However, the STI mode of innovation does not explain the paradox of firms in countries such as Norway, where reduced investments in R&D lead to high innovation performance and economic growth rate (OECD, 2007).

The DUI mode of innovation is based on practice, experience and interactions. The learning-by-doing introduced by Arrow (1962) increases productivity by repeating the same manufacturing operations that lead to experiential learning advantages. Amara et al. (2008) relate learning-by-doing to formal and informal activities including promotion and marketing. Repeating activities in experimentation and promotion of new or improved goods and services in the markets help problem solving and encourage learning-by-doing. Rosenberg (1982) argues that learning from user experience and demand in customizing products contributes to innovation and productivity growth. The use of technologies, machines and equipment facilitates learning-by-using, e.g. acquiring competences by deploying relevant state-of-the-art technology (Rosenberg, 1982; Amara, et al., 2008). Interaction with external organizations and the establishment of linkages with different actors conduce to the generation of innovation (Lundvall, 1988; Ritter & Gemünden, 2004; Fitjar & Rodriguez-Pose, 2013). The need to find a solution to specific problems or to respond to specific requests is the main reason for SMEs to adopt this type of innovation process. The DUI mode of innovation relies on tacit (Nonaka & Takeuchi, 1995; Jensen, et al., 2007), synthetic and context-based (Asheim and Coenen, 2005; Asheim et al., 2011) knowledge. The knowledge is often generated from trial-and-error processes, shared mainly through tacit knowledge flows by employees and, therefore, it is highly localized (Isaksen & Karlsen, 2012b).

According to the degree of novelty, innovation can be classified as incremental and radical. Incremental innovations are dominated by the modification of existing products and processes, while radical innovations are considered as dramatically changed products leading to new market creation and existing products obsolescence (OECD, 2005). The DUI mode is typically associated with incremental types of innovation (Parrilli & Elola, 2012). However, Lorenz (2012) opposes this view and argues that the DUI mode as an interactive way to innovation also leads to radical innovation. He identifies creativity and labor market mobility as two of the most significant factors of radical innovation (Ibid). The STI and DUI modes of innovation are rarely found in pure forms in specific industries; however, industries can be dominated by either the STI or the DUI mode (Isaksen and Karlsen, 2010; Chen, et al. 2011). For example, pharmaceutical and chemical manufacturing industries are dominated by the STI mode, while machine-tools, cars, textiles, furniture and mechanical engineering are industries in which the DUI mode is dominant (Chen, et al, 2011; Isaksen and Karlsen, 2012a).

The third mode was identified as a combination of STI and DUI modes of innovation. Within this approach, firms that used one mode intensively may benefit from paying more attention to the other. Jensen et al. (2007) argue that firms that combine the STI with DUI modes are more innovative. The recent studies by Aslesen et al. (2012), Isaksen and Karlsen (2012a) on Norway, Isaksen and Nilsson (2012) on Norway and Sweden, Nunes et al. (2013) on Portugal and Chen and Guo (2010) on China, confirm the Jensen et al's. (2007) result. On the contrary, based on empirical evidence from Spain, Parrilli and Elola (2012) argue that product innovation is in fact more sensitive to STI drivers than to DUI drivers.

The majority of studies on modes of innovation mainly focus on developed countries that operate in market economies. In post-soviet transition economies no studies have been performed on the influence of STI/DUI modes of innovation on innovation performance.

3.3 Transition economies: the case of Belarus

To understand the environment in which firms operate, we provide some peculiarities of countries in transition. A transition economy is an economy of the former Soviet Union[1] and some South-Eastern European countries[2] shifting from a centrally planned economic system to a free market regime (Feige, 1994; UN, 2013). These countries try to attain the efficiency advantages of the market economy. However, this process is complex because it requires a fundamental restructuring of a

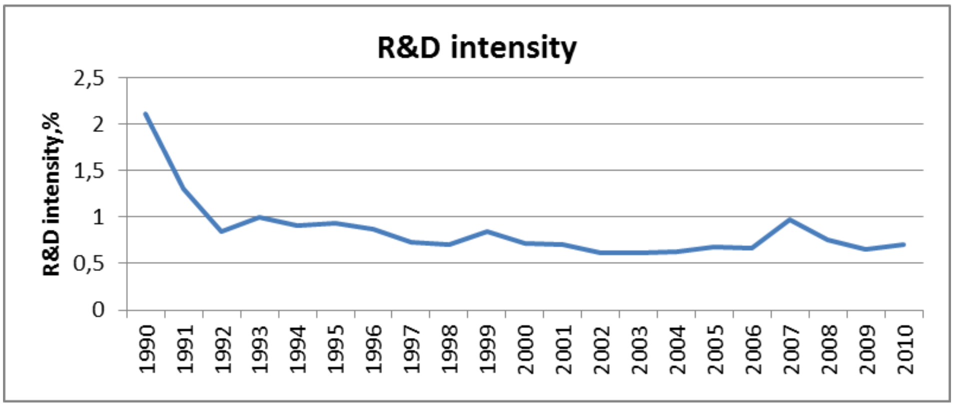
[1] Members of CIS (Commonwealth of Independent States) and Georgia

[2] Bosnia and Herzegovina, Croatia, Montenegro, Serbia, The former Yugoslav Republic of Macedonia

nation’s economic, political, social institutions and infrastructure (Feige, 1994). Countries in transition bring in economic liberalization and shift to an economy where market forces set prices rather than where prices are dictated by central planning institutions (Feige, 1990; Aidis, et al., 2008; Krammer, 2009). Countries in transition are characterized by financial constraints and lack of experience in innovation management and state-of-the-art technology (Qian & Weingast, 1996; Goetz & Wollmann, 2001; Havas, 2002; Aidis, et al., 2008; Fink, et al., 2009). Also for these reasons, such economies operate behind the frontier of technology (Varblane, et al., 2007; Alam, et al., 2008).

For our empirical analysis, we selected Belarus as a representative of countries in transition. The collapse of the Soviet Union brought forward radical changes in economic, social and political spheres in Belarus that caused a fundamental transformation in scientific and technological development in the country. In 1990 the value of R&D intensity (investments in R&D as percent of GDP) in Belarus was comparable with the leading OECD countries. Figure 3.1 shows that during the period from 1990 to 2010 the value of this indicator decreased threefold.

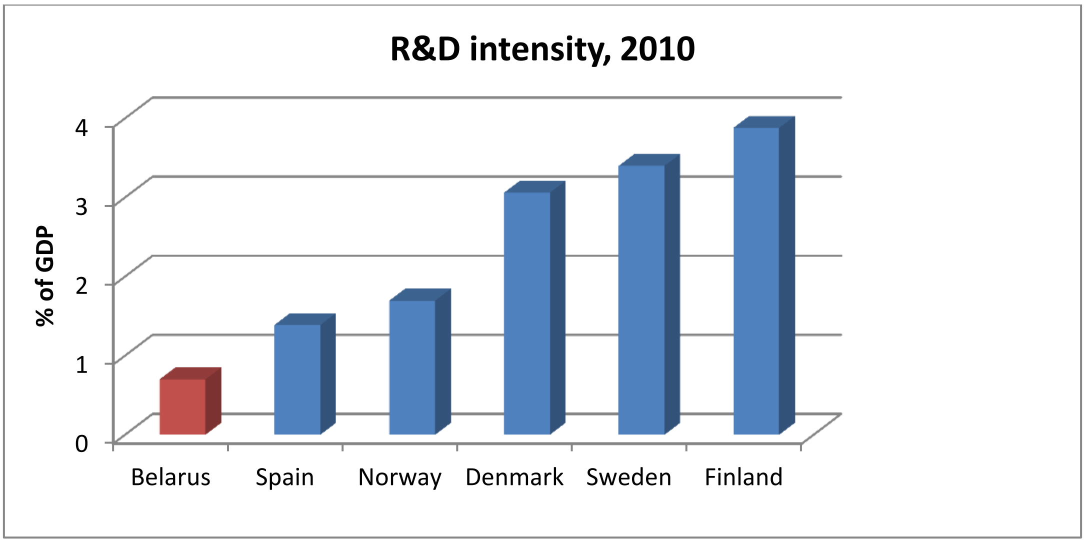
Figure 3.1. Research and development expenditure (% of GDP) in Belarus



Source: World Bank, 2013, International Economics indicators

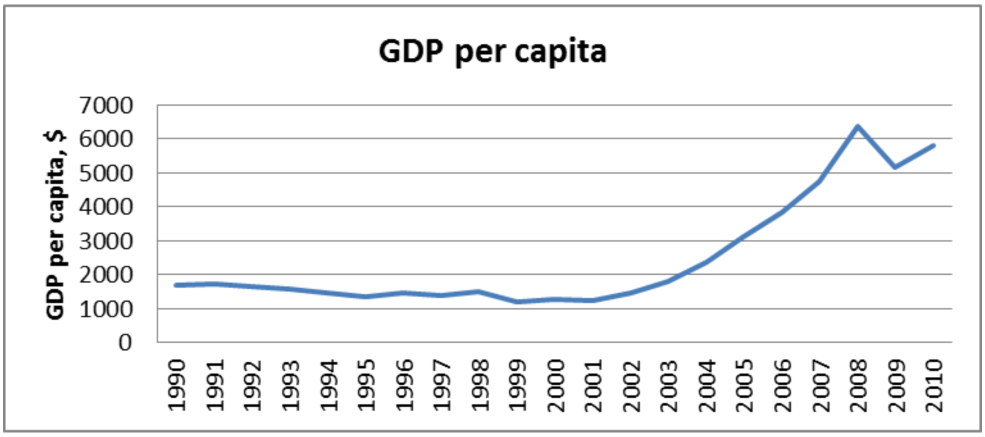
According to the Program of Social and Economic Development of the Republic of Belarus 2007-2010 (SPID, 2007) it was planned to increase R&D intensity by 2010 to 1.2-1.4% of the GDP. However, this objective was not reached and the value of this indicator in 2010 was 0.7%, which is three times lower than the world average and six times lower when compared to Finland. Alas, Belarus does not fit into the global trend of rising expenditures in R&D. The comparison with European countries shows that Belarus has a low level of R&D investment Figure 3.2. This parameter indicates, on the one hand, insufficient governmental support for innovation activities and, on the other, the reluctance of businesses to invest in R&D. Surprisingly, notwithstanding the reduction of R&D investments, Belarus demonstrates a threefold increase in GDP per capita (Figure 3.3) from 1990 to 2010.

Figure 3.2. Research and development expenditures (% of GDP) in Belarus



Source: World Bank, 2013, International Economics indicators

Figure 3.3. GDP per capita in Belarus, US $



Source: World Bank, 2013, International Economics indicators

The Belarusian case resembles the "innovation paradox" of Norway and Denmark, where despite the relatively reduced investments in R&D, high economic growth is observed (OECD, 2007; Asheim & Parrilli, 2012). The "innovation paradox" can be explained by the bias of innovation indicators towards formal R&D and high-tech development (Sotarauta, et al., 2006). Therefore, these proxies capture only scientific types of knowledge and indicators that characterize the STI mode of innovation.

However, practice, specialization in production, product customization, interaction and networking (the DUI mode) (Lundvall, 1988; Ritter and Gemünden, 2004; Sotarauta et al., 2006; Amara et al, 2008) are other ways for SMEs to be innovative that cannot be described and assessed by STI indicators. In Denmark (Jensen et al., 2007) and Norway (Isaksen and Karlsen, 2012a; Aslesen, et al., 2012), the combination of STI and DUI modes is proved to lead to better innovation performance that, in turn, leads to economic growth. However, we cannot extrapolate Scandinavian conclusions to the Belarusian case and to transition economies in general, due to the important differences in innovation policy, private sector dynamics and market institutions (Varblane, et al., 2007; Alam, et al., 2008). For countries in transition, the "Norwegian paradox" is not a paradox because these countries operate behind the technology frontier and grow mostly on the basis of imported technology and production capacity (Radosevic, 2011).

Many influential scholars recognize that firms that establish a strong science base and perform R&D activities are successful in generating product innovation (Cohen & Levinthal, 1990; Romer, 1994; Greunz, 2005; Love & Mansury, 2007). Other scholars argue that the probability of product innovation increases when the firm has organized itself in order to promote learning-by-doing, by-using and by-interacting drivers (Arrow, 1962; Rosenberg, 1982; Lundvall, 1992). We hypothesize that both the STI and the DUI mode are positively related to product innovation:

Hypothesis 1a: The STI mode of innovation is positively related to product innovation.

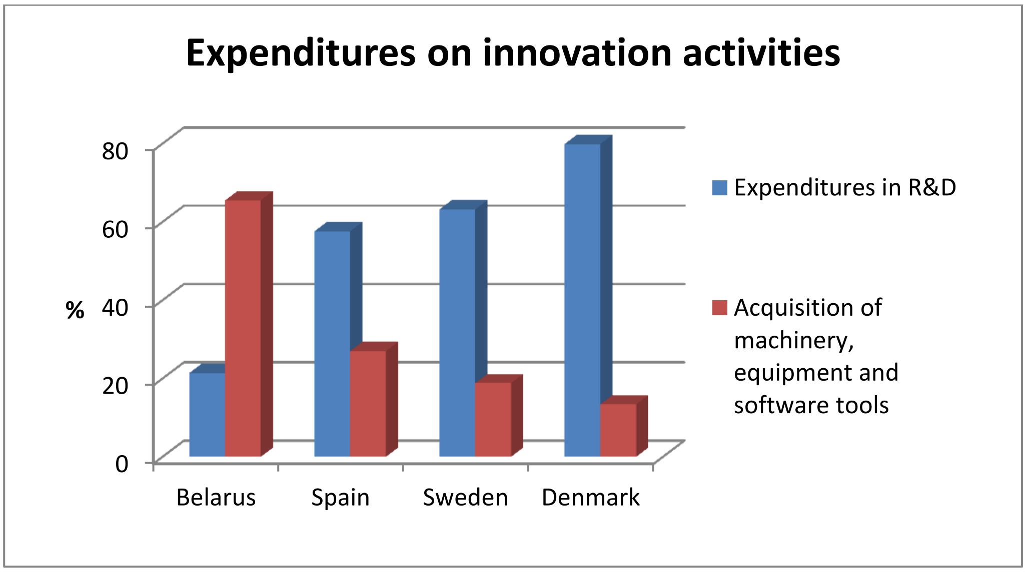
Hypothesis 1b: The DUI mode of innovation is positively related to product innovation.

If we observe Figure 3.4 and compare the shares of expense items in total business expenditure on innovation activities, Belarusian enterprises invest three times more in acquisition of new machinery equipment and software tools (basic machinery, not sophisticated technology) than in R&D (Belstat, 2012). On the contrary, Swedish enterprises invest three times more in R&D than in machinery and equipment. The high share of expenditure on machinery and equipment in Belarus suggests that as in many economies that operate behind the technology frontier, technological innovation in Belarus concerns mainly the purchase of machinery whereas investments in R&D are not primary components. Much attention in the State Program for Innovative Development of the Republic of Belarus 2011-2015 (SPID, 2011) is given to the modernization of Belarusian enterprises and replacement of archaic machinery that dates back to Soviet times. In catching-up processes, the key issue in productivity growth is the effective use of newer technologies rather than the generation of brand-new technologies (Varblane, et al., 2007; Alam, et al., 2008; Radosevic, 2011).

Therefore, we argue that, in the catching-up economy, SMEs are used to relying on experience-based learning, as well as learning-by-using new technology. Thus, SMEs that rely on DUI mode alone are more likely to be innovative than those that rely on basic R&D activities and generate new technologies.

Hypothesis 1c: Firms that rely on DUI mode alone are more effective in generating product innovation than those that rely on the STI mode alone.

Figure 3.4. Expenditures on innovation activities, 2012



Source: National Statistical Committee of the Republic of Belarus (2013), Science and Innovation Activity in the Republic of Belarus. Statistical book

Nevertheless, we argue that firms that combine learning-by-doing, by-using and by-interacting with the current R&D activities and cooperation with universities, research institutions are likely to be more innovative. We propose following hypothesis:

Hypothesis 1d: Firms combining the STI and DUI modes of innovation are the most effective in generating product innovation.

