UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL
ESCOLA DE ENGENHARIA
PROGRAMA DE PÓS-GRADUAÇÃO EM ENGENHARIA DE PRODUÇÃO

MASTER'S DISSERTATION

A STUDY OF INNOVATION BARRIERS AND THE RESULTING STRATREGIC OPTIONS IN THE BRAZILIAN INDUSTRY

Mateus José do Rêgo Ferreira Lima

Porto Alegre, 2018

UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL
ESCOLA DE ENGENHARIA
PROGRAMA DE PÓS-GRADUAÇÃO EM ENGENHARIA DE PRODUÇÃO

A STUDY OF INNOVATION BARRIERS AND THE RESULTING STRATREGIC OPTIONS IN THE BRAZILIAN INDUSTRY

Mateus José do Rêgo Ferreira Lima

Advisor: Prof. Alejandro Germán Frank, PhD.

Examination board:

Prof. Daniel de Abreu Pereira Uhr, PhD.
Department of Economics / UFPEL

Prof. Marcelo Nogueira Cortimiglia, PhD.
Department of Production Engineering / UFRGS

Prof. Néstor Fabián Ayala, PhD.
Department of Production Engineering / Grenoble Institute of Technology (France)

Dissertation submitted to the Graduation Program in Industrial Engineering as a partial requisite to obtain the title of
MASTER IN ENGINEERING

Area of concentration: Quality Systems
Porto Alegre, March 16th, 2018

This dissertation was deemed adequate to obtain the Master's degree in Engineering and approved in its final form by the Advisor and by the Examination Board designated by the Graduate Program in Production Engineering.

_____

Prof. Alejandro Germán Frank, PhD.
PPGEP / UFRGS
Advisor

_____

Prof. Flávio Sanson Fogliatto, Ph.D.
Coordinator PPGEP / UFRGS

Examination Board:

Prof. Daniel de Abreu Pereira Uhr, PhD.
Department of Economics / UFPEL

Prof. Marcelo Nogueira Cortimiglia, PhD.
Department of Production Engineering / UFRGS

Prof. Néstor Fabián Ayala, PhD.
Department of Production Engineering / Grenoble Institute of Technology (France)

“Shoot for the moon, even if you miss, you´ll land among the stars.” (Les Brown)

ACKNOWLEDGMENTS

First of all, I thank God and Santo Expedito, who gave me the opportunity to join this well-acclaimed graduate program as a master degree student and get to the end with a job that I am very proud and with the maximum grades in all the courses I have taken. I am very blesses for having a life goal and for waking up every day felling motivated in taking a step further towards it. Thank God for all. Thank Santo Expedito, the saint of all students.

I thank my dad João Bosco and my mom Lilia for providing me with all the support that I need to succeed and most of all, for keep reminding me what is my life goal, my personal legend. You guys are my angels and I must honor you with my best. You are just amazing in every sense. We will get much further, all three of us together.

Thank you very much professor Alejandro Frank. Professor Frank, I´m truly and deeply inspired by you as a professor, a researcher and a human being. I simply wish to be as great as you are. Thank you for being my advisor, providing me the chance of working at NEO and for supporting me throughout my journey as a master student. I´ve learner so much with you and I could not have started my carrers as a researcher in a better way.

I also thank every member and past member of the Organizational Engineering Group (NEO). You guys are my second family, and I´m very greatful for having such great friends and coworkers. Each one of you contributed for my work either directly or indirectly.

Thanks to all the professors at the Lab for product and process optimization (LOPP) for inspiring dreamers like me who wish to become a great researcher.

I thank professor Daniel Uhr for the crucial contributions for the development of this dissertation.

Lastly, I thank the people from Rio Grande do Sul for adopting me in your land, specially Porto Alegre. This is a place of amazing people which I have a huge consideration.

CREDITS

The development of this dissertation was possible thanks to the master's degree scholarship granted to the candidate by The Brazilian National Council for Scientific and Technological Development (Cnpq) of the Ministry of Education (MEC), Federal Government of Brazil.

ABSTRACT

Innovation has been acknowledged as a main driver for competitiveness whether it is for a firm, industry, region or country. Solutions for improvements in products and processes have emerged from the multitude of innovation tools and its techno-scientific features. However, the path traced by firms to innovate is rarely clear and not always successful. In this regard, a variety of uncertainties have been shaped into the obstacles that hinder firm's innovation activities and prevent them to innovate. To the best of our knowledge, there is no literature that directly addresses the obstacles for innovation in Brazil in a broader sense. Also, the articles focused on the strategies of innovation did not investigated its antecedents, characterizing a clear avenue for research. The objective of this study is to understand which innovation barriers affect the Brazilian industry and how they influence the adoption of innovation strategies. In this way, one of the main strategies that stand out in literature is industrial cooperation. Secondly, a discussion that stands out in literature regards the existence of two juxtaposed strategies, known as *Market-orientation* and *Technology-acquisition.* This work combined with an exploration of the current state of industrial innovation studies in Brazil through a systematic review. Also, we combined multiple methods to quantitatively analyze the relationship among variables of the Brazilian innovation survey (PINTEC). The main results of this dissertation are: (i) the systematization of the industrial innovation literature in Brazil and the proposition of a research agenda; (ii) the assessment of which innovation barriers trigger or which affect industrial cooperation for R&D; (iii) the exploration of the innovation barriers' role on the choice of firms to adopt either *Market-orientation* or *Technology-acquisition* as innovation strategies. From an academic perspective, this study contributes to clarify future avenues of research on industrial innovation in Brazil and to provide insights about the role of innovation barriers in the Brazilian industry. From a practical point of view, this manuscript presents a map of findings so as industries can use in a strategic way. Also, we bring insights on how innovation strategies should be adopted in relation to innovation barriers.

Keywords: Industrial innovation, innovation barriers, innovation strategies, emerging countries.

SUMMARY

FIGURE LIST

TABLE LIST

1 INTRODUCTION

Innovation is a topic of discussion largely recognized as a key driver of welfare and competitiveness for countries (Tourigny and Le, 2004; Hölzl and Janger, 2014; Santos et al, 2014; Watkins et al., 2015). Several areas have focused on the development of research on this topic. For instance, we may cite business management, engineering, political and social sciences and public administration (Godói-de-Sousa I and Valadão Junior, 2010; Cavalcante e Camões, 2016; Alves et al., 2017). For the industry, the tools and techno-scientific features of innovation have supported the development of new products as well and enhancements in both products and processes.

In Brazil, both industrial and academic community have contributed with case studies, theoretical works and empirical evidences. Nevertheless, there is a need to congregate these research and understand how they pinpoint weaknesses and strategies for the development of industrial innovation in Brazil.

Although innovation has been treated as a motor for competitiveness, the path traced by industry to innovate is susceptible to uncertainties. These uncertainties assume the form of obstacles when they affect industries and hinder their innovation activities (Ferriani et al., 2008; Madrid-Guijarro et al., 2009; D'este et al., 2012; Leoncini, 2016). Whether these obstacles inhibit firms to fully exploit their innovative potential depend upon how the industry and public policies solve them.

In this sense, one of the alternatives that emerged as a response for a constrained innovation scenario is the strategy of cooperation (Luzzini et al., 2015; Robin and Schubert, 2013; Lewandowska et al., 2016). Such orientation may be adapted to the objectives of each situation. For instance, alliances may be formed to share financial risks and R&D costs (Kale and Singh, 2007; Sheth and Parvatiyar, 1992; Stanek, 2004) or to increment internal knowledge (Gudergan et al., 2012, Tsou et al., 2016). However, due to the multitude of characteristics inherent to each innovation barrier (Blanchard, 2013), it is unclear which tend to trigger firms towards cooperation.

Furthermore, we investigate the relationship between the innovation barriers and the innovation path traced by firms. We approach the two most prominent innovation strategies for the Brazilian industry, known as *Market-orientation* and *Technology-acquisition* (Goedhuys and Veugelers, 2012; Frank et al., 2016). In short, *Market-orientation* stands for the firm's own capacity to innovate, by focusing on internal R&D

and product launching efforts (Tsai et al., 2008; Frank et al., 2016). On the other hand, the *Technology-acquisition* option means the obtaining of technological capabilities by external means (Zuniga and Crespi, 2013; Frank et al., 2016; Ahuja and Katila, 2001; Tsai et al., 2008; Tsai et al., 2011; Jones et al., 2001).