In addition to product innovation, in this chapter we also investigate *organizational innovation* in order to deliver a wider picture of the innovation processes within SMEs. There is a lack of studies on organizational innovations as the existing literature is more focused on technological innovations (Damanpour & Aravind, 2012). Academics clearly separate organizational from technological innovations (Chandler, 1962; Lam, 2005; Sanidas, 2005). For example, technological process innovations are new machines, equipment and other goods that are used in the production process (Edquist, et al., 2001). Organizational process innovations are a new way of organizing and coordinating business activities (Ibid). Lam (2005) argues that organizational innovation is a precondition for technological innovations. Such innovations can improve the quality, efficiency of work and firms’ ability to learn and utilize new knowledge and technologies (OECD, 2005). According to the Oslo manual (OECD, 2005, p. 153), organizational innovation is “the implementation of a new organizational method in the firm’s business practices, workplace organization or external relations”. A firm that generates organizational innovations can be characterized as a creative and flexible organization, oriented towards continuous learning and creating new knowledge

(Nonaka & Takeuchi, 1995; Cohen & Levinthal, 1990; Lam, 2005; Asheim & Coenen, 2005). This type of innovation involves new ways of introducing and organizing management systems for general production, such as supply chain management systems, business re-engineering, lean production, and quality-management systems (Damanpour & Aravind, 2012).

Organizational innovations are "normally initially developed through processes of trial-and-error and learning-by-doing within the innovating firms" (Edquist, et al., 2001, p. 16). The process of creative problem-solving is argued to be a source of organizational innovations (Lam, 2005) that requires frequent collaborations and interactions between various people, including managers, office workers, production workers, consultants, among others. For example, the problem can be expressed as the conflict between two departments in terms of distribution of resources. The solution requires positive interactions. The DUI drivers act through learning from everyday work and problem-solving and decentralized softened functional demarcations that can lead to important organizational innovations. On these bases, we propose the following hypothesis:

Hypothesis 2a: The DUI mode of innovation is positively related to organizational innovations.

Organizational process innovations are a new way of organizing and coordinating business activities. This type of innovation has to do with coordination of human resources and has no technological elements (Edquist, et al., 2001). Organizational innovations are not "usually based on formal R&D activities" (Edquist, et al., 2001, p. 16). These premises lead us to following hypothesis:

Hypothesis 2b: The STI mode of innovation is not significantly related to organizational innovations.

Following the logic of 2a and 2b hypotheses, we do not expect any additional contribution in the combination of STI and DUI mode. This leads to the following hypothesis:

Hypothesis 2c: Firms combining the STI and DUI modes of innovation are not more effective in generating organizational innovation than firms relying on the DUI mode alone.

3.4 Data and methods

This section presents the empirical setting and data, the matching procedure, the variables and measures used in the analysis, and the econometric technique employed. We have followed a well-recognized methodology used in STI/DUI studies (which we introduce in this section) (Jensen, et al., 2007; Parrilli & Elola, 2012). The empirical analysis is based on a sample of Belarusian firms taken from an extensive database, which is compiled and maintained by the National Statistical Committee of the Republic of Belarus (Belstat) on the bases of CIS format. We consider the Belstat dataset appropriate to test the hypotheses in this study for several reasons. First of all, it allows us to identify key characteristics in the firms' invention activities, capabilities, strategies and behavior. Secondly, the data is compiled from public sources that can be checked and scrutinized. Thirdly, this dataset has not been employed in the literature on innovation modes, which means that our results can test and increase the robustness of previous findings on the role of STI/DUI modes in shaping business (or SME) firms' innovation strategies.

We started with a set of 1266 manufacturing and service firms. However, for 5 firms, data could not be reliably obtained. Therefore, they were subsequently dropped from the analysis. The number of firms available for the analysis was reduced to 1261. In order to restrict the sample to SME, we followed the European Commission Recommendation (2003) criteria based on the number of employees and firm's turnover. Therefore, we excluded from the analysis those companies with less than 10 employees and 2 million euros in turnover, and firms with more than 250 employees and 50 million euros turnover. The resulting sample is composed of 489 firms from the manufacturing and service industries.

3.4.1 Dependent variables description

We have two dependent variables in our study – product innovation and process innovation. Therefore, we conduct two regression models. We consider *product innovation output (ProdIO)* as the first dependent variable. It is a widely used measure of innovation performance (OECD, 2005; Jensen, et al., 2007). Belstat provides data on business turnover related to the development of products new-to-firm, new-to-national and international markets. This allows us to classify product innovation output according to the degree of novelty (Jensen, et al., 2007; Parrilli & Elola, 2012) that corresponds to the CIS format (2008): (0) – no innovation, (1) - new to firm innovation, (2) - new to the market (Table 3.1). The ‘zero’ level of the variable indicates that a firm did not report any sales of innovative products during the year 2012. The degree of novelty classified as ‘one’ demonstrates that a firm sold new or significantly improved new-to-firm products during the year 2012. ‘Two’ was assigned when a firm launched products that were new to the local and international markets. If a firm reported sales new-to-firm and new-to- market simultaneously, the highest level was chosen.

Table 3.1 Classification of product innovation

Variables	**Description**
No innovation	A firm did not report sales of innovative products (0)
New to firm innovation	A firm report sales of innovative products that are new to firm (1)
New to the market	A firm report sales of innovative products that are new to market (national and international) (2)

Source: own elaboration

The second dependent variable is *organizational innovation output (OrgIO)*. This type of innovation can be characterized as the implementation of new methods and procedures for organizing business activities that have not been used before in the firm (OECD, 2005). Such innovations improve the efficiency of work and the ability of the firm to learn; these are preconditions for technical innovations (Lam, 2005). The indicators of organizational innovation show whether or not (1 or 0) a firm implemented new strategy development, new managerial methods, working schedule changes, new control and product certification systems and new corporate knowledge management systems (Table 3.2). In order to get the final variable characterizing organizational innovations, we calculate the sum of these indicators and transform the value into an ordinal scale. We assigned a 'low' level to the variable that characterizes organizational innovation when the sum of its indicators equaled zero. The variable was equated to 'medium' level (1) when the sum of the indicators' values exceeded zero but was less or equal to the mean. When the sum possessed a value greater than the mean the 'high' level (2) was assigned. The explanatory table of variable transformation is provided in Table 3.4.

Table 3.2 Indicators of organizational innovation

Variables	**Description**
Strategy development	1 whether a firm reported new strategy development, 0 otherwise
New managerial methods	1 whether a firm reported new managerial methods, 0 otherwise
Working schedule changes	1 whether a firm reported working schedule changes, 0 otherwise
Control and product certification systems	1 whether a firm implemented new control and product certification systems, 0 otherwise
Corporate knowledge management systems	1 whether a firm developed new corporate knowledge management systems, 0 otherwise

Source: own elaboration

3.4.2 Independent variables description

We propose two groups of indicators to identify STI and DUI modes (Table 3.3). Specifically, in our construct, three indicators define the STI mode and three variables are designated as indicators of the DUI mode of innovation. The first group of STI indicators emphasizes that innovations are the result of science and R&D (Jensen et al., 2007; Parrilli and Elola, 2012) suggesting that investment in R&D and scientific human capital are considered as key innovation inputs. In this regard, the first indicator is the total expenditure on R&D. The next two indicators are the number of R&D personnel employed by a firm and the number of R&D departments. These indicators show whether a firm strategically relies on research and reflect the diversity of research portfolio of a firm. Unlike the STI mode, the DUI mode of learning is based on non-science-based indicators. We enrich the methodology of measuring the DUI mode by adding new indicators that help to measure learning-by-doing and using drivers. Firms perform more efficiently if they can learn from repeating operations or, in other words, they learn-by-doing (Arrow, 1962). We support the view of Amara et al. (2008) that marketing is one of the constituents of learning-by-doing. Repeating activities in the commercial promotion of new or improved goods and services in the markets encourage learning-by-doing that in turn improves the related knowledge capability and innovation capacity of the firm. Therefore, we chose the expenditure on preliminary marketing related to technological innovation as the first indicator of the DUI mode of innovation. The appropriation of advanced technologies leads to learning-by-using (Rosenberg, 1982; Amara, et al., 2008). A firm’s ability to understand and use relevant state-of-the-art technology, and exploring new ways of solving technical problems helps it to generate innovations that outperform competitors and increase profitability (Ritter and Gemünden, 2004; Rammer et al., 2009). Learning-by-using includes adopting more or less familiar technologies that hasten technological progress. This is more important in high-technology industries (Rosenberg, 1982). To facilitate this type of learning, many IT companies distribute trial versions of new software before their formal release. In this regard, our second variable indicates whether a firm reported expenditure on technological preparation for production. Then, our third selected indicator is related to the ability of the firm to learn-by-interacting (Lundvall, 1992), showing whether a firm closely cooperated with customers, suppliers and distributors. SMEs benefit from such interactions as these create opportunities to access experience-based knowledge and information about markets and technologies (Lundvall, 1992; Ritter & Gemünden, 2004).

Table 3.3. STI and DUI indicators

Variables	**Description**
STI indicators	
Expenditures on R&D	Expenditures on R&D as share of total sales (Belarusian rubles)
Scientifically trained personal	Number of scientifically trained personnel employed by a firm (units)
R&D departments	Number of R&D departments in a firm (units)
DUI indicators	
Expenditures on marketing related to technological	Indicates whether a firm reported expenditures on a preliminary study, market research, adaptation of the

innovation	product in different markets and initial advertising (0, 1)
Technological preparation for production	Indicates whether a firm reported expenditures on technological preparation for production including design and engineering of products(0, 1)
Interacting	Indicates whether a firm interacts either with customers or/and suppliers or/and distributors (0, 1)

Source: own elaboration

Following a well-recognized methodology used in STI/DUI studies (Jensen, et al., 2007; Parrilli & Elola, 2012), we transformed our STI and DUI indicators (having different measures) except interacting (0, 1) nominal scale into an ordinary scale (0, 1, 2). For this purpose, we computed the mean of non-zero cases for each indicator. If the indicator was equal to zero, we assigned ‘low’ level (0) to a new STI indicator. The ‘medium’ level (1) was set if a value of an indicator exceeded zero but was less or equal to the mean. Finally, when an indicator had a value greater than the mean the ‘high level’ (2) was assigned. After we transformed each indicator into the ordinary scale, we calculated the final variable that characterizes the STI mode. This variable was set to 0 (‘low’ level) when the sum of new STI indicators (transformed into ordinary scale) was equal to zero. ‘Medium’ level (1) was assigned when the sum of new indicators exceeded zero but was less or equal to the mean. When the sum possessed a value greater than the mean, the ‘high’ level (2) was assigned. The same procedure was performed to transform variables describing the DUI mode and the explanatory table of variable transformation is presented in Table 3.4.

Table 3.4. The explanatory table of transformation of variables

	Indicators	**Measure used in survey**	**Measure of indicators (transformation scale)**	**Measures of variable in regression model**
STI	Expenditures on R&D	Belarusian rubles (BYR)	If I =0 – low level (0); If 0 < I <= m – intermediate level (1); If I > m – high level (2)	If SI =0 – low level (0); If 0 < SI <= M – intermediate level (1); If SI > M – high level (2)
	Number of scientifically trained personal	Units		
	Number of R&D departments			
DUI	Expenditures on marketing related to technological innovation	BYR		
	Expenditures on technological preparation for production			
	Interacting (customers, suppliers and distributer). If firm cooperate at least with one of the partners 1 was assigned, 0 otherwise	(0) no, (1) yes		

Product innovation	Sales of innovative products and services new to firm	BYR	0 – no innovation; 1 – new to firm; 2 – new to the market	0 – no innovation; 1 – new to firm; 2 – new to the market
	Sales of innovative products and services new to local and international market			
Organizational innovation	New strategy development	(0) no, (1) yes	(0) no, (1) yes	If SI =0 – low level (0); If 0 < SI <= M – intermediate level (1); If SI > M – high level (2)
	New managerial methods			
	Working schedule changes			
	New control and product certification systems			
	New corporate knowledge management systems			

* I – value of any indicator

* m – mean of each indicator

* SI – sum of measures of indicators (I)

* M – mean of SI

Source: own elaboration

3.5 Results

Firstly, we performed the Spearman correlation procedure to determine whether constructed STI and DUI variables were not correlated pairwise. The results of this analysis are presented in Table 3.5 and demonstrate that there are no statistically significant correlations between STI and DUI indicators. The absence of correlation shows that there is no relation between indicators of the different modes of innovation. Therefore, the variables do not share commonalities across the STI and DUI modes.

Table 3.5. Correlations between STI and DUI indicators

Spearman's rho	R&D expenditures	R&D departments	Scientifically trained employees	Technological preparation for production	Preliminary marketing	Interacting
R&D expenditures	1,000	,246**	,275**	-,024	-,038	,061
R&D departments	,246**	1,000	,956**	-,082	-,076	-,007
Scientifically trained employees	,275**	,956**	1,000	-,062	-,088	,002
Technological preparation for production	-,024	-,082	-,062	1,000	-,007	,026
Preliminary marketing	-,038	-,076	-,088	-,007	1,000	,123**
Interacting	,061	-,007	,002	,026	,123**	1,000

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

3.5.1 Product innovation

In order to analyze the effect of the STI and DUI modes on product innovation of Belarusian SMEs, we perform correlation and regression analyses. The results of the Spearman's correlation analysis demonstrate that there is a positive correlation between the DUI mode and product innovation (0,285) and between the STI mode and product innovation (0,147), both significant at the 0,01 level.

As the dependent variable product innovation output (ProdIO) is categorical (0,1,2), the ordinal regression analysis was conducted to test the relationship between the modes of innovation and product innovation. In fact, ordinal regression enables the consolidation of the ordinal nature of the dependent variables to the model. In order to test model accuracy, we test the fitness of the model. Table 3.6 shows the significance of the model by the rejection of the null hypothesis.

Table 3.6. Model-fitting information

Model	-2 Log Likelihood	Chi-Square	Df	Sig.
Intercept Only	160,678			
Final	96,249	64,430	4	,000

Link function: Logit.

Secondly, we examine the individual coefficients of the model. Table 3.7 contains the parameter estimates for the model. The significance levels observed in Table 3.7 indicate that the combination of the STI and DUI modes of innovation exerts influence on product innovation. We add interactions in our model to check whether the STI and DUI modes are additive. Interactions turned out not to be significant (Annex 1), thus, the STI and DUI modes are additive (Hair, et al., 2010) in our model. Based on the results of the regression analysis, we conclude that there is a statistically significant relationship between both the STI and DUI modes and product innovation. Thus, firms with greater levels of STI and DUI mode achieve better product innovation outputs.

Table 3.7. Parameter estimates

	Estimate	Std. Error	Wald	Df	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
[ProdIO = ,00]	-3,429	,488	49,308	1	,000	-4,386	-2,472
[ProdIO = 1,00]	-1,781	,472	14,252	1	,000	-2,706	-,856
[STI=,00]	-1,089	,244	20,008	1	,000	-1,567	-,612
[STI=1,00]	-,678	,247	7,515	1	,006	-1,162	-,193
[STI=2,00]	0[a]	.	.	0	.	.	.
[DUI=,00]	-2,079	,460	20,410	1	,000	-2,981	-1,177
[DUI=1,00]	-,978	,459	4,537	1	,033	-1,877	-,078
[DUI=2,00]	0[a]	.	.	0	.	.	.

Link function: Logit.

a. This parameter is set to zero because it is redundant.