We highlight in our work that there is a fertile field for studies about innovation obstacles. Although there are articles discussing innovation strategies and their influence to innovation outcomes, there is no study approaching their influence for adoption of innovation strategies. This study proposes to offer a broader understanding about innovation barriers and its on innovation strategies adoption. In this regard, we aim to answer the following research question: *What is the role of innovation barriers as triggers to industrial innovation strategies adoption?*

1.1 THEME AND OBJECTIVES

This dissertation comprehends a study about the industrial innovation in Brazil. The general objective of this study is to explore the role of innovation obstacles to the adoption of innovation strategies. The study offers a map of findings for future research regarding industrial innovation in Brazil. Also, the research presents result of a quantitative analysis based on secondary data from the Brazilian innovation survey (PINTEC-2014).

In order to achieve the general objective, the following specific objectives are proposed:

a) Synthesize and present empirical findings about industrial innovation in Brazil covering the period from 2008 to 2018;
b) Examine which innovation barriers trigger or which affect industrial cooperation for R&D;
c) Explore the role of innovation barriers on the choice of firms to adopt either ‘Market-orientation’ or ‘Technology-acquisition’ as innovation strategies.

1.2 JUSTIFICATION OF THE THEME AND OBJECTIVES

The strategic orientation that a firm is one of the most important aspects of its innovation system (Keith Pavitt, 1984; Dosi, 1989). Its understanding allows the

identification of the context in which the industry is inserted, the weaknesses of its innovation system and how these downsides could be undermined in order to generate more stable scenarios. Therefore, it is essential to comprehend what lead firms to construct its process.

Among the many elements that contribute to the strategic formation of firms towards innovation, an important one is related to its barriers. According to Hadjmanolis (1999) and D'este et al. (2012) these obstacles may either fully inhibit firms to innovate, a phenomenon called failure without learning, or appear during the innovation process. While the former type does not allow firms to innovate, the latter presents itself constantly during the innovation process.

Although these obstacles are constantly present in the innovation path of industries, few works have addressed them. This feature fundament the necessity of a study such as the one presented here. This dissertation enriches the understanding of innovation barriers in two different ways. Firstly, it provides a review of the the most cited papers regarding this theme which, notably, are few. Secondly, it brings empirical evidence from the Brazilian context, using aggregated data that covers approximately 40.000 industrial businesses in the country.

We approach the influence of innovation barriers for the adoption of innovation strategies in two different ways. In the first one, we examined which barriers trigger the adoption of cooperation as an industrial strategy. We bieleve this analysis is important, since cooperation has been classified as a relevante strategy for innovation in industries. Secondly, we addressed which barriers motivated the adoption of the two most prominent Brazilian strategies to innovation (Goedhuys and Veugeler, 2012; Frank et al., 2016). Both approaches cover crucial aspects of strategic innovation in Brazil. Furthermore, this dissertation presents a research agenda for future research in industrial innovation in Brazil. There is a lack of research providing an integration of the studies about innovation in Brazil, which justifies the need for this work.

This dissertation aims to shed light on aspects not previously approached by previous studies. The contributions of this work intend to serve both industrial and academic communities to a better understanding of both strategies and needs of industrial innovation in Brazil.

1.3 RESEARCH DESIGN

In this topic we bring details about the research methods applied. These methods aimed to achieve the general and specific objectives described in the subsection 1.1.

1.3.1 Research method

The nature of research method applied falls into the category of applied research, since it seeks to offer a solution for a specific issue. The issue analyzed here is related to the innovation barriers. Therefore, this research aims to shed light on how innovation barriers influence the adoption of innovation strategie. Also, it may be useful for a comprehension regarding what strategic actions are taken so as innovation barriers can be surmounted. This knowledge may be applied in future research on the topic. Furthermore, the research approach is both qualitative and quantitative. In the qualitative part it was used previous research to build a literature review about the Brazilian industrial innovation. Secondly, the quantitative approach used data from the Brazilian innovation survey (PINTEC) to examine the relationships among innovation barriers and innovation strategies.

In accordance to Gil (2007), the objectives of a research can be classified in three different ways: exploratory, descriptive and explanatory:

- The exploratory research promotes greater familiarity with the problem under analysis. The main objective of the explanatory research is to make the problem more explicit for the construction of hypotheses (Gil, 2007).
- The descriptive type of research intends to describe facts and phenomena associated to a certain reality (Triviños, 1987).
- The explanatory analysis is concerned to identifying the factors that determine or contribute to the occurrence of the phenomena (Gil, 2007).

Hence, the general objective of this research is classified as explanatory, since it aims to understand real aspects of an innovation system. However, this research is complementarily composed by an exploratory research, since it uses a systematic review of the literature to generate a deeper understanding on the topic (Gil, 2007). In synthesis, this research uses both bibliographic and experimental research to contemplate the objectives proposed in 1.1.

1.3.2 Work method

The development of this dissertation was divided in three different stages. Each stage comprehends an article whose main objective is associated to one of the objectives of this research. The structure of the dissertation is presented in Figure 1.

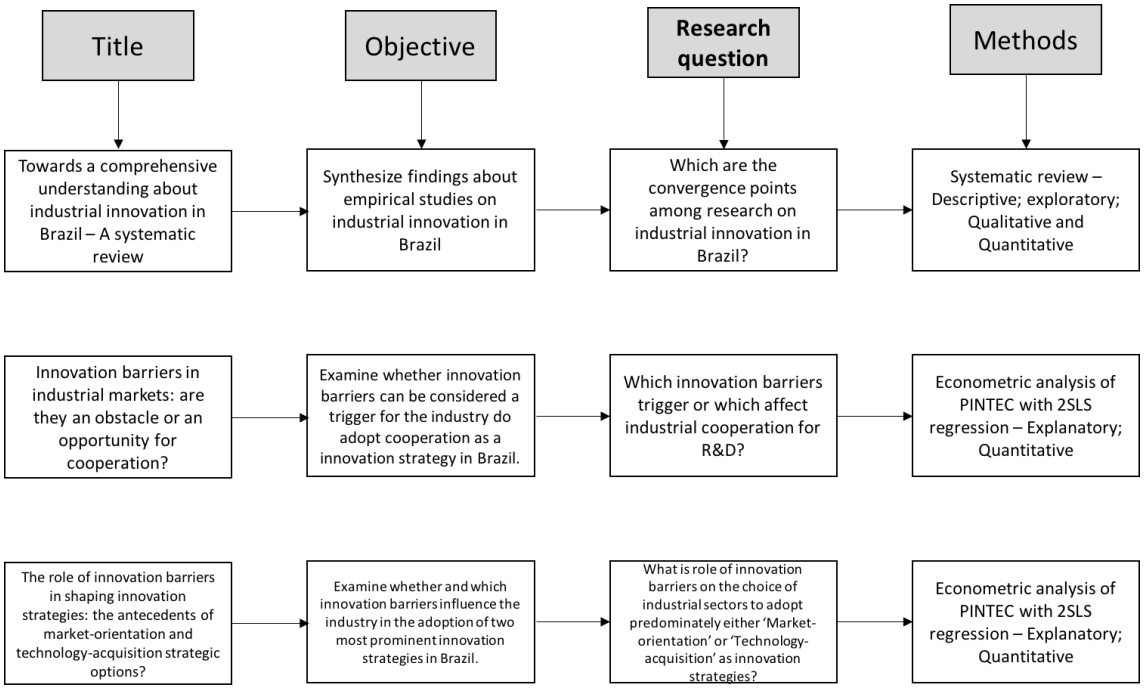

Figure 1 – Stages of the dissertation

The first article – "Towards a comprehensive understanding about industrial innovation in Brazil – A systematic review" aims to reach a general understanding regarding the studies in industrial innovation in Brazil. The results of this study was used to promote insights for the following stages of the dissertation.

The second article – "Innovation barriers in industrial markets: are they an obstacle or an opportunity for cooperation?" investigated the role of innovation barriers as triggers for the adoption of cooperation strategy. The objective of this articles is to asses whether and which innovation barriers can be considered antecedents for industrial cooperation in Brazil.

The third article – "The role of innovation barriers in shaping innovation strategies: The antecedents of market-orientation and technology-acquisition options" analyzed the formation of the two most adopted innovation strategies in Brazil from the perspective of the innovation barriers. Therefore, the objective of this article is to explore whether and which innovation barriers can be considered antecedents to the formation of innovation strategies in Brazil.

Both second and third articles used empirical evidenced from the most recent report of the Brazilian innovation survey (PINTEC – 2014). Econometric analysis was conducted in both studies. In the second article, an econometric model based on the use of two stage least square regression (2SLS) was applied. In the third article, it was used the Generalized Method of Moments (GMM) with the Continuously Updated Estimator (CUE).

1.4 STUDY BOUNDARIES

Innovation can be studied from different perspectives. For the purpose of this research, however, this dissertation aims to approach innovation from an industrial perspective.