In order to analyze if firms combining the STI and DUI modes of innovation are more successful in radical product innovation than the STI and the DUI modes separately, we put the values of the STI and DUI in a logistic regression equation

(Agresti, 2002). To calculate probabilities using results of ordinal logistic regression fit we use equation 1, 2 and 3. The detailed calculation of probabilities using results of ordinal logistic regression fit is presented in Annex 2;

$$Prob(IO = 0|STI, DUI) = \frac{1}{1 + exp(-a_0 + b_{STI,0}X_{STI,0} + b_{STI,1}X_{STI,1} + b_{DUI,0}X_{DUI,0} + b_{DUI,1}X_{DUI,1})} \quad (1)$$

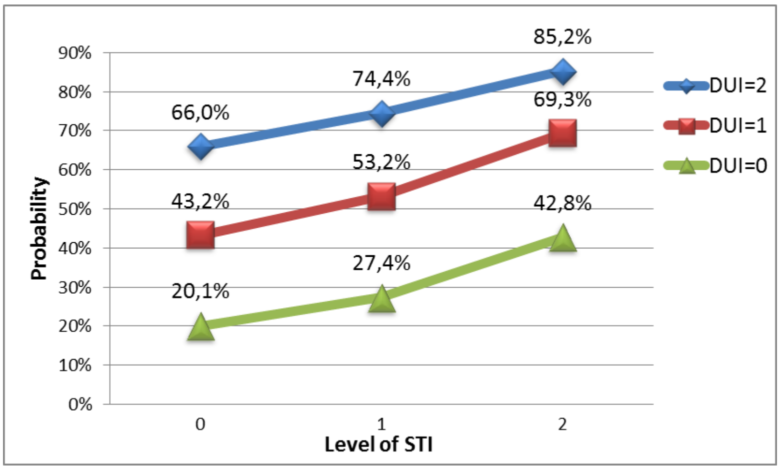
$$Prob(IO = 1|STI, DUI) = \frac{1}{1 + exp(-a_1 + b_{STI,0}X_{STI,0} + b_{STI,1}X_{STI,1} + b_{DUI,0}X_{DUI,0} + b_{DUI,1}X_{DUI,1})} - Prob(IO = 0|STI, DUI) \quad (2)$$

$$Prob(IO = 2|STI, DUI) = 1 - Prob(IO = 0|STI, DUI) - Prob(IO = 0|STI, DUI) \quad (3)$$

In Figure 3.5 we can observe the probabilities of generating radical innovation (new-to- market) when both the STI and DUI are in the model. Therefore, if firms reported 'high' levels of both STI and DUI modes they would attain radical product innovation with the highest probability of 85.2%. If firms reported 'medium' level (1) of both STI and DUI modes they would attain radical innovation with the probability of 53.2%. We can observe that increasing the DUI level to 'high' (2) when the STI remains "medium" (1) provides a higher probability (74.4%) of generating radical innovation than the increasing of STI to 'high' (2) (when DUI=1) (69.3%). Based on the increasing probabilities of generating radical product innovation and the results of regression analysis, we can accept both the 1a and 1b hypotheses that the STI and DUI modes of innovation are positively related to this kind of innovation. If we consider the STI and DUI modes separately, the probability of generating radical innovation is higher when a firm relies only on the DUI mode (DUI=2 'high' level) and equal to

73.9% when a firm's innovation activities are based only on the STI mode (STI=2), which equals 56.3% (Figure 3.5). The table with distribution of probabilities of generating radical product innovation is presented in Annex 3.

Figure 3.5. Distribution of probabilities of generating radical product innovation



Source: own elaboration

Therefore, we support our 1c hypothesis that the combination of the STI and DUI modes of innovation is the most effective for product innovation. This finding confirms the previous studies focused on Denmark (Jensen et al, 2007), Norway and Sweden (Aslesen et al, 2012; Isaksen and Nilsson, 2012). We also support our 1d hypothesis stating that firms which rely on the DUI mode separately are more likely to generate radical product innovations than those ones that rely on the STI mode alone. This finding confirms the result derived by Lorenz (2012) that the DUI mode as an interactive way to innovation may lead to radical innovation.

3.5.2 Organizational innovation

In order to analyze the effect of the STI and DUI modes on the organizational innovation of Belarusian SMEs, we perform correlation and regression analyses. The results of the Spearman’s correlation analysis demonstrate that there is a positive correlation between DUI mode and organizational innovation (0,248), significant at the 0,01 level. However, there is no statistically significant correlation between organizational innovation and the STI mode (0,056).

Since the organizational innovation output (OrgIO) is measured on the ordinal scale (0, 1.2), the model to fit is an ordinal regression model. Before examining the individual coefficients of the model, we check the overall test of the model-fit. Table 3.8 shows that the difference between the two log-likelihoods has a p-value of .000. This means that we can reject the null hypothesis that the model without predictors is as good as the model with the predictors.

Table 3.8. Model-fitting information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	87,416			
Final	55,233	32,182	4	,000

Link function: Logit.

We add interactions in our model to check whether STI and DUI modes are additive. Interactions turned out not to be significant, thus, in our model the STI and DUI modes are additive. The significance levels observed in Table 3.9 indicate that the DUI mode exerts influence on the innovation output. As regards the case of STI drivers, these do not appear to be related to organizational innovations to a significant extent, thus we accept 2b hypothesis.

Table 3.9. Parameter estimates

	Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
[OrgIO = ,00]	-,090	,567	,025	1	,874	-1,201	1,022
[OrgIO = 1,00]	1,232	,578	4,545	1	,033	,099	2,365
[STI=,00]	,418	,511	,670	1	,413	-,583	1,419
[STI=1,00]	,355	,609	,339	1	,560	-,838	1,547
[STI=2,00]	0[a]	.	.	0	.	.	.
[DUI=,00]	-3,047	,540	31,866	1	,000	-4,105	-1,989
[DUI=1,00]	-1,783	,549	10,533	1	,001	-2,859	-,706
[DUI=2,00]	0[a]	.	.	0	.	.	.

Link function: Logit.

a. This parameter is set to zero because it is redundant.

As the STI mode does not have strong relationship with innovation output, in order to get the best model, we reran the model without it. Before examining the individual coefficients of the model, we look at the overall test of the model-fit. Table 3.10 shows the significance of the model by the rejection of the null hypothesis.

Table 3.10. Model-fitting information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	59,948			
Final	28,460	31,488	2	,000

Link function: Logit.

Table 3.11 contains new estimate coefficients in the model. Concluding the results of regression analysis, we can see that there is a positive statistically significant relationship between the DUI mode and organizational innovation. Therefore, firms with greater levels of DUI attain greater organizational innovations. Thus we accept the 2a hypothesis. Simultaneously, there is not statistically significant relationship between the STI mode and organizational innovation. Therefore, the combination of the STI and DUI mode of innovation is not more effective in generating organizational innovation than relying on DUI drivers alone. This leads us to accept hypothesis 2c.

Table 3.11. Parameter estimates

	Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
[OrgIO = ,00]	-,333	,470	,500	1	,480	-1,254	,589
[OrgIO = 1,00]	,984	,481	4,190	1	,041	,042	1,927
[DUI=,00]	-2,894	,509	32,321	1	,000	-3,892	-1,897
[DUI=1,00]	-1,709	,539	10,068	1	,002	-2,765	-,653
[DUI=2,00]	0[a]	.	.	0	.	.	.

Link function: Logit.

a. This parameter is set to zero because it is redundant.

3.6 Conclusions and policy implications

This study analyses the effect of STI, DUI and combined STI+DUI modes of innovations on SMEs’ innovation performance. The majority of empirical cross-country studies on modes of innovation mainly focus on countries that operate in a market economy. This study demonstrates the way in which SMEs innovate in the context of transition economies and provides an analysis of the most effective business innovation modes in Belarus.

We would like to point out that there are no definitive indicators of DUI mode of innovation. Vis-a-vis other studies in the field, we enrich the methodology of measuring the DUI mode by adding new indicators such as ‘preliminary marketing expenditure’ and ‘technological preparation for production’, which measure factors that were not measured in previous studies (i.e. the D (doing) and U (using) aspects of the DUI mode). In addition, we study the influence of STI and DUI, not only on product, but also on organizational innovation that represents a different, “softer” and “non-technological” type of innovation, yet relevant for businesses that want to be competitive in current globalized markets.

Synthesizing the results of our regression analysis, we found a first common result: that firms that combine the STI and DUI modes of innovation are more likely to generate product innovation than those firms that focus only on STI or DUI modes alone. This finding confirms the previous studies focused on Danish (Jensen et al, 2007), Norwegian and Swedish (Aslesen, et al., 2012; Isaksen & Nilsson, 2013) economies and firms. One of the most significant and important results is that firms that rely on the DUI mode are more likely to generate product innovation than ones relying on the STI mode alone. As mentioned before, this is justified by the fact that, as in many economies that operate behind the technology frontier, technological innovation in Belarus concerns mainly the purchase and effective used of machinery, whereas investments in R&D are not primary components.

As far as we know, organizational innovations have not been studied in the context of STI and DUI modes before. We have found out that there is a positive and significant relationship between organizational innovation and the DUI mode. Thus, the probability of successful organizational innovation increases when the firm is organized in a way that promotes learning-by-doing, by-using and by-interacting efforts. In contrast, we observe that the STI does not relate to this type of innovation to a significant extent. Therefore, we can state that R&D activities tend not to stimulate the generation of organizational innovation, at least in the context of transition economies such as Belarus. As there is not a statistically significant relationship between the STI mode and organizational innovations, in contrast to product innovation, firms combining the STI and DUI modes of innovation are not more effective in generating organizational innovation than firms relying on the DUI mode alone.

The results of the study are potentially useful for academics, policy-makers, and managers. Academics can measure the DUI mode more adequately if they employ the learning-by-doing and learning-by-using types of indicators used in this study. Moreover, as we extend the geographical context of the STI/DUI country studies, this study has significant implications for academics who analyze the geographical perspective of SME innovation modes and innovation performance in transition economies.

Policy-makers can deduce the tools and program that may create a more appropriate environment for the development of innovative SMEs in these types of regions. The emphasis on the whole set of innovation-related regulation and policy acts in Belarus is based on science and technology-based (STI) innovation (Djarova, 2011). The relevance of the DUI approach discussed in this chapter is neglected. Company managers might consider this in order to organize more appropriate and effective innovation modes. For example, they can promote effective interactions not only with universities, but also with customers, suppliers, competitors, and other stakeholders.

Our work is not without limitations. In this analysis, we only use data of a one-year period (2012). Longitudinal data would be more relevant to verify such tendencies over a longer time span. In addition, it might be appropriate to create and conduct one’s own survey as a means to obtain more purpose-specific indicators than those offered by the CIS instrument. In order to propose a more comprehensive conclusion about the modes of innovation in post-soviet countries in transition, it would be a useful to study and use the data of another country in transition, for example Ukraine or Russia. Finally, the studies on modes of innovation do not show what the composition of innovation drivers is in the combination of the STI and DUI mode of innovation. Therefore, there is a need for a new classification tool for innovative firms to show how SMEs mix STI and DUI modes of innovation. In this regard, a good research line could be the analysis of how different drivers of innovation could be combined and reconciled within the firm (Chapter 4).

Chapter 4. Influence of research, technology and HRM drivers on SME innovation: case of Belarus

Chapter 4. Influence of research, technology and HRM drivers on SME innovation: case of Belarus

4.1 Introduction

Innovation plays a crucial role in today's fast changing economy, enabling SMEs, which have been affected negatively by the global financial crisis, to grow and gain competitive advantage. Therefore, many SMEs are switching to the high-road innovation strategy (Asheim & Parrilli, 2012) that is associated with higher productivity, better quality, and innovation.

Inasmuch as SMEs can be as innovative as larger enterprises (Audretsch, 2003), governments around the world have started to focus their research funding on this group of firms, recognizing the vital role of such enterprises in the economic and social development of any country. These enterprises are often regarded as a driving force for innovation (Rammer, et al., 2009). This chapter addresses the following research questions: which drivers promote SME innovation? What is the most effective innovation profile (combination of innovation drivers)? What is the most effective mode of innovation?

The majority of studies on STI and DUI modes of innovation argue that the combination of the STI and DUI is the most effective mode (Jensen, et al., 2007; Chen & Guo, 2010; Aslesen, et al., 2012; Isaksen & Nilsson, 2013). However, these studies do not show how SMEs can mix different drivers of innovation in different innovation modes (Isaksen & Karlsen, 2012a). What is the proportion of the drivers in this combination? To answer this question, we need a new research instrument and classification tool.

We contribute to the literature on drivers and modes of firms' innovation by proposing a new tool to determine the relevant innovation profiles and modes of business innovation – the RTH model of innovation. This model implies three drivers such as the Research (R), Technology (T) and HRM (H). The strength of this study is the theoretical context-embedded selection of business innovation drivers that help to explain why some firms are more innovative than others. The literature is relatively silent on how to connect the 'R', 'T' and 'H' drivers in one mode of innovation. In this regard, we attempt to fill this gap. The novelty of our study is that we go beyond the analysis of modes of innovation and propose an *innovation profile* as a mean to identify innovative firms. The innovation profile implies the combination of the three drivers in different proportions. Firms with similar innovation profiles are then grouped into clusters, which are defined as *modes of innovation*. The description of *drivers*, *profiles* and *modes* is presented in Table 4.1. The interrelation between innovation profiles and modes of innovation enables identifying the most effective innovation mode and the levels of each driver within this mode. The study is based on the purpose-made survey of "innovative firms" (OECD, 2005) of a one-year period (2012) in the sphere of IT technology in Belarus.

Table 4.1. Description table drivers, profiles and modes of innovation

Concept	Definition	Example
Drivers of RTH model	Research (R), Technology (T) and HRM (H)	‘R’, ‘T’ and ‘H’ drivers
Innovation profile	Numerical characteristic of the drivers of innovation	Profile RTH (3, 2, 1) shows that the SME has a high level of ‘R’, medium ‘T’ and low level of H driver
Mode of innovation	A cluster (group) of innovation profiles	Low learning mode: low level of ‘R’, ‘T’ and ‘H’ drivers

Source: own elaboration

This chapter is structured as follows. In section 4.2 we discuss the main streams of research focusing on the sources of innovation within the RTH model. The description of the RTH model of innovation and our research hypotheses are provided in section 4.3. The empirical section 4.4 describes the sample, variables and econometric techniques employed. Section 4.5 presents the results of the statistical and econometric analysis, whereas the final section summarizes the findings and discusses the implications for research and for policy-making.

4.2 Antecedents of the RTH mode

Theoretically, the RTH mode of innovation is based on studies of modes of innovation and studies on the Human Resource Management (HRM) practices and their influence on innovation performance (Shipton, et al., 2005; Beugelsdijk, 2008; Oke, et al., 2012). With respect to the modes of innovation, we differentiate between the three modes introduced by Jensen et al. (2007): STI, DUI and STI+DUI. The STI mode emphasizes scientific and technology-based nature of innovation. Firms can benefit in terms of innovation capability from a stronger connection to science that provides a platform for the firm's technological learning and innovation (Parrilli & Elola, 2012). The majority of innovation activities and research-based projects that characterize the STI mode of innovation take place in R&D departments, universities and research institutes. Therefore, the key inputs for innovation are investments in R&D, scientific human capital and collaboration with scientific partners (Cohen & Levinthal, 1989; Romer, 1994; Griliches, 1979). However, this mode cannot explain the capacity of economies such as Denmark and Norway to demonstrate high innovation performance despite the more limited R&D investments vis-à-vis other highly-R&D investing countries. The DUI mode of innovation emphasizes the innovation based on learning-by-doing, by-using and by-interacting (Jensen, et al., 2007). Learning-by-doing is based upon the accumulation of experience (Arrow, 1962). Learning-by-using machines and technological equipment is very important in modern industries because helps to acquire competences by deploying relevant state-of-the-art technologies (Rosenberg, 1982). Learning-by-interacting and collaboration between various organizations impact positively on (the degree of novelty) innovation and provide access to different kinds of knowledge and information, particularly about markets (Von Hippel, 1988; Lundvall, 1992; Fu, et al., 2013).

However, firms seldom rely completely on one mode of innovation. A third mode is a combination of the STI and DUI modes of innovation. Jensen et al. (2007) argue that firms combining the STI and DUI modes of innovation are more likely to generate product innovation than those emphasizing the STI or the DUI mode alone. The recent studies on modes of innovation in Norway and Sweden (Aslesen, et al., 2012; Isaksen & Karlsen, 2012a; Isaksen & Nilsson, 2013), Portugal (Varum & Monteiro, 2007), China (Chen and Guo 2010) confirm the results obtained by Jensen et al. (2007). However, Isaksen and Karlsen (2012a, p. 120) point out that Jensen (2007) et al. "don't show how firms can mix the two modes of innovation". Table 2.4 provides information about the country comparison in terms of the most effective mode of innovation.

In the majority of studies that analyze the STI and DUI modes of innovation, the STI+DUI mode is the most effective. At the same time, these countries differ a lot in terms of their levels of development (Nielsen, 2011; UN, 2013). The studies on the modes of innovation do not show what the composition of innovation drivers in the combined STI+DUI mode of innovation. In this regard, a future research line could focus on analyzing how different drivers of innovation can be effectively aggregated within a firm. With this objective in mind, we propose a new research tool for innovative firms.

4.3 The RTH model of innovation

Jensen et al. (2007) established an original classification of the three modes of innovation: the STI, DUI and mixed STI+DUI. While the STI mode encourages the power of highly educated scientific employees to exploit codified knowledge and collaborate with other researchers, the DUI mode requires experienced and skilled managers and employees who can adapt solutions that respond to the needs of lead customers (Isaksen & Karlsen, 2012a). The DUI mode "is akin to a set of HRM practices" (Laursen & Foss, 2012, p. 13). In a complementary theoretical framework, innovation-focused HRM practices are positively related to product innovation performance (Shipton, et al., 2005; Beugelsdijk, 2008; Oke, et al., 2012).