The purpose of the first article is to provide an overview of the studies about industrial innovation in Brazil. The second and third articles, in turn, aim to conduct quantitative analysis regarding the innovation barriers and its influence to the innovation activities in Brazil.

This extension of this dissertation faces certain limitations. Some of them that are worth to point out:

We focus on articles published by journals and empirical evidences to conduct our literature review. Therefore, we excluded any type of publication that felt in the categories of expert´s opinion and consultancy reports.

Our econometric analysis used cross-sectional data from the latest report of the Brazilian innovation survey (PINTEC-2014). Other ways to asses the same variables that were used here is to conduct longitudinal analysis. Perhaps, this type of approach may bring more comprehensive results.

Particular nuances among variables could have been studied. For instance, cooperation could have been addressed in terms of its particular actors: govern, universities, other firms, to mention a few.

These boundaries mentioned can be used as a starting point for future research.

1.5 DISSERTATION STRUCTURE

This dissertation is organized in five chapters, including the one presented here. The first chapter discussed the research problem, the objectives and their respective justifications. Furthermore, it was also presented the research methods, the research

boundaries and the structure of the dissertation. Chapters 2, 3 and 4 present the first, second and third articles, respectively. Finally, the fifth and last chapter is dedicated to discussions and conclusions, focusing on the summary of the general objectives and future research propositions.

1.6 REFERENCES

AHUJA, Gautam; KATILA, Riitta. Technological acquisitions and the innovation performance of acquiring firms: A longitudinal study. **Strategic management journal**, v. 22, n. 3, p. 197-220, 2001.

DA SILVA ALVES, Alex; BOTELHO, Antonio José Junqueira; MENDES, Luciano. An exploratory assessment of the gaps for health innovation in Brazil: challenges and a proposed research agenda. RAI **Revista de Administração e Inovação**, 2017, 14.2: 98-108.

BLANCHARD, Pierre et al. Where there is a will, there is a way? Assessing the impact of obstacles to innovation. **Industrial and Corporate Change**, v. 22, n. 3, p. 679-710, 2012.

CAVALCANTE, Pedro; CAMÕES, Marizaura. Do the Brazilian innovations in public management constitute a new model? **RAI Revista de Administracao e Inovacao**, 2017, 14.1: 90-96.

DE SOUSA, Edileusa Godói; JÚNIOR, Valdir Machado Valadão. Social Enterprises in Brazil: Socially Produced Knowledge Versus Social Innovation. **Journal of Technology Management & Innovation**, 2013, 8: 166-176.

D'ESTE, Pablo et al. What hampers innovation? Revealed barriers versus deterring barriers. **Research policy**, v. 41, n. 2, p. 482-488, 2012.

DOSI, Giovanni. Technological paradigms and technological trajectories: a suggested interpretation of the determinants and directions of technical change. **Research policy**, v. 11, n. 3, p. 147-162, 1982.

FERRIANI, Simone; GARNSEY, Elizabeth; PROBERT, David. Sustaining breakthrough innovation in large established firms: learning traps and counteracting strategies. **Edward Elgar Publishing**, 2008.

FRANK, Alejandro Germán et al. The effect of innovation activities on innovation outputs in the Brazilian industry: Market-orientation vs. technology-acquisition strategies. **Research Policy**, v. 45, n. 3, p. 577-592, 2016.

GIL, Antonio. C. Como elaborar projetos de pesquisa. 4. ed. São Paulo. **Atlas**, 2007.

GOEDHUYS, Micheline; VEUGELERS, Reinhilde. Innovation strategies, process and product innovations and growth: Firm-level evidence from Brazil. **Structural change and economic dynamics**, v. 23, n. 4, p. 516-529, 2012.

GUDERGAN, Siegfried P., et al. Strategic implications for (non-equity) alliance performance. **Long Range Planning**, 45.5-6: 451-476, 2012.

HADJIMANOLIS, Athanasios. Barriers to innovation for SMEs in a small less developed country (Cyprus). **Technovation**, v. 19, n. 9, p. 561-570, 1999.

HÖLZL, Werner; JANGER, Jürgen. Distance to the frontier and the perception of innovation barriers across European countries. **Research Policy**, v. 43, n. 4, p. 707-725, 2014.

JONES, Gary K.; LANCTOT JR, Aldor; TEEGEN, Hildy J. Determinants and performance impacts of external technology acquisition. **Journal of Business venturing**, v. 16, n. 3, p. 255-283, 2001.

KALE, Prashant; SINGH, Harbir. Building firm capabilities through learning: the role of the alliance learning process in alliance capability and firm-level alliance success. **Strategic management journal**, 2007, 28.10: 981-1000.

LEONCINI, Riccardo. Learning-by-failing. An empirical exercise on CIS data. **Research Policy**, 45.2: 376-386, 2016.

LEWANDOWSKA, Małgorzata Stefania; SZYMURA-TYC, Maja; GOŁĘBIOWSKI, Tomasz. Innovation complementarity, cooperation partners, and new product export: Evidence from Poland. **Journal of Business Research**, 69.9: 3673-3681, 2016.

LUZZINI, Davide, et al. From sustainability commitment to performance: The role of intra-and inter-firm collaborative capabilities in the upstream supply chain. **International Journal of Production Economics**, 165: 51-63, 2015.

MADRID-GUIJARRO, Antonia; GARCIA, Domingo; VAN AUKEN, Howard. Barriers to innovation among Spanish manufacturing SMEs. **Journal of Small Business Management**, v. 47, n. 4, p. 465-488, 2009.

PAVITT, Keith. Sectoral patterns of technical change: towards a taxonomy and a theory. **Research policy**, v. 13, n. 6, p. 343-373, 1984.

ROBIN, Stéphane; SCHUBERT, Torben. Cooperation with public research institutions and success in innovation: Evidence from France and Germany. **Research Policy**, 42.1: 149-166, 2013.

SANTOS, David Ferreira Lopes et al. Innovation efforts and performances of Brazilian firms. **Journal of Business Research**, v. 67, n. 4, p. 527-535, 2014.

SHETH, Jagdish N.; PARVATIYAR, Atul. Towards a theory of business alliance formation. **Scandinavian International Business Review**, 1992, 1.3: 2

STANEK, Mary, B. Measuring alliance value and risk: a model approach to prioritizing alliance projects. **Management Decision**, 42.2: 182-204, 2004.

TOURIGNY, Dominique; LE, Can D. Impediments to innovation faced by Canadian manufacturing firms. **Economics of Innovation and New Technology**, 13(3), 217-250, 2004.

TRIVIÑOS, A. N. S. Introdução à pesquisa em ciências sociais: a pesquisa qualitativa em educação. São Paulo. **Atlas**, 1987.

TSAI, Kuen-Hung; WANG, Jiann-Chyuan. External technology acquisition and firm performance: A longitudinal study. **Journal of Business Venturing**, v. 23, n. 1, p. 91-112, 2008.

TSAI, Kuen-Hung; HSIEH, Ming-Hung; HULTINK, Erik Jan. External technology acquisition and product innovativeness: The moderating roles of R&D investment and configurational context. **Journal of Engineering and Technology Management**, v. 28, n. 3, p. 184-200, 2011.

TSOU, Hung-Tai; CHENG, Colin CJ; HSU, Hsuan-Yu. Selecting business partner for service delivery co-innovation and competitive advantage. **Management Decision**, 53.9: 2107-2134, 2015.

ZUNIGA, Pluvia; CRESPI, Gustavo. Innovation strategies and employment in Latin American firms. **Structural Change and Economic Dynamics**, v. 24, p. 1-17, 2013.

WATKINS, Andrew, et al. National innovation systems and the intermediary role of industry associations in building institutional capacities for innovation in developing countries: A critical review of the literature. **Research Policy**, 44.8: 1407-1418, 2015.

2 ARTICLE 1 – Towards a comprehensive understanding about industrial innovation in Brazil –a systematic review

Mateus José do Rêgo Ferreira Lima[1]

Rafael Elter[1]

Alejandro Germán Frank[1 **]

[1] Organizational Engineering Group (*Núcleo de Engenharia Organizacional – NEO*), Department of Industrial Engineering, Universidade Federal do Rio Grande do Sul, Brazil.

This paper is under submission at Journal of Management Reviews (Wiley Online Library).

Abstract

This article presents a systematic review of the literature on industrial innovation in Brazil, covering the research published during the last ten years (2008 to 2018). Using a systematic review protocol, we considered only empirical studies to analyze innovation in Brazil. We identified 64 studies in the national and international literature. We analyzed four main issues based on the CDM model of Crepón et al. (1998): innovation inputs, innovation process, innovation outputs and innovation performance. This review investigates the links among the research about industrial innovation in Brazil and brings an update about the gaps related to the topic. We highlight a number of implications that we found from the articles we reviewed. Furthermore, we provide an agenda with suggestions for future research. This is useful not only for research in Brazil but also to shed light on innovation research in emerging countries, since Brazil stands out as one of the most promising emerging economies. Practitioners can be also benefited from our findings since we show the challenges this industry faces.