The study by Jensen et al. (2007) did not aim at showing how SMEs can mix effectively the STI and DUI modes of innovation or what the effective proportion of drivers of innovation is. We propose the RTH model that allows revealing proportions of innovation drivers in SME innovation profiles and help to identify the most effective mode of innovation. The three-driver model fills the gap by connecting the set of economic drivers of innovation such as Research and Technology (Cohen & Levinthal, 1989; Romer, 1994; Greunz, 2005) with HRM (Gupta and Singhal 1993; Shipton et al. 2005; Beugelsdijk 2008; Oke et al. 2012). Our RTH model benefits from Research (level of scientific development), Technology (level of technological development) and HRM (HRM practices and interaction) innovation drivers (Table 4.2). The literature is relatively silent on how to separate research and technology; they are usually proxied by the same indicators within STI mode (Jensen, et al., 2007; Parrilli & Elola, 2012). One of the main reasons why we decided to separate the 'R' from 'T' driver is that in the Belarusian context there are two main ways for firms to innovate. Firstly, as in many catching-up economies, technological innovation in Belarus is to a large extent connected to the purchase and installation of new machinery and the effective use of new equipment (Palacín & Radosevic, 2011). Secondly, Belarusian enterprises can benefit from R&D activities and outcomes (R driver) conducted either by themselves or by public institutions and large enterprises. The separation of 'R' and 'T' in the RTH model and the ability of such model to measure the impact of each driver are very important for countries in transition.

Table 4.2. Description of RTH drivers

RTH drivers	**Academic categorizations**	**Seminal contribution**	**Categories description**
Research	Science	Romer, 1994	Basic Research
Technology	Learning-by-doing	Arrow, 1962	Manufacturing, operations management
	Learning-by-using	Rosenberg, 1982	Product development and customization
HRM	Learning-by-interacting	Lundvall, 1992	Collaboration
	HR practices	Shipton et al., 2005	Human Resource management practices

Source: own elaboration

4.3.1 The 'R' driver

The Research driver targets innovation based on research and development (R&D), human capital (scientifically trained personnel with PhD and MSc degrees in S&T who work full time in innovation projects) and research collaborations. Business

R&D teams increase the absorptive capacity of a company (Cohen & Levinthal, 1990). External R&D activities are considered as a main source of innovation in SMEs (Rammer et al. 2009). The firm investment in R&D can be considered as a long-term placement of capital and if such investments do not have a direct commercial application, they can start generating a cash flow in the next few years or even later on (Rosenberg, 1990). Moreover, investing in R&D is connected with high costs and risks. Therefore, a firm has to carefully weigh up all the pros and cons and find a proper balance between the expected benefits from successful R&D activities and the costs and probability of failure and loss of invested capital (Rammer et al. 2009).

Nevertheless, SMEs benefit a lot in terms of innovation activities from a stronger connection to science (Fleming & Sorenson, 2004; Fabrizio, 2009; Parrilli & Elola, 2012). A large amount of such activities take place in the collaboration with the centers that produce new knowledge, for example, R&D departments, research-intensive small firms and universities. Such interactions promote the generation of codified/scientific knowledge that a firm can use to produce innovations. Along this line, Audretsch (2003) argued that the promotion of innovative SMEs should focus on knowledge-based small firms which benefit from investing in research activities. The Research driver emphasizes the importance of science and considers investments in R&D, scientific human capital, infrastructure and interaction with research partners as the key inputs to innovation (Cohen & Levinthal, 1989; Romer, 1994; Fabrizio, 2009; Jong & Slavova, 2014).

On these bases, we propose the following hypothesis:

Hypothesis 1: The 'R' driver is positively related to product innovation when it operates together with 'T' and 'H' drivers.

4.3.2 The 'T' driver

In the RTH model of innovation, we separate the Research driver from the Technology driver. The relationship between science and technology was discussed in Nathan Rosenberg's book (1982). He questioned the statement that science precedes technological development and stated that technology is not only the application of scientific knowledge. Technology is "knowledge of techniques, methods and designs" and "if the human race had been confined to technologies that were understood in a scientific sense, it would have passed from the scene long ago" (Rosenberg, 1982, p. 143). Technologies are not compulsory and direct products of science because they have to satisfy customer needs. "One of the stylized facts coming out of research on the relation between science and technology is that in most areas, the results of scientific research are not directly useful for technological advance" (Jensen, et al., 2007, pp. 682-683). The separation of the 'R' and 'T' driver does not mean that we have to choose only one driver. In the RTH model they coexist, whilst the impact of each driver of the innovation output can be measured.

Innovative SMEs should constantly scan markets for new technologies that might help to further develop new ideas. The Technology driver includes important components such as the technological base (Adler & Shenhar, 1990) and the technological competences (Ritter and Gemünden, 2004; Rammer et al. 2009) that firms with their experts and technicians identify and value as a means to develop new products and processes. The *technological base* implies the technological know-how that enables a firm to develop and manufacture new products using the appropriate process technologies, and to benefit from opportunities that require prompt actions involving technology (Adler & Shenhar, 1990). The development of the technological base includes adopting more or less familiar technologies that hasten the technological process (Rosenberg 1982; Chen and et al. 2011; Isaksen and Karlsen 2012a). *Technological competence* implies a firm's ability to understand and use relevant state-of-the-art technology, build and deploy that know-how effectively, explore new ways of solving technical problems, produce and deliver goods and services that will help firms to generate innovations that outperform competitors and increase profitability (Ritter and Gemünden, 2004; Rammer et al. 2009). Such competences have a positive impact on innovation and product development (Patel & Pavitt, 1997; Ritter & Gemünden, 2003). Technologies have direct commercial applications and aim at meeting market demand. In a nutshell, it is an instrument for producing marketable goods and services. Crosby (2000) argues that the international flows of capital and ideas are so intensive that there is no necessity to conduct large amounts of R&D in small countries. Such countries can purchase new technology and know-how.

Due to the fast rate of technology change, there is a need for constant monitoring of the-state-of-the-art-technologies. The 'T' driver can be approximated with indicators such as monitoring and acquisition of up-to-date machinery, equipment and sophisticated technologies, engineering capabilities, and the interaction with technology organizations. A more detailed description of the indicators of this driver is provided in the empirical part of this chapter. The rapid growth in complexity and cost of new technologies promotes inter-organizational, technical cooperation and alliances, the number of which has been constantly increasing (Sen & Egelhoff, 2000). The interaction with centers producing new technology (e.g. with technical alliances, technology centers and engineering companies) leads to the acquisition of product innovation capabilities (Sen & Egelhoff, 2000; Hagedoorn, 1993).

These above-mentioned premises lead to the following hypothesis:

Hypothesis 2: The ‘T’ driver is positively related to product innovation when it is considered together with ‘R’ and ‘H’ drivers.

4.3.3 The ‘H’ driver

The third HRM driver of innovation comprises *HRM practices* (Shipton, et al., 2005; Beugelsdijk, 2008; Laursen & Foss, 2012) and *interaction* (Ritter & Gemünden, 2004; Jensen, et al., 2007; Spithoven, et al., 2013). *HRM practices* involve methods of organizing work responsibilities and decision-making, employees’ training, extensive lateral and vertical communication channels and the use of reward and recognition systems. According to Shipton et al. (2005, p. 119), such practices manage the “three stages of the organizational learning cycle – the creation, transfer and implementation of knowledge”. It was shown by Rammer et al. (2009) that SMEs that do not apply in-house R&D can obtain a similar innovation performance by applying appropriate HRM practices to facilitate innovation processes. In this regard, the implementation of innovation-focused HRM practices influence positively the innovation performance in a firm and contribute to a sustained competitive advantage (Laursen and Foss 2003; Shipton et al. 2005; Beugelsdijk 2008; Oke et al. 2012). Managerial skills can be more important for innovation than access to modern technology (Varblane, et al., 2007).

Amabile (1998, p. 6) raised the question of motivation of scientists that can have outstanding education and a great facility for generating new knowledge, but if they lack “the motivation to do a particular job”, they “simply won't do it”; “their expertise and creative thinking will either go untapped or be applied to something else”. The capacity to generate innovations is largely dependent on the way employees are motivated to perform research activities and commercialize their results. The reward and recognition systems encourage innovation and reinforce entrepreneurial behavior and team work. A reward system that is oriented towards fostering creativity, stimulates the ability of employees to make additional efforts and achieve innovative results. A reward and recognition system can be multifaceted, for example, HR managers can provide their personnel with additional time to develop their own ideas. A Google company created a rule and named it “70-20-10” that gives to their employees the opportunity to spend 10 percent of their time on the development of their own ideas. In addition, HR policies that include rewards and recognition systems that promote innovation activities are likely to facilitate an innovative organizational culture. Such a culture tends to back up a firm's innovation strategy because it creates an environment that can be characterized as innovation encouraging, and provides the freedom to experiment and the openness to new ideas (Damanpour 1991; Oke et al. 2012). Such a notion that all employees are innovators enables one of the largest Chinese steel manufacturing companies to achieve extraordinarily innovative performance (Chen, et al. 2011).

Beugelsdijk (2008) shows that HRM practices can foster both radical and incremental innovation: for example, training and performance-based pay promote incremental innovations, while radical innovations can be achieved by task autonomy and flexible working hours. Lorenz (2012) argues that if creativity and labor market mobility are mediated by an appropriate HRM they generate a range of novel knowledge outputs (Lorenz, 2012). Creativity is expected to be supported and fostered by the creation and promotion of complex jobs within a firm (Beugelsdijk, 2008). Such jobs are associated with high levels of autonomy, a variety of skills, significance and feedback (Beugelsdijk, 2008; Lorenz & Lundvall, 2011). The literature on HRM suggests that providing training facilities may create a positive employee attitude and commitment to promote sustainable development (Benson et al. 2004). By the same token, education and complex jobs, creativity and innovation can be promoted by teamwork (Nonaka & Takeuchi, 1995), especially cross-functional teamwork (Lau & Ngo, 2004). Team meetings provide employees with a broad range of information and may be organized to search for and to discuss new ideas and perspectives. The involvement of employees in decision-making improves the business innovation propensity (Cosh et al. 2012). Before 2008, several authors had applied quantitative methodology to delve with the HRM contribution to innovative performance.

Beugelsdijk (2008) stated that only Shipton et al. (2005) have tested the relationship between HRM and innovation, applying a statistical approach Notwithstanding the precipitous expansion of the literature, the link between HR practices and innovation performance is not clearly investigated and explained (Laursen & Foss, 2012).

The 'H' driver of our classification tool includes also both internal and external *interactions* (Lundvall, 1988; Ritter & Gemünden, 2004). Internal interaction arises as part of the company logic and communication works in both directions: top-down and bottom-up (vertical communication) and between different company departments (horizontal communication) (Hinds & Kiesler, 1995). External interaction involves cooperation with customers, including pilot-customers, suppliers, competitors, distributors, venture capitalists. SMEs that have a highly developed interactive network are more market-oriented (Ritter & Gemünden, 2003). However, it was found that SME cooperation with rivals can have a poor impact on innovation (Tomlinson & Fai, 2013) and a detrimental effect on the propensity of firms to innovate (Fitjar and Rodriguez-Pose, 2013).

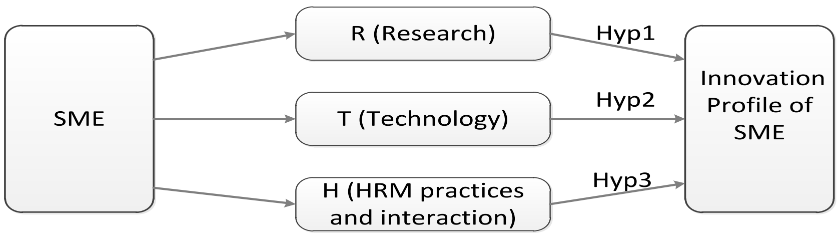
Thus, the 'H' driver can be approximated with indicators such as some HRM practices (e.g. training, teamwork, communication and reward systems) and interaction with actors across the supply chain and with competitors. A more detailed description of the indicators of the 'T', 'H' and 'R' drivers is provided in the empirical part.

The above mentioned considerations lead to our third hypothesis:

Hypothesis 3: The 'H' driver is positively related to product innovation when it is considered together with 'R' and 'T' drivers.

The three above mentioned hypotheses are summarized in Figure 4.1.

Figure 4.1. The theoretical model



Source: own elaboration

4.4 Data and methods

This study focuses on drivers and modes of innovation specific to Belarusian SMEs. In chapter 3 we have conducted an analysis of the effect of the STI and DUI modes on innovation performance across Belarusian SMEs. The results of the regression analysis show that SMEs combining the STI and DUI modes are more likely to generate radical product innovation. However, we had difficulty in estimating the extent to which SMEs rely on STI or DUI modes, and what drivers are crucial in this combination. Therefore, we decided to present a new research instrument that enables to characterize the modes of innovation in detail – in this case the RTH model. Unfortunately, the survey carried out by Belstat (National Statistical Committee of the

Republic of Belarus) adopts a similar format to that of the CIS and does not provide data concerning the HRM practices and Technology drivers. Therefore, we conducted a specific survey of Belarusian IT firms located in Minsk and its capital region. Minsk is the capital and largest urban city of Belarus with about 2 million inhabitants.

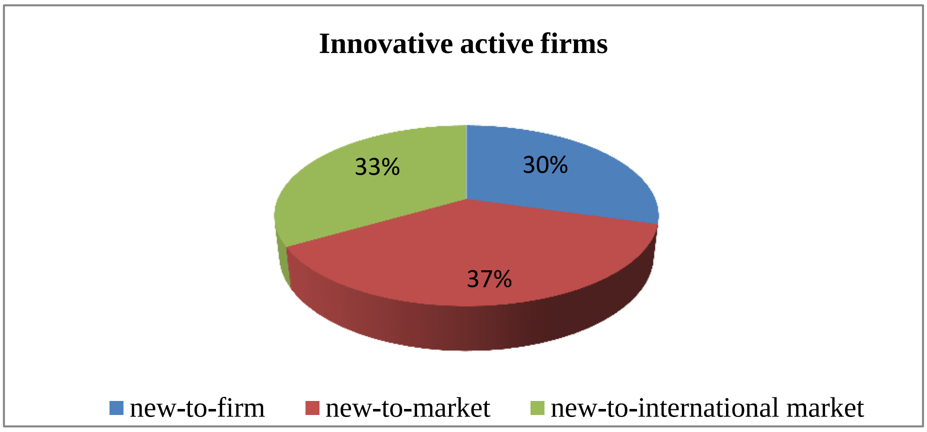
The main reason why we have chosen the ICT sector refers to its high potential for producing innovation, where the achievements of knowledge, science, technology, information, and management are consolidated into one environment (UN, 2002). This industry is considered by the policy-makers as a sector with the highest potential growth rate (SPID, 2011). During the last years the IT sector has received strong governmental support in Belarus and it has become one of the top-priority economic sectors. The IT cluster in Belarus was formed in 2004. As a result, Belarus today is one of IT leaders in the CEE region (Maznyuk & Sergiychuk, 2010) and Minsk is one of the largest centers of offshore programming in the former USSR. The main outputs of the companies are software services for clients, application development, solutions and IT consulting services. The export share in total production exceeds 80 percent. Belarusian IT companies are successfully exporting their software products and services to North American and European high-tech markets. Engineers and software developers are the main human resources of Belarusian IT firms.

The survey was conducted through a web-based questionnaire and personal e-mails sent to 245 out of 257 (total number in Minsk and its region) IT firm. 82 firms completed the questionnaire. The response rate is 32%. In order to restrict the sample to SME firms, we follow the European Commission Recommendation (2003) criteria based on the number of employees. Therefore, we excluded companies with less than 10 employees and firms with more than 250 employees from the analysis. The final sample is composed of 51 IT firms. According to Hair et al. (2010) a multiple regression can be effective with a minimum sample of 50 and a minimum ratio of observations to variables is 5:1 (the preferred ratio is 15:1 or 20:1). In our analysis the ratio of observations is 17:1. For this reason our sample is valid.

4.4.1 Dependent variables description

The dependent variable in our study is product innovation. We classified firm´s product innovation by the degrees of novelty: (1) new-to-firm, (2) new-to-national market and (3) new-to-international market innovation. The validity of this classification has been proven in the literature (Jensen, et al., 2007). Thus, in our analysis, we distinguish between incremental (new-to-firm) and radical (new-to-national and international market) innovations. This classification corresponds to the CIS format. The classification of firms by the degrees of novelty in our sample is presented in Figure 4.2.

Figure 4.2. Classification of firms in the sample by degrees of novelty



Source: own elaboration

4.4.2 Independent variables description

The Research, Technology, and HRM drivers are independent variables in our study. We propose three groups of indicators to identify each driver (Table 4.3). The first Research driver contains 3 indicators that reflect the scientific approach and state that innovation is a result of R&D. In this regard, we identified the following indicators of 'R' driver: expenditures on R&D; the employment of the personnel with third-level degrees and cooperation with researchers attached to universities or research institutes. The indicators of the 'R' drivers are in line with studies on the STI mode of innovation (Jensen et al. 2007). The 'T' driver, emphasizes that the knowledge of techniques and methods (Rosenberg, 1982), technological competence (Ritter and Gemünden 2004; Rammer et al. 2009) and know-how enables a firm to develop and manufacture new products using the appropriate process technologies. In this regard, the first indicator shows whether a firm is constantly monitoring new technology appearance in the market in order to be aware of know-how, state-of-the-art technologies. The next variable indicates if a firm purchases patents of sophisticated technology. The next two indicators show whether a firm possesses state-of-the-art production facilities and whether the technological competence enables the implementation and development of this technology. The last indicator points out on the ability and desire of a firm to develop and use technology-oriented inter-organizational relationships and alliances to complement its technological competencies with those of its partners. According to some studies (Sen and Egelhoff 2000; Hagedoorn 1993) such technical alliances lead to the acquisition of additional technological competence that facilitates product innovation. The HRM driver stresses that innovation is the result of HRM practices (Shipton et al. 2005; Beugelsdijk 2008; Laursen and Foss 2012) and interactions (Lundvall 1992; Ritter and Gemünden 2004; Jensen et al. 2007). The indicators of this driver show whether employees are involved in problem-solving and decision-making, whether teamwork is promoted by the company, if the reward system encourages innovation, and how the firm interacts with supply value chain partners and competitors.

Table 4.3. Indicators of the Research, Technology and HRM drivers

Variables	**Description**
The Research driver	
Expenditures on R&D	Expenditures on R&D as share of total revenue
Scientifically trained	A firm employs scientifically trained personnel

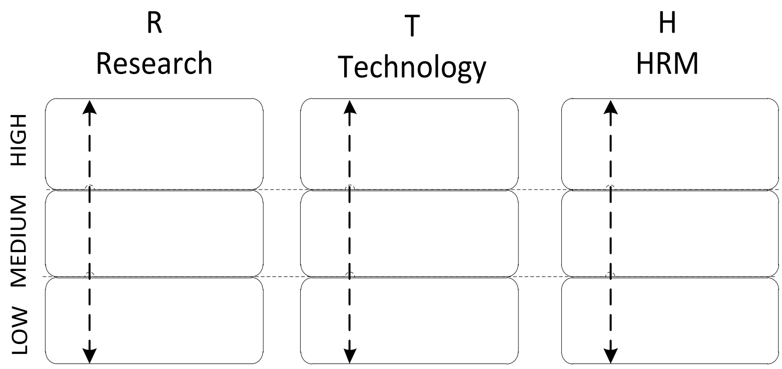
personnel	(master and PhD degree)
Interaction with research organizations	A firm cooperates with universities, scientific institutes, research centers
The Technology driver	
Monitoring of new technology in the market	A firm is constantly monitoring new technology appearance in the market
Purchase of technology, patents or external knowledge	The frequency of purchasing patents, external knowledge or licensing of patents and non-patented inventions, know-how, and other types of knowledge from other enterprises or organizations
Production facilities	A firm possesses state-of-the-art production facilities
Technological competence	The ability to development and adapt current and new technology
Interaction with technology organizations	Interaction and collaboration exist with technology centers, engineering companies and technical alliances
The HRM driver	
Reward systems	The reward and recognition systems encourage innovation and reinforce entrepreneurial behavior and teamwork
Training	A firm organizes training aimed to acquire and develop skills that are crucial to introduce new or significantly improved products and processes
Organizing work responsibilities and decision making	A firm has implemented new methods of organizing work responsibilities and delegation of decisions (decentralized form)
Extensive lateral and vertical communication	Communication works in both directions: top-down and bottom-up (vertical communication) and between

	different company departments (horizontal communication)
Teamwork	Teamwork and collaboration between employees arises spontaneously as part of the company logic.
Interaction	A firm interacts with customers and pilot-customers, suppliers, competitors, distributors.

Source: own elaboration

Due to the qualitative nature of the data collected in our study, in order to analyze the information, we extracted key information, classified it using Likert type scales, and treated it on a quantitative basis. In practice, we grouped firms’ answers into three categories: (1) ‘low’ level of ‘R’, ‘T’, ‘H’ drivers, (2) ‘medium’ level of ‘R’, ‘T’, ‘H’ drivers and (3) ‘high’ level of ‘R’, ‘T’, ‘H’ drivers. This classification is presented in Table 4.3 and is consistent with previous studies in the field (Parrilli & Elola, 2012). The RTH model implies 27 innovation profiles (numerical combination of 3 innovation drivers and 3 levels of each driver) that precisely reveal the innovation profile of firms in a particular region.

Figure 4.3. Categories of RTH drivers

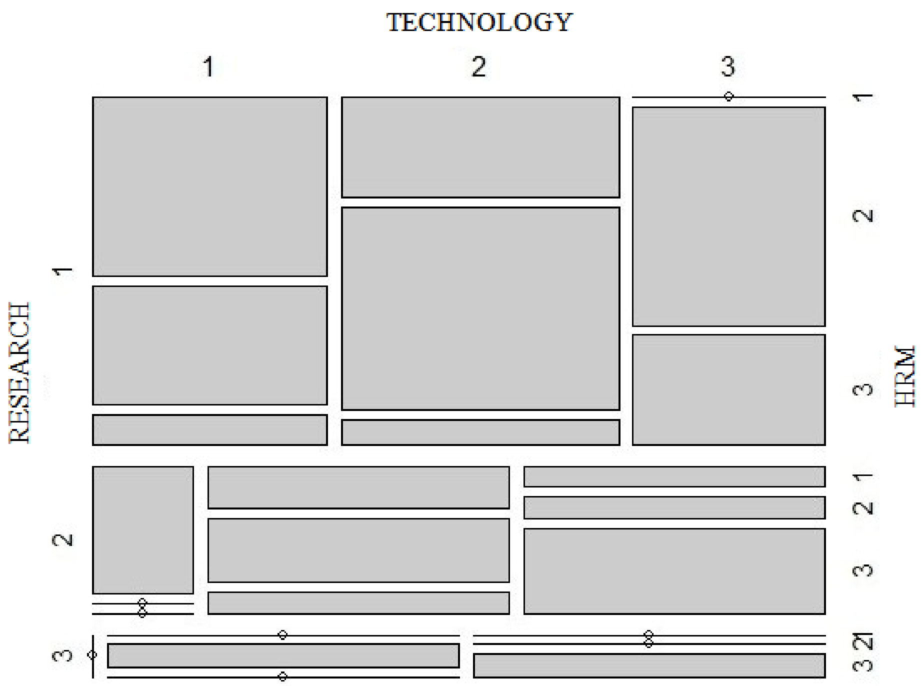


Source: own elaboration

Once we categorized the ‘R’, ‘T’, ‘H’ drivers, we obtained an innovation profile of the firms. For example, the RTH profile (3, 2, 1) shows that the SME has a high level of the ‘Research’ driver, a medium level of ‘Technology’ and a low level of the ‘HRM’ driver within our framework. Thus, a firm’s innovation profile is a ‘numerical combination’ of the drivers of innovation. Innovative profiles of the surveyed firms are visualized in Figure 4.4 using the mosaic plot (Friendly, 1999). The mosaic plot is a graphical presentation of business innovation profiles. It is divided into rectangles, so that the area of each rectangle is proportional to the frequencies of RTH innovation profiles in each level. The most frequent innovation profile (15,7% of firms) is RTH (1,2,2). We can see that there are 17 firm profiles out of 27 possible profiles in the

Minsk region. For example, there is not such profile as RTH (3,2,1). We define the mode of innovation as a set or cluster of similar innovation profiles. We describe the procedure of identification of these modes of innovation in the next section.

Figure 4.4. Mosaic plot the 'R', 'T' and 'H' drivers)



Source: own elaboration

4.5 Results

4.5.1 Empirical analysis

In order to analyze the relationship between the 'R', 'T' and 'H' drivers of innovation and innovation output we perform a regression analysis. Since the outcome is measured as an ordinal scale (1,2,3), an ordinal regression model fits best. The ordinal regression allows the consolidation of the ordinal nature of both the dependent and independent variables. Before examining the individual coefficients of the model, we test overall model-fit. Table 4.4 shows the difference between the two log-likelihoods has p-value of .000. This means that using the model is better than guessing the mean.

Table 4.4. Model-fitting information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	79,416			
Final	41,683	37,733	6	,000

Link function: Logit.

Table 4.5 contains the parameters estimated for the model. The significance levels observed in Table 4.5 indicate that the ‘T’ and ‘H’ drivers exert significant influence on the innovation output. In the case of the ‘R’ driver, the test indicates that this driver does not appear to be significantly related to innovation output.

Table 4.5. Parameter estimates

	Estimate	Std. Error	Wald	Df	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
[IO = 1]	-5,286	1,673	9,983	1	,002	-8,565	-2,007
[IO = 2]	-2,458	1,506	2,666	1	,103	-5,409	,493

[R=1]	-,563	1,324	,181	1	,671	-3,159	2,032
[R=2]	-,003	1,420	,000	1	,998	-2,786	2,780
[R=3]	0[a]	.	.	0	.	.	.
[T=1]	-3,660	1,042	12,331	1	,000	-5,703	-1,617
[T=2]	-2,019	,819	6,077	1	,014	-3,624	-,414
[T=3]	0[a]	.	.	0	.	.	.
[H=1]	-2,639	1,081	5,954	1	,015	-4,759	-,519
[H=2]	-1,603	,938	2,917	1	,088	-3,442	,237
[H=3]	0[a]	.	.	0	.	.	.

Link function: Logit

a. This parameter is set to zero because it is redundant.

Science the ‘R’ driver does not have a strong relationship with innovation output, in order to get a better model, we re-run the model without this driver. Before examining the individual coefficients of the model, we checked if there was a good overall fit. Table 4.6 shows the significance of the model with rejection of the null hypothesis.

Table 4.6. Model-fitting information

Model	-2 Log Likelihood	Chi-Square	Df	Sig.
Intercept Only	66,847			
Final	29,795	37,052	4	,000

Link function: Logit

Table 4.7 contains new estimated coefficients for the model. The significance levels observed in Table 4.7 indicate that the ‘T’ and ‘H’ drivers have a significant relationship with innovation output. Therefore, firms with greater levels of ‘T’ and ‘H’ obtain greater innovation outputs.

Table 4.7. Parameter estimates

	Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
[IO = 1]	-4,946	1,103	20,094	1	,000	-7,109	-2,784
[IO = 2]	-2,160	,869	6,184	1	,013	-3,862	-,458
[T=1]	-3,769	1,031	13,352	1	,000	-5,790	-1,747
[T=2]	-1,967	,810	5,899	1	,015	-3,555	-,380
[T=3]	0[a]	.	.	0	.	.	.
[H=1]	-2,661	1,066	6,233	1	,013	-4,749	-,572
[H=2]	-1,684	,919	3,356	1	,067	-3,486	,118
[H=3]	0[a]	.	.	0	.	.	.

Link function: Logit

a. This parameter is set to zero because it is redundant.

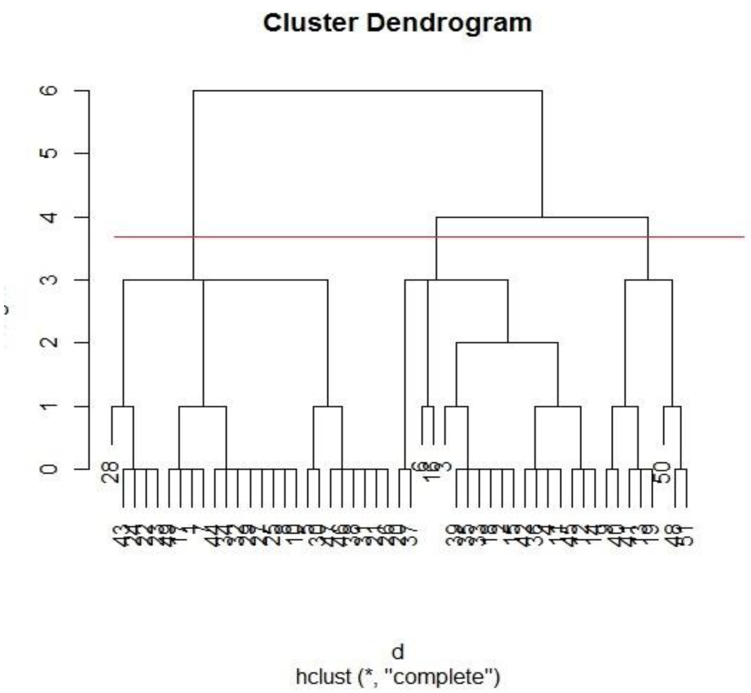
Concluding the results of the regression analysis, we can see that there is no statistically significant relationship between and product innovation output. Therefore, we reject the H1 hypothesis. However, we observe the strong relationship between the 'T' driver and innovation output and between The 'H' driver and innovation output. Thus, those firms with greater levels of the T and H drivers get better innovation output. Therefore, we accept the H2 and H3 hypotheses.

4.5.2 Modes of innovation

We identified the 'mode of innovation' as a group (cluster) of innovation profiles from 27 possible profiles[3]. To group innovation profiles in clusters (modes of innovation), we employ the hierarchical clustering algorithm (Kaufman & Rousseeuw, 1990). Cluster analysis is consistent with some influential works in this area (Jensen, et al., 2007; Fitjar & Rodriguez-Pose, 2013). The Manhattan distance method was used to measure the distance between points, complete linkage – to compute the distances between joined elements (Hastie et al. 2001). Three clusters were defined and cut by the red line in the dendrogram (Figure 4.5). According to Hastie et al. (2001) the dendrogram provides a complete description of the hierarchical clustering in a graphical format.

[3] The explanation of the term 'innovation profile' is provided in paragraph 4.4.2

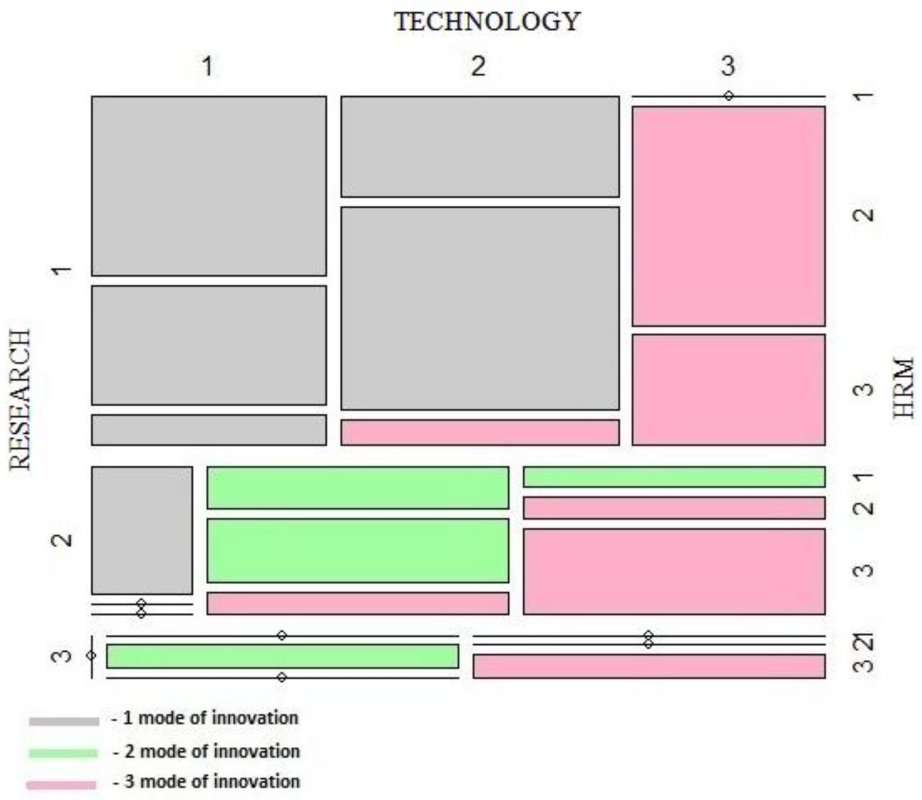
Figure 4.5. Cluster dendrogram



Source: own elaboration

The three modes (groups of similar innovation profiles) of innovations are visualized in the Mosaic plot (Figure 4.6) and are colored in different colors.

Figure 4.6. Three modes of innovation, Mosaic plot



Source: own elaboration

The first mode of innovation is represented by the largest amount of firms (49% of total SMEs in our sample). As each driver has a low level, we designate this mode as ‘low learning mode’. Firms in this cluster report only new-to-firm innovation. Innovation activities of firms constituting the second group of innovation profiles or mode of innovation rely on strong 'R' and 'T' drivers and low level of H driver. As a result, these SMEs are able to produce, in addition to new-to-firm, new-to-national market innovation. We can explain the increase in the degree of novelty of product innovation by the growth of the 'T' driver from law to medium. We identified this mode as a S&T-based mode of innovation. 16% of the sampled SMEs apply this mode. The third mode can be characterized by low level of the 'R', high level of the 'T' and above medium level of the 'H' driver. It encompasses 35 % of the sampled SMEs. Firms in this cluster report the highest innovation output among the revealed modes i.e. manage to produce new-to-international market products and services. We designate firms belonging to this mode as creative organizations. Creative organizations can adapt technology and benefit from HR and open interactions. The synthetic view of the innovation modes and innovation outputs can be seen in Table 4.8.

Table 4.8. Characteristics of modes of innovation

Mode	**Name**	**Characteristics**	**Innovation output**
1 mode	Low learning	Low level of 'R', 'T' and 'H' drivers	New-to-firm
2 mode	S&T	Medium level of 'R' and 'T' drivers and low of 'H' driver	New-to-national market
3 mode	Creative organizations	Low level of 'R' and high level of 'T' and above medium level of 'H' driver	New-to-international market

Source: own elaboration

4.6 Conclusions and policy implications

In this study, we analyze the sources of innovation of SMEs and propose a new model to determine relevant ‘innovation profiles’ and ‘business modes of innovation’ – the RTH model of innovation. The degree to which the Research, Technology and HRM drivers dominate, however, depends on the characteristics of the firms and the types of activities that they carry out. Concluding the regression analysis, we found that there is a statistically significant relationship between the ‘T’ and ‘H’ driver and product innovation in the context of the Belarusian IT sector. In contrast, the ‘R’ driver does not relate to innovation output to a significant extent. Thus, those firms with greater levels of the ‘T’ and ‘H’ driver get better innovation output. There is a big variety of articles that analyze how different drivers influence innovation (Jensen et al. 2007; Oke et al. 2012; Isaksen and Karlsen 2012a). However, none of these studies consider the ‘R’, ‘T’ and ‘H’ drivers together in one model and weight the specific effect of their contributions on innovation output.

The novelty of our study is that we go beyond the analysis of ‘modes of innovation’ as contemplated by Jensen et al. (2007), Isaksen and Karlsen (2010), Chen, et al. (2011) and Parrilli and Elola (2012) and propose an ‘innovation profile’ as a more specific identification of the critical features of different sets of innovative firms. The innovation involves the combination in different extents, of the ‘R’, ‘T’ and ‘H’ drivers. This helps to recognize the unique characteristics of innovative firms. Firms with similar innovation profiles are grouped into clusters which we identify as ‘modes of innovation', which are different from the more abstract modes identified by Jensen et al. The relationship between innovation profiles and modes of innovation helps identifying the most effective innovation mode (and the level of each driver associated with this mode). Across Belarusian SMEs, we have identified 17 innovation profiles (whereas other ten potential profiles were not represented by any firm) that we grouped through cluster analysis in the 3 archetypical modes of innovation. The first mode of innovation is represented by 49% of SMEs. This mode can be characterized as a "low learning" mode due to the low levels of the 'R', 'T' and 'H' drivers. The "low learning" cluster gathers firms that neither invest in HRM, technology nor employ scientifically trained personnel. The firms belonging to this cluster do not have highly developed forms of organizations that support technology acquisition or HRM practices and do not cooperate with researchers and value chain partners. In general, they can mostly develop new-to-firm type of innovations. The second mode, which encompasses 16% of the SMEs, has a rather high level of 'R' and 'T' drivers, and a low level of 'H'. As the value of 'T' has grown in comparison with the first mode, the degree of novelty of product innovation has also increased. As a result, these SMEs are able to produce, in addition to new to firm, new-to-national-market innovations. We identified this mode as the 'S&T-based mode' of innovation. The third mode is characterized by low level of 'R' and high level of 'T' and above the average level of 'H'. Firms in this cluster report the highest innovation output among the revealed modes i.e. manage to produce new-to-international-market products and services. Firms belonging to this mode are characterized as 'creative organizations'.

A new research instrument – the RTH model – for analyzing innovation processes across firms can be used not only by researchers, but also by policy-makers and managers. It enables the exploration of the mode of innovation at the industry level. Policy-makers can use the concept of ‘modes of innovation’ to develop strategies and programs aimed at improving the innovation capacities of regions and sectors. The RTH model enables the exploration of the mode of innovation at the industry level, which emerges from specific innovation profiles at the firm level. Based on the RTH model, company managers can recognize the exact innovation profile that helps to exploit limited resources in the most appropriate way. Thus, identifying the drivers that promote product innovation helps to create a more conducive environment for innovation-based development, and enhances the sustainability and competitiveness of SMEs.

Our work is not exempt of limitations. In this analysis, we use data that represent one sector. It might be more appropriate to collect data from several sectors. On the grounds of the analysis of data collected by Belstat (National Statistical Committee of the Republic of Belarus) that adopts a similar format to the CIS’, it seems reasonable to explore those SMEs that represent a large set of manufacturing industries in Belarus: metallic construction, furniture, apparel, footwear, bread and confectionery. These sectors are of great importance for the national economy and are characterized by a considerable amount of SMEs and innovation-active enterprises. Unfortunately, Belstat does not provide data concerning the HRM practices. In addition, there is a shortage of indicators which define the ‘T’ driver. Therefore, there is a need to conduct a specific survey that enables a wider access to relevant data, with the potential to extract results of interest to a larger universe of businesses. In conclusion, our study aims to encourage other researchers and policy analyst to continue investigating the modes of innovation.

Chapter 5. Conclusions

Chapter 5. Conclusions

This thesis focuses on the business modes of SME innovation. One of the main aims of the thesis has been to contribute to the theoretical and empirical understanding of the role of business modes in firm innovation performance in different country contexts and, in particular, in transition economies. We have answered the following research questions: (i) What are the core characteristics of STI and DUI modes of innovation? (ii) What are the indicators of STI and DUI modes of innovation? (iii) What are the characteristics of the most effective mode of innovation in different country contexts? (iv) What is the most effective mode of innovation in economies in transition? (v) What is the most effective combination of drivers in terms of SME innovation? The thesis consists of 3 studies that are presented in chapters 2, 3 and 4 respectively, and provides conceptual, methodological and empirical contributions. Our literature review and meta-analysis (Chapter 2) have provided insights to the evolution of the innovation theories that preconditioned the emergence of the concept of the STI and DUI innovation modes. We have conducted a meta-analysis based on the grounded theory approach to provide a comprehensive analysis of qualitative and quantitative studies of these modes. We have synthesized the research purposes, methodologies and results of the studies and have identified research trends and patterns in the field. The results of the grounded meta-analysis have revealed several aspects. Firstly, there are no standard indicators of the DUI mode of innovation. This can cause difficulty for researchers to empirically assess the modes of innovation or can lead to implausible results and to impropriate policy initiatives. Secondly, firms in different country contexts (Denmark, Norway, Sweden, Portugal, Canada and China), which combine the STI and DUI modes of innovation are more likely to innovate. Thirdly, the results of meta-analysis have shown a lack of studies in countries in transition and have opened a new research focus that discussed chapter three. We have conducted a pioneering study of this type of context (Chapter 3) and have analyzed the effect of business innovation modes: STI, DUI and the combination of the two on the innovation performance of SMEs. Therefore, the study has extended the geographical application of STI/DUI country studies. We have enriched the methodology of measuring the DUI mode by adding new indicators such as “marketing related to technological innovation” and “technological preparation for production”, which measure the D (doing) and U (using) aspects of the DUI mode that were not measured in previous studies conducted by Jensen, et al. (2007), Chen & Guo (2010) and Parrilli & Elola (2012). In addition, vis-a-vis other studies in the field, we study the impact of innovation modes not only on product innovation but also on organizational innovation, which represent a “non-technological type of innovation” which may require a different set of effective drivers. The results of regression analyses have provided evidence of how the STI and DUI modes influence these two types of innovation. SMEs combining the STI and the DUI modes are more likely to generate product innovation, especially in the case of Belarus. However, SMEs that rely on the DUI mode alone are more likely to generate product innovation than those that rely on the STI mode alone. This can be explained by the fact that Belarus operates behind the technology frontier and that its economic growth is based more on imported technology and production capability than on R&D (Varblane, et al., 2007; Palacín & Radosevic, 2011). With respect to ‘organizational innovations’, we have found out that the STI mode does not relate to this type of innovation to a significant extent. In contrast to product innovation, firms combining the STI and DUI modes of innovation are not more effective in generating 'organizational innovation' than firms relying on the DUI mode alone. However, while conducting this analysis, we have faced difficulties in estimating the extent to which SMEs rely on STI or DUI modes, and what drivers are crucial in this combination. The STI and DUI modes of innovation are not able to show how SMEs can mix the different drivers of innovation or what the composition of innovation drivers is in the combination of the STI and DUI mode of innovation. Therefore, Chapter 4 has explored how different drivers of innovation can be fruitfully combined and reconciled within a firm.

Thus, Chapter 4 has provided some conceptual novelties. We have introduced a new research instrument that enables us to determine the innovation profiles and modes adopted by SMEs – the RTH (Research, Technology and Human Resource Management) model of innovation. This model implies Research (R), Technology (T) and HRM (H) drivers. Based on the results of regression analyses, we have found that there is a statistically significant relationship between the 'T' and 'H' driver and product innovation in the context of the Belarusian IT sector. In contrast, the 'R' driver does not relate to product innovation to a significant extent. Thus, those firms with greater levels of the 'T' and 'H' driver get a better degree of innovation output in terms of new-to-international market innovations. The novelty of this study is that it goes beyond the analysis of 'modes of innovation' introduced by Jensen et al. (2007) and proposes an 'innovation profile' as a detailed description of any innovative firm. The innovation profile implies the combination to different extent (low, medium and high) of the ‘R’, ‘T’ and ‘H’ drivers, and forms the unique characteristics of innovative firms. Firms with similar innovation profiles have been grouped into clusters which are identified as ‘modes of innovation’. Thus, we have revealed 17 (out of 27 possible) innovation profiles, which we have grouped in the 3 main modes of innovation by means of cluster analysis, which is quite different from those introduced by Jensen et al. (2007). The first mode of innovation has been characterized as a ‘low learning mode’ due to the low levels of the ‘R’, ‘T’ and ‘H’ drivers. The firms that belong to this cluster do not have highly developed organizational forms supporting technology acquisition or HRM practices and do not cooperate with researchers and value chain partners. They are capable of generating only incremental type of innovations. The second mode has been defined as ‘S&T-based mode’. This mode is characterized by a quite high level of ‘R’ and ‘T’ drivers and a low level of ‘H’ and resembles the STI mode introduced by Jensen et al. (2007). As the value of ‘T’ driver increases in comparison with the first mode, firms are capable of producing new-to-national-market innovations in addition to new-to-firm types of innovation. The third mode is characterized by a low level of ‘R’ and high level of ‘T’ and an above average level of ‘H’. As we have already mentioned, the ‘R’ driver does not relate to product innovation to a significant extent. However, there is a strong relationship between the ‘T’ and ‘H’ drivers and product innovation. Firms in this cluster are characterized as ‘creative organizations’ and report the highest innovation output among the revealed modes. They manage to produce new-to-international-market products and services.

5.1 Implications

At present, there are some discrepancies regarding statistical indicators describing the innovation performance in Belarus as compared to most European countries. Such discrepancies prevent direct international comparisons of Belarusian innovation performance with other countries. As we realize the importance of international comparability of such statistical data for benchmarking and policy-making initiatives, we have taken further steps to develop the well-known concept of modes of innovation.

The results of the study are potentially useful for academics, policy-makers and managers. Academics can measure the DUI mode more adequately if they employ the ‘doing’ and ‘using’ types of indicators that have been introduced in this thesis. Moreover, as we extend the geographical context of the STI/DUI country studies, this study has significant implications for academics that analyze the geographical perspective of SME innovation modes and innovation performance in transition economies.

Policy-makers can use the concept of modes of innovation to develop strategies and programs aimed at improving the innovation capacities of regions and sectors. This thesis generates more debate on the most effective mode of innovation that can be the basis for the definition of effective public programs for innovation promotion and can be useful in the context of post-soviet countries. The innovation-related regulatory acts in Belarus are based on the STI approach to innovation, whereas the role of the DUI approach is quite neglected. Policy-makers and company managers might take this into account in order to build more effective programs to generate innovation, which can include the promotion of DUI drivers (for example, interactions with customers, suppliers and distributors). In addition, a new research instrument – the RTH model – for analyzing innovation processes across firms has been elaborated. It can be used, not only by researchers, but also by policy-makers and managers. The RTH model enables the exploration of the mode of innovation at the industry level. Based on the RTH model, company managers can recognize the exact innovation profile that helps to harness critical and limited resources in the most appropriate way, by identifying the drivers, the innovation profiles and, then, the most effective mode of innovation, we can create a more conducive environment for innovation-based development. In our RTH model we separated the 'R' from 'T' driver. However, the literature is relatively silent on how to distinguish between these drivers, which are usually proxied by the same indicators within the STI mode (Jensen, et al., 2007; Parrilli & Elola, 2012). The separation of the R from the 'T' driver may be relevant not only in the context of Belarus, but also in the context of other catching up economies.

5.2 Limitations and future research lines

In our research process, we have revealed a number of limitations that need to be acknowledged and some interesting issues for further research. In the literature, there is a lack of standard indicators of the STI and DUI modes. Therefore, we have made an effort to systematize these indicators. It is worth noting that researchers can face difficulties to empirically assess different typologies of modes of innovation because of a significant diversity of STI/DUI indicators. With regard to this, a future research line could be to further investigate the modes of innovation in order to identify more reliable indicators, which are essential for high-quality empirical analysis.

Although we have conducted the first research focused on the effects of modes of innovation on the innovation performance of firms in the context of post-soviet countries in transition, it would be useful to encompass other countries in this group (for example, Russia and Ukraine). It would help to deliver more comprehensive conclusions about the modes of innovation in post-soviet countries in transition, and provide a theoretical framework for the development of a more effective innovation policy.

The third issue relates to the fact that the majority of studies use only data of a one-year period. Longitudinal data would be more relevant in verifying the relationship between business modes and innovation output over a longer time span. Moreover, it can take several years until the R&D activities and interaction (Rosenberg, 1990) start generating a cash flow and affect industrial productivity. Therefore, panel data may help to control also for these longer-term effects.

.

References

Acs, Z. J., Anselin, L., & Varga, A. (2002). Patents and innovation counts as measures of regional production of new knowledge. *Research policy, 31*(7), 1069-1085.

Acs, Z. J., Braunerhjelm, P., Audretsch, D. B., & Carlsson, B. (2009). The knowledge spillover theory of entrepreneurship. *Small Business Economics*, *32*(1), 15-30.

Adler, P. S., & Shenhar, A. (1990). Adapting your technological base: the organizational challenge. *Sloan Management Review, 32*(1), 25-37.

Agresti, A. (2002). *Categorical Data Analysis (2nd ed.).* Wiley.

Aidis, R., Estrin, S., & Mickiewicz, T. (2008). Institutions and entrepreneurship development in Russia: A comparative perspective. *Journal of Business Venturing, 23*, 656–672.

Alam, A., Casero, P. A., Khan, F., & Udomsaph, C. (2008). *Unleashing Prosperity: Productivity Growth in Eastern Europe and the Former Soviet Union.* Washington, DC: World Bank.

Amabile, T. M. (1998). How to kill creativity. *Harvard Business Review, 76*(5), 76–87.

Amara, N., Landry, R., Becheikh, N., & Ouimet, M. (2008). Learning and novelty of innovation in established manufacturing SMEs. *Technovation, 28*(7), 450-463.

Arrow, K. J. (1962). The economic implications of learning by doing. *The review of economic studies, 29*(3), 155-173.

Asheim, B. T., & Coenen, L. (2005). Knowledge bases and regional innovation systems: Comparing Nordic clusters. *Research policy, 34*, 1173-1190.

Asheim, B. T., & Parrilli, M. D. (2012). Introduction: Learning and Interaction – Drivers for Innovation in Current Competitive Markets. In B. T. Asheim, & M. D. Parrilli (Eds.), *Interactive learning for innovation A Key Driver within Clusters and Innovation Systems* (pp. 1-33). Basigstroke: Michalin.

Asheim, B. T., Boschma, R., & Cooke, P. (2011). Constructing Regional Advantage: Platform Policies Based on Related Variety and Differentiated Knowledge Bases. *Regional Studies, 45*(7), 893–904.

Aslesen, H. W., Isaksen, A., & Karlsen, J. (2012). Modes of Innovation and Differentiated Responses to Globalisation—A Case Study of Innovation Modes in the Agder Region, Norway. *Journal of the Knowledge Economy, 3*, 389-405.

Audretsch, D.B. (2003). Standing on the shoulders of old midgets: the US small business innovation program. *Small Business Economics*, *20*, 129-135.

Audretsch, D. B., & Keilbach, M. (2004). Entrepreneurship capital and economic performance. *Regional studies, 38*(8), 949-959.

Belstat. (2012). *Statistical book Science and innovation activity.* Minsk: National Statistical Committee of the Republic of Belarus (Belstat).

Beugelsdijk, S. (2008). Strategic human resource practices and product innovation. *Organization Studies, 29*(6), 821–847.

Bilbao-Osorio, B., & Rodriguez-Pose, A. (2004). From R&D to innovation and economic growth in the EU. *Growth and Change, 35*(4), 434-455.

Bush, V. (1945). *Science: The Endless Frontier.* North Stratford: Ayer Co.

Chandler, A. (1962). *Strategy and structure.* Cambridge, MA: MIT Press.

Chen, J., & Guo, A. (2010). An empirical study on the relationship between the STI/DUI Learning and technological innovation performance in Chinese's industries. *International Schumpeter Society Conference 2010*, 1-20.

Chen, J., Chen, Y., & Vanhaverbeke, W. (2011). The influence of scope, depth, and orientation of external technology sources on the innovative performance of Chinese firms. *Technovation, 31*, 362-373.

Chesbrough, H. (2003). *Open innovation: The new imperative for creating and profiting from technology.* Harvard Business Press.

Chesbrough, H. (2006). Open innovation: a new paradigm for understanding industrial innovation. In H. Chesbrough, W. Vanhaverbeke, & J. West (Eds.), *Open innovation: Researching a new paradigm.* Oxford university press.

CIS. (2008). *Community Innovation Survey.* Dublin: Forfas.

Cohen, W. M., & Levinthal, D. A. (1989). Innovation and learning: the two faces of R&D. *The economic journal, 99*(397), 569-596.

Cohen, W. M., & Levinthal, D. A. (1990). Absorptive capacity: a new perspective on learning and innovation. *Administrative science quarterly*, 128-152.

Corbin, J. M., & Strauss, A. (1990). Grounded theory research: Procedures, canons, and evaluative criteria. *Qualitative sociology*, *13*(1), 3-21.

Corbin, J., & Strauss, A. (2007). *Basics of qualitative research: Techniques and procedures for developing grounded theory.* Sage Publications, Incorporated.

Cosh, A., Fu, X., & Hughes, A. (2012). Organisation structure and innovation performance in different environments. *Small Business Economics, 39*(2), 301-317.

Crosby, M. (2000). Patents, innovation and growth. *Economic Record, 76*(234), 255-262.

Damanpour, F., & Aravind, D. (2012). Managerial innovation: Conceptions, processes, and antecedents. *Management and Organization Review, 8*(2), 423-454.

Damijan, J. P., Knell, M., Majcen, B., & Rojec, M. (2003). The role of FDI, R&D accumulation and trade in transferring technology to transition countries: evidence from firm panel data for eight transition countries. *Economic systems, 27*(2), 189-204.

Djarova, J. (2011). National innovation system and innovation governance. In *The Innovation Performance Review of Belarus* (pp. 21-39). New York: United Nations.

Dosi, G., Freeman, C., Nelson, R., Silverberg, G., & Soete, L. (Eds.). (1988). *Technology and economic theory.*

Duguay, C. R., Landry, S., & Pasin, F. (1997). From mass production to flexible/agile production. *International Journal of Operations & Production Management, 17*(12), 1183-1195.

Edquist, C. (Ed.). (1997). *Systems of innovation: technologies, institutions and organizations.* Psychology Press.

Edquist, C. (2005). Systems of Innovation. Perspectives and Challenges. In J. Fagerberg, D. Mowery, & R. Nelson (Eds.), *The Oxford Handbook of Innovation.* Oxford: Oxford University Press.

Edquist, C., Hommen, C. L., & McKelvey, M. (2001). *Innovation and employment: Process versus product innovation.* Cheltenham: Edward Elgar.

Ejermo, O. (2009). Regional Innovation Measured by Patent Data—Does Quality Matter? Research Paper. *Industry and Innovation, 16*(2), 141-165.

EU. (2013). *Annual Report on European SMEs.*

Fabrizio, K. R. (2009). Absorptive capacity and the search for innovation. *Research Policy, 38*, 255–267.

Feige, E. (1990). Perestroika and Ruble Convertibility. *Cato Journal, 10*, 631-653.

Feige, E. (1994). The transition to a market economy in Russia: property rights, mass privatization and stabilization. In S. A. Gregory, & S. Grazyna, *A*

Fourth Way?: Privatization, Property, and the Emergence of New Market Economics (pp. 57-78). New York: Routledge.

Fink, G., Haiss, P., & Vuksic, G. (2009). Contribution of financial market segments at different stages of development: Transition, cohesion and mature economies compared. *Journal of Financial Stability, 5*(4), 431-455.

Fitjar, R. D., & Rodriguez-Pose, A. (2013). Firm collaboration and modes of innovation in Norway. *Research policy, 42*(1), 128-138.

Fleming, L., & Sorenson, O. (2004). Science as a map in technological search. *Strategic Management Journal, 25*, 909–928.

Freeman, C. (1987). *Technology policy and economic performance: lessons from Japan.* London: Pinter Publishers.

Freeman, C. (1995). The 'National System of Innovation'in historical perspective. *Cambridge Journal of Economics, 19*(1), 5-24.

Friendly, M. (1999). Extending mosaic displays: marginal, conditional, and partial views of categorical data . *Journal of Computational and Graphical Statistics, 8*(3), 373-395.

Fu, W., Diez, J. R., & Schiller, D. (2013). Interactive learning, informal networks and innovation: Evidence from electronics firm survey in the Pearl River Delta, China. *Research Policy, 42*, 635–646.

Gemünden, H. G., Ritter, T., & Heydebreck, P. (1996). Network configuration and innovation success: An empirical analysis in German high-tech industries. *International Journal of Research in Marketing, 13*(5), 449-462.

Glaser, B., & Strauss, A. (1967). *The discovery grounded theory: strategies for qualitative inquiry.* (Aldine, Ed.) Chicago.

Godin, B. (2006). The Linear Model of Innovation The Historical Construction of an Analytical Framework. *Science, Technology & Human Values, 31*(6), 639-667.

Goetz, K., & Wollmann, H. (2001). Governmentalizing central executives in post-communist Europe: a four-country comparison. *Journal of European Public Policy, 8*(6), 864-887.

Gonzalez-Pernia, J. L., Parrilli, M. D., & Pena, I. (2012a). Learning Modes, Types of Innovation and Economic Performance. *Orkestra Working Paper Series in Territorial Competitiveness*, 1-34.

González-Pernía, J. L., Peña-Legazkue, I., & Vendrell-Herrero, F. (2012b). Innovation, entrepreneurial activity and competitiveness at a sub-national level. *Small Business Economics, 39*(3), 561-574.

Greunz, L. (2005). Intra-and inter-regional knowledge spillovers: Evidence from European regions. *European Planning Studies, 13*(3), 449-473.

Griliches, Z. (1979). Issues in assessing the contribution of research and development to productivity growth. *Bell Journal of Economics, 10*(1), 92-116.

Guo, A., Chen, J., & Jin, J. (2010). An analysis of the complementary innovation mechanism between STI and DUI modes. *International Journal of Learning and Intellectual Capital, 7*(3), 265-273.

Hagedoorn, J. (1993). Understanding the rationale of strategic technology partnering: Nterorganizational modes of cooperation and sectoral differences. *Strategic management journal, 14*(5), 371-385.

Hair, J. F., Black, W., Babin, B., & Anderson, R. (2010). *Multivariate Data Analysis. A Global Perspective.* New Jearsey: Pearson Prentice Hall.

Hastie, T., Tibshirani, R., & Friedman, J. (2001). *The elements of statistical learning* . New York: Springer.

Havas, A. (2002). Does innovation policy matter in a transition country? The case of Hungary. *Journal of International Relations and Development, 5*(4), 380-402.

Hinds, P., & Kiesler, S. (1995). Communication across boundaries: Work, structure, and use of communication technologies in a large organization. *Organization Science, 6*(4), 373-393.

Hossler, D., & Scalese-Love, P. (1989). Grounded Meta-Analysis: A Guide for Research Syntheses. *Review of Higher Education, 13*(1), 1-28.

Howells, J., Ramlogan, R., & Cheng, S.-L. (2012). Universities in an open innovation system: a UK perspective., 18(4). *International Journal of Entrepreneurial Behaviour & Research, 18*(4), 440-456.

Hunter, J. E., & Schmidt, F. L. (2004). *Methods of meta-analysis: Correcting error and bias in research findings.* Thousand Oaks: SAGE Publications Incorporation.

Isaksen, A., & Karlsen, J. (2010). Different modes of innovation and the challenge of connecting universities and industry: case studies of two regional industries in Norway. *European Planning Studies, 18*(12), 1993-2008.

Isaksen, A., & Karlsen, J. (2012a). Combined and complex mode of innovation in region cluster development: analysis of the light-weight material cluster in Raufoss, Norway. In B. T. Asheim, & M. D. Parrilli, *Interactive Learning for Innovation: a key drive within clusters and innovation systems* (pp. 115-136). Basingstroke: Palgrave-Macmilan.

Isaksen, A., & Karlsen, J. (2012b). What Is Regional in Regional Clusters? The Case of the Globally Oriented Oil and Gas Cluster in Agder, Norway. *Industry and innovation, 19*(3), 249-263.

Isaksen, A., & Nilsson, M. (2013). Combined Innovation Policy: Linking Scientific and Practical Knowledge in Innovation Systems. *European Planning Studies, 21*(12), 1919-1936.

IPM. (2013). Business in Belarus 2013: Status, Trends, Perspectives . IPM Research Center.

Jensen, M. B., Johnson, B., Lorenz, E., & Lundvall, B. A. (2007). Forms of knowledge and modes of innovation. *Research Policy, 36*, 680-693.

Jong, S., & Slavova, K. (2014). When publications lead to products: The open science conundrum in new product development. *Research Policy, forthcoming, 43*(4), 645–654.

Jong, S., & Slavova, K. (2014). When publications lead to products: The open science conundrum in new product development. *Research Policy, forthcoming*.

Katila, R., & Ahuja, G. (2002). Something old, something new: A longitudinal study of search behavior and new product introduction. *Academy of management journal, 45*(6), 1183-1194.

Kaufman, L., & Rousseeuw, P. J. (1990). *Finding Groups in Data: An Introduction to Cluster Analysis* (1 ed.). New York: John Wiley.

Ke, F. (2009). A qualitative meta-analysis of computer games as learning tools. In R. Ferdig, *Handbook of research on effective electronic gaming in education* (Vol. 1, pp. 1-32). New York: Hershey.

Kleine, S. J. (1985). Innovation is not a linear process. Research management. *28*(4), 36-45.

Kline, S. J., & Rosenberg, N. (1986). An overview of innovation. The positive sum strategy: Harnessing technology for economic growth. In R. Landau, & N. Rosenberg (Eds.). National Academies Press.

Krammer, S. (2009). Drivers of national innovation in transition: Evidence from a panel of Eastern European countries. *Research Policy, 38*(5), 845-860.

Lam, A. (2005). Organizational Innovation. In J. Fagerberg, D. Mowery, & R. Nelson , *The Oxford Handbook of Innovation* (pp. 115-148). Oxford: Oxford University Press.

Lane, P. J., & Lubatkin, M. (1998). Relative absorptive capacity and interorganizational learning. *Strategic management journal, 19*(5), 461-477.

Lau, C. M., & Ngo, H. Y. (2004). The HR system, organizational culture and product innovation. *International Business Review, 13*, 685–703.

Laursen, K., & Foss, N. J. (2012). Human Resource Management Practices and Innovation. *DRUID Conference*, 1-30.

Laursen, K., & Salter, A. (2006). Open for innovation: the role of openness in explaining innovation performance among UK manufacturing firms. *Strategic Management Journal, 27*(2), 131–150.

Lederman, D., & Saenz, L. (2005). Innovation and Development around the World, 1960-2000. Washington, DC, USA: World Bank.

Lorenz, E. (2012). Labour Market Institutions, Skills, and Innovation Style: a Critique of the Varieties of Capitalism perspective. In B. T. Asheim, & M. D. Parrilli (Eds.), *Interactive learning for innovation A Key Driver within Clusters and Innovation Systems* (pp. 72-89). Basingstoke: Palgrave Macmillan.

Lorenz, E. (2012). Labour Market Institutions, Skills, and Innovation Style: a Critique of the Varieties of Capitalism perspective. In B. T. Asheim, & M. D. Parrilli, *Interactive learning for innovation A Key Driver within*

Clusters and Innovation Systems (pp. 72-89). Basingstoke: Palgrave Macmillan.

Lorenz, E., & Lundvall, B. A. (2007). Modes of Innovation and Knowledge Taxonomies in the Learning economy. *CAS workshop in Innovation in Firms.* Oslo.

Lorenz, E., & Lundvall, B. A. (2011). Accounting for Creativity in the European Union: A multi-level analysis of individual competence, labour market structure, and systems of education and training. *Cambridge Journal of Economics, 35*(2), 269-294.

Love, J. H., & Mansury, M. A. (2007). External linkages, R&D and innovation performance in US business services. *Industry and Innovation, 14*(5), 477-496.

Lowe, J., & Taylor, P. (1998). R&D and technology purchase through licence agreements: complementary strategies and complementary assets. *R&D Management, 4*, 263-278.

Lundvall, B. A. (1988). Innovation as an interactive process: from user-producer interaction to the national system of innovation. In G. Dosi, C. Freeman, R. Nelson, G. Silverbe, & L. Soete, *Technical change and economic theory* (pp. 349-369). London: Pinter.

Lundvall, B. A. (1992). *National innovation system: towards a theory of innovation and interactive learning.* London: Pinter.

Lundvall, B. A. (2006). Knowledge Management in the Learning Economy. *Druid conference*, ISBN 87-7873-196-8.

Lundvall, B. A., & Johnson, B. (1994). The learning economy. *Journal of industry studies, 1*(2), 23-42.

Lundvall, B. A., Johnson, B., Andersen, E. S., & Dalum, B. (2002). National systems of production, innovation and competence building. *Research policy, 31*(2), 213-231.

Maclaurin, W. R. (1953). The sequence from invention to innovation and its relation to economic growth. *The Quarterly Journal of Economics, 67*(1), 97-111.

Maznyuk, V., & Sergiychuk, I. (2010). *Central and Eastern Europe IT Outsourcing Review 2010*. Central and Eastern European Outsourcing Association, Kiev.

Mintzberg, H. (1980). Structure in 5's: A Synthesis of the Research on Organization Design . *Management science, 26*(3), 322-341.

Nelson (Ed.). (1993). *National Systems of Innovation: A Comparative Study.* Oxford: Oxford University Press.

Nelson, & Winter. (1982). *An evolutionary theory of economic change.* Cambridge: Belknap Press.

Nielsen, L. (2011). Classifications of Countries Based on Their Level of Development: How it is done and how it could be done. *Working Paper IMF*.

Nonaka, I. (1991). The knowledge-creating company. *Harvard business review, 69*(6), 96-104.

Nonaka, I., & Takeuchi, H. (1995). *The Knowledge Creating Company.* Oxford: Oxford University Press.

Nunes, S., Lopes, R., & Dias, J. G. (2013). Innovation Modes and Firm Performance: Evidence from Portugal. Paper presented at 53rd ERSA Congress.

OECD. (1992). *OECD proposed guidelines for collecting and interpreting technological innovation data - OSLO Manual.* Paris: OECD.

OECD. (1999). *Managing national innovation systems.* Paris.

OECD. (2005). *Oslo manual: Guidelines for collecting and interpreting innovation data.* OECD publishing.

OECD. (2007). *Economic Surveys: Norway.* Paris: OECD.

Oke, A., Walumbwa, F. O., & Myers, A. (2012). Innovation Strategy, Human Resource Policy, and Firms' Revenue Growth: The Roles of Environmental Uncertainty and Innovation Performance. *Decision sciences, 43*(2), 273-302.

Palacín, J., & Radosevic, S. (2011). Recent economic and innovation performance. In *The Innovation Performance Review of Belarus* (pp. 1-18). New York: United Nations.

Parrilli, M. D., & Elola, A. (2012). The strength of science and technology drivers for SME innovation. *Small Business Economics, 39*(4), 897-907.

Patel, P., & Pavitt, K. (1997). The technological competencies of the world's largest firms: complex and path-dependent, but not much variety. *Research policy, 26*(2), 141-156.

Patel, P., & Pavitt, K. (1994). National innovation systems: why they are important, and how they might be measured and compared. *Economics of innovation and new technology, 3*(1), 77-95.

Pavitt, K. (1984). Sectoral patterns of technical change: towards a taxonomy and a theory. *Research policy, 13*(6), 343-373.

Porter, M. E. (1990). The Competitive Advantage of Nations. *Harvard business review*.

Presutti, M., Boari, C., & Majocchi, A. (2011). The Importance of Proximity for the Start-Ups' Knowledge Acquisition and Exploitation. *Journal of Small Business Management, 49*(3), 361-389.

Qian, Y., & Weingast, B. R. (1996). China's transition to markets: market-preserving federalism, Chinese style. *The Journal of Policy Reform, 1*(2), 149-185.

Radosevic, S. (2011). Science-industry links in Central and Eastern Europe and the Commonwealth of Independent States: conventional policy wisdom facing reality. *Science and Public Policy, 38*(5), 365-378.

Rahimi, B., Vimarlund, V., & Timpka, T. (2009). Health information system implementation: A qualitative meta-analysis. *Journal of medical systems, 33*(5), 359-368.

Rammer, C., Czarnitzki, D., & Spielkamp, A. (2009). Innovation success of non-R&D-performers: substituting technology by management in SMEs. *Small Business Economics, 33*(1), 35-58.

Rees, C. J., & Miazhevich, G. (2009). Socio-cultural change and business ethics in post-Soviet countries: The cases of Belarus and Estonia. *Journal of business ethics, 86*(1), 51-63.

Ritter, T., & Gemünden, H. G. (2003). Network competence: its impact on innovation success and its antecedents. *Journal of Business Research, 56*(9), 745–755.

Ritter, T., & Gemünden, H. G. (2004). The impact of a company's business strategy on its technological competence, network competence and innovation success. *Journal of Business Research, 57*(5), 548-556.

Rodríguez-Pose, A., & Crescenzi, R. (2008). Research and development, spillovers, innovation systems, and the genesis of regional growth in Europe. *Regional studies, 42*(1), 51-67.

Romer, P.M. (1986). Increasing returns and long-run growth. *The Journal of Political Economy, 94*(5), 1002-1037.

Romer, P.M. (1994). The origins of endogenous growth. *The Journal of Economic Perspectives, 8*(1), 3-22.

Rosenberg, N. (1982). *Inside the black box: technology and economics.* Cambridge: Cambridge University Press.

Rosenberg, N. (1990). Why do firms do basic research (with their own money)? *Research policy, 19*(2), 165-174.

Rosenberg, N. (1994). *Exploring the black box: Technology, economics, and history.* . Cambridge: Cambridge University Press.

Rosenbusch, N., Brinckmann, J., & Bausch, A. (2011). Is innovation always beneficial? A meta-analysis of the relationship between innovation and performance in SMEs. *Journal of Business Venturing, 26*(4), 441-457.

Rothwell, R. (1994). Towards the fifth-generation innovation process. *International marketing review, 11*(1), 7-31.

Sala-i-Martin, X., & Schwab, K. (2011). The global competitiveness report 2011-2012.

Sanchez, R. (2008). 15 'Tacit knowledge'versus 'explicit knowledge'approaches to knowledge management practice. In D. Rooney, G. Hearn, & A. Ninan (Eds.), *Handbook on the knowledge economy* (pp. 191-203). Cheltenham: Edward Elgar Publishing.

Sanidas, E. (2005). *Organizational innovations and economic growth: Organosis and growth of firms, sectors, and countries.* Cheltenham: Edward Elgar.

Schulz, M., & Jobe, L. A. (2001). Codification and tacitness as knowledge management strategies: an empirical exploration . *The Journal of High Technology Management Research, 12*(1), 139-165.

Schumpeter, J. A. (1934). *The theory of economic development: An inquiry into profits, capital, credit, interest, and the business cycle.* Transaction Publishers.

Schumpeter, J. A. (1942). *Socialism, capitalism and democracy.* New York: Harper and Brothers.

Sen, F. K., & Egelhoff, W. G. (2000). Innovative capabilities of a firm and the use of technical alliances. *IEEE Transactions on Engineering Management, 47*(1), 174-183.

Shipton, H., Fay, D., West, M., Patterson, M., & Birdi, K. (2005). Managing people to promote innovation. *Creativity and Innovation Management, 14*(2), 118–128.

Smith, A. (1776). *An Inquiry into the Nature and Causes of the Wealth of Nations (5th edition, 1904).* London: Methuen and Co.Ltd.

Sotarauta, M., Gulbrandsen, M., Dubarle, P., & Nauwelaers, C. (2006). Peer Review Report: Trøndelag (Mid-Norwegian Region).

SPID. (2007). *The State Programme for Innovative Development of the Republic of Belarus for 2007-2010.*

SPID. (2011). *The State Programme for Innovative Development of the Republic of Belarus for 2011-2015.*

Spithoven, A., Vanhaverbeke, W., & Roijakkers, N. (2013). Open innovation practices in SMEs and large enterprises. *Small Business Economics, 41*(3), 537-562.

Stall-Meadows, C. (1998). Grounded meta-analysis of qualitative case study dissertations in distance education pedagogy. *Doctoral dissertation, Oklahoma State University*.

Stall-Meadows, C., & Hyle, A. (2010). Procedural methodology for a grounded meta-analysis of qualitative case studies . *International Journal of Consumer Studies, 34*(4), 412-418.

Stanley, T. D. (2001). Wheat From Chaff: Meta-Analysis As Quantitative Literature Review. *Journal of Economic Perspectives, 15*(3), 131–150.

Sterlacchini, A. (2008). R&D, higher education and regional growth: Uneven linkages among European regions. *Research Policy, 37*(6), 1096-1107.

Strauss, A. L., & Corbin, J. (1990). *Basics of qualitative research.* Newbury Park, CA: Sage publications.

Strauss, A., & Corbin, J. (1994). Grounded theory methodology. In *Handbook of qualitative research* (pp. 273-285).

Tether, B. S. (2002). Who co-operates for innovation, and why: an empirical analysis. *Research policy, 31*(6), 947-967.

Timulak, L. (2009). Meta-analysis of qualitative studies: A tool for reviewing qualitative research findings in psychotherapy. *Psychotherapy Research, 19*(4-5), 591-600.

Tomlinson, P. R., & Fai, F. M. (2013). Meta-heuristics for manufacturing scheduling and logistics problems. *International Journal of Production Economics, 141*(1), 316–326.

Trippl, M. (2011). Regional innovation systems and knowledge-sourcing activities in traditional industries—evidence from the Vienna food sector. *Environment and Planning A, 43*(7), 1599-1616.

UN. (2002). *Towards a Knowledge-based Economy: Country Readiness Assessment Report. Belarus.* New York and Geneva: United Nations Publications .

UN. (2013). World Economic Situation and Prospects country classification.

UNECE. (2011). Innovation Performance Review of Belarus.

Van Den Bosch, F. A., Volberda, H. W., & De Boer, M. (1999). Coevolution of firm absorptive capacity and knowledge environment: Organizational forms and combinative capabilities. *Organization Science, 10*(5), 551-568.

Varblane, U., Dyker, D., Tamm, D., & von Tunzelmann, N. (2007). Can the National Innovation Systems of the New EU Member States Be Improved? *Post-Communist Economies, 19*(4), 399-416.

Varum, C., & Monteiro, L. (2007). Modes Of Innovation & Uncertainties In The Capital Goods Industry. (G. e. Departamento de Economia, Ed.) *Working paper (No. 47).*

Von Hippel, E. (1976). The dominant role of users in the scientific instrument innovation process. *Research policy, 5*(3), 212-239.

Von Hippel, E. (1986). Lead users: a source of novel product concepts. *Management science, 32*(7), 791-805.

Von Hippel, E. (1988). *The sources of innovation.* New York: Oxford University Press.

Wong, P. K., Ho, Y. P., & Autio, E. (2005). Entrepreneurship, innovation and economic growth: Evidence from GEM data. *Small Business Economics, 24*(3), 335-350.

Wu, W. H., Jim Wu, Y. C., Chen, C. Y., Kao, H. Y., & Lin, C. H. (2012). Review of trends from mobile learning studies: A meta-analysis. *Computers & Education, 2*, 817-827.

Wuyts, S., Dutta, S., & Stremersch, S. (2004). Portfolios of interfirm agreements in technology-intensive markets: consequences for innovation and profitability. *Journal of marketing*, 88-100.

Yeo, R. K. (2005). Revisiting the roots of learning organization: a synthesis of the learning organization literature. *Learning Organization*, *12*(4), 368-382.

Annex 1. Regression model with interactions

Table 1. Model Fitting Information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	160,678			
Final	79,865	80,813	8	,000

Link function: Logit.

Table 2. Parameter Estimates

	Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
[IO = ,00]	-2,505	4,784	,274	1	,601	-11,881	6,872
[IO = 1,00]	-,815	4,785	,029	1	,865	-10,193	8,563
[STI=,00]	-,527	,991	,282	1	,595	-2,470	1,416
[STI=1,00]	-,630	1,336	,223	1	,637	-3,248	1,988
[STI=2,00]	0[a]	.	.	0	.	.	.
[DUI=,00]	-1,588	,838	3,592	1	,058	-3,231	,054
[DUI=1,00]	-,894	,875	1,044	1	,307	-2,610	,821
[DUI=2,00]	0[a]	.	.	0	.	.	.
[S0D0=,00]	,425	1,041	,166	1	,683	-1,616	2,466
[S0D0=1,00]	0[a]	.	.	0	.	.	.
[S0D1=,00]	,544	1,067	,260	1	,610	-1,547	2,635
[S0D1=1,00]	0[a]	.	.	0	.	.	.

[S0D2=,00]	0[a]	.	.	0	.	.	.
[S0D2=1,00]	0[a]	.	.	0	.	.	.
[S1D0=,00]	,574	1,371	,175	1	,675	-2,113	3,261
[S1D0=1,00]	0[a]	.	.	0	.	.	.
[S1D1=,00]	-,918	1,410	,424	1	,515	-3,683	1,846
[S1D1=1,00]	0[a]	.	.	0	.	.	.
[S1D2=,00]	0[a]	.	.	0	.	.	.
[S1D2=1,00]	0[a]	.	.	0	.	.	.
[S2D0=,00]	0[a]	.	.	0	.	.	.
[S2D0=1,00]	0[a]	.	.	0	.	.	.
[S2D1=,00]	0[a]	.	.	0	.	.	.
[S2D1=1,00]	0[a]	.	.	0	.	.	.
[S2D2=,00]	0[a]	.	.	0	.	.	.
[S2D2=1,00]	0[a]	.	.	0	.	.	.

Link function: Logit.

a. This parameter is set to zero because it is redundant.

Annex 2. Calculation of probabilities

Equations to calculate probabilities using results of ordinal logistic regression fit.

$$Prob(IO=0|STI,DUI) = \frac{1}{1+exp(-a_0+b_{STI,0}X_{STI,0}+b_{STI,1}X_{STI,1}+b_{DUI,0}X_{DUI,0}+b_{DUI,1}X_{DUI,1})}$$

$$Prob(IO=1|STI,DUI) = \frac{1}{1+exp(-a_1+b_{STI,0}X_{STI,0}+b_{STI,1}X_{STI,1}+b_{DUI,0}X_{DUI,0}+b_{DUI,1}X_{DUI,1})} - Prob(IO=0|STI,DUI)$$

$$Prob(IO=2|STI,DUI) = 1 - Prob(IO=0|STI,DUI) - Prob(IO=0|STI,DUI)$$

Calculation of probabilities using results of ordinal logistic regression fit.

$$Prob(IO=0|STI,DUI) = \frac{1}{1+exp(3.429-1.089X_{STI,0}-0.678X_{STI,1}-2.079X_{DUI,0}-0.978X_{DUI,1})}$$

$$Prob(IO=1|STI,DUI) = \frac{1}{1+exp(1.781-1.089X_{STI,0}-0.678X_{STI,1}-2.079X_{DUI,0}-0.978X_{DUI,1})} - Prob(IO=0|STI,DUI)$$

$$Prob(IO=2|STI,DUI) = 1 - Prob(IO=0|STI,DUI) - Prob(IO=1|STI,DUI)$$

	Estimate	Std. Error	Wald	Df	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
a0	-3,429	,488	49,308	1	,000	-4,386	-2,472
a1	-1,781	,472	14,252	1	,000	-2,706	-,856
$\mathbf{b_{STI,0}}$	-1,089	,244	20,008	1	,000	-1,567	-,612
$\mathbf{b_{STI,1}}$	-,678	,247	7,515	1	,006	-1,162	-,193
$\mathbf{b_{STI,2}}$	0[a]	.	.	0	.	.	.

$\mathbf{b_{DUI,0}}$	-2,079	,460	20,410	1	,000	-2,981	-1,177
$\mathbf{b_{DUI,1}}$	-,978	,459	4,537	1	,033	-1,877	-,078
$\mathbf{b_{DUI,2}}$	0^a	.	.	0	.	.	.

Annex 3. Distribution of probabilities of generating radical product innovation

STI	DUI	STI and DUI	Only DUI	Only STI
0	0	20,1%	28,3%	35,7%
1	0	27,4%	28,3%	37,8%
0	1	43,2%	50,2%	35,7%
2	0	42,8%	28,3%	56,3%
0	2	66,0%	73,9%	35,7%
1	1	53,2%	50,2%	37,8%
2	2	85,2%	73,9%	56,3%
2	1	69,3%	50,2%	56,3%
1	2	74,4%	73,9%	37,8%

Annex 4. Survey conducted for RTH study

Analyzed year 2012

1. General information about the enterprise

Main activity	
Size (number of employees)	
Less 10 (micro)	
From 10 to 249 (SME)	
More than 249 (large)	

2.1 Did your enterprise introduce:

		Yes	No
1	New or significantly improved products (goods or services). (Exclude the simple resale of new goods purchased from other enterprises and changes of a solely aesthetic nature)		

2.2 Were any of your product (service):

		Explanation	Yes	No
1	Only new to your firm?	Your enterprise introduced a new or significantly improved good or service that was already available from your competitors in your market		
2	New to your market?	Your enterprise introduced a new or significantly improved good or service onto your market before your competitors (it may have already been available in other markets)		
3	New to international market?	Your enterprise introduced a new or significantly improved good or service onto international market before your competitors		

Please give the percentage of your total revenue:

Annual turnover, million euros	
Less than 2	
From 2 to 50	
More than 50	

3. Sources of innovation

	0%	0-2%	3-5%	6-15%	Above 15%
How large a share of total revenue did expenditure on R&D constitute?					

How many of your employees have following degrees?	A university technical degree (Specialist diploma)	Master	Ph.D. within the natural sciences
0%			
1% to 4%			
5% to 24%			
25% to 49%			
50% to 74%			
75% to 100%			

Annex 4. Survey conducted for RTH study

	Never	Rarely	Occasionally	Frequently	Always
Does the firm collaborate with researchers, universities, research institutions?					
Does the firm monitor new technology appearance in the market?					
Does your firm purchase patents, external knowledge or licensing of patents and non-patented inventions, know-how, and other types of knowledge from other enterprises or organizations					
	Very poor	Poor	Good	Very good	Excellent
A firm possesses state-of-the-art production facilities					
Development and adaptation of current and new technology					
	Never	Rarely	Occasionally	Frequently	Always
Does the firm collaborate with technology centers, engineering companies, technical alliances?					

Did your enterprise engage in the following innovation activities:

	Never	Rarely	Occasionally	Frequently	Constantly
The reward and recognition systems encourage innovation and reinforce entrepreneurial behavior and team work.					
How often your firm organizes training aimed to acquire and develop skills that are crucial to introduce new or significantly improved products and processes.					
Whether the firm has implemented new methods of organizing work responsibilities and delegation of decisions. Clear innovation targets are set for all employees					
Do communications work well in both directions: top-down and bottom-up (vertical communication) and between different company departments (horizontal communication)?					
Communication works in both directions: top-down and bottom-up (vertical communication) and between different company departments (horizontal communication).					
The firm has mechanisms and procedures for generating, evaluating and implementation of innovative ideas.					

Does the firm interact with?					
Customers					
Suppliers					
Competitors					
Distributer					