Keywords: Industrial innovation; literature review; empirical evidences; emerging markets; Brazil.

2.1 INTRODUCTION

Innovation has been a theme widely discussed in recent decades. Areas beyond business management and engineering, such as healthcare, political and social sciences and public administration have developed research on this topic (Godói-de-Sousa I and Valadão Junior, 2010; Cavalcante e Camões, 2016; Alves et al., 2017). Solutions for improvement in products and processes have emerged from the multitude of tools and techno-scientific features around innovation. Furthermore, this is a reality in almost every country. Although developed industrialized countries were the first to exploit innovation, a host of relevant works in emerging economies may also be found (Filippetti and Archibugi, 2011; Goehuys and Veugelers, 2012; Frank et al., 2016).

In Brazil, the interest for innovation has in recent decades. Many studies have been published about innovation in Brazil, starting at the firm level (Mendonça et al., 2009;

Evangelista and Vezzani, 2010; Goedhuys and Veugelers, 2012). More recently, some studies have focused on innovation in a more industrial perspective, as exemplified by Frank et al. (2016). In every three years, a report strictly dedicated provide information on innovation in the country is released. The report, called the Brazilian innovation survey, comprises information about industrial sectors with innovation activities going on in Brazil (IBGE, 2016). To the best of our knowledge, however, no systematic review of studies on industrial innovation in Brazil has been published. This means that researchers and practitioners do not have a source that provides a general overview about these studies in Brazil. This highlights the need for a more cohesive and structured comprehension about the subject. Similar studies have already applied literature reviews on industrial innovation of specific countries (Chen et al., 2013). Therefore, some questions arise, which are addressed in this paper:

1. What literature has been dedicated to discuss about industrial innovation in Brazil?
2. What is currently known about the weaknesses of the Brazilian industrial innovation scenario?
3. What are the implications of these findings for both industry and academia?

Thus, the aim of this paper is to conduct a systematic review of the research on innovation at the industry-level in Brazil. More specifically, it aims to provide an overview regarding the papers researched: their findings, strengths and weaknesses, as well as implications for research and practice. This overview may be valuable for practitioners who want to understand the main challenges and strategies for innovation in this industry, as well as for researchers who want to identify areas for development of future studies. Lastly, we present relevant results for the identification of strategic gaps and challenges about innovation in the Brazilian industry.

This study is organized as follows: In section 2, we present a background about industrial innovation research in Brazil. In section 3, we describe the methodological approach used for this review. Section 4 brings the findings in terms of the research methods we found as most common among the papers, a quality assessment of the articles and a description of the studies in accordance to four main thematic groups (CDM model). Finally, section 5 discusses the implications for research and practice and the study`s limitations. Also in section 5 we present a research agenda. Section 6 concludes this review.

2.2 THE CONTEXT OF STUDIES ABOUT INDUSTRIAL INNOVATION IN BRAZIL

Whether it is for an industry, region or nation, innovation is acknowledged as a vector of competitiveness and economic growth (Grupp, 1998; Lawson and Samson, 2001; Miozzo and Walsh, 2006; Ireland and Webb, 2007; Santos et al., 2014; Frank et al., 2016). In Brazil, the reality is not different. Many incentives have been made to promote innovation in the country. For instance, we may cite the implementation of the Brazilian federal innovation law; the Brazilian agency for industrial development; the Productive Development policy; the 2007-2010 Action Plan and the Law of Biosafety (Lopes and Barbosa, 2014). However, literature has emphasized that Brazilian firms are traditionally considered unlikely to innovate, often experiencing obstacles in managing technology (Nagano et al., 2014). In fact, as reported by Kannebley et al. (2005), Queiroz and Carvalho (2005) and Ruiz and Bhawan (2010), multinational corporations (MNC) constitute and important driver of innovation in Brazil. However, the role of MNC subsidiaries in the country is mainly applied to adapting the innovation of technologies produced elsewhere (Salerno, 2012). This reality brings misconceptions about what is, in fact, an industrial innovation produced in Brazil.

This scenario reflects what is considered in Brazil to be an innovation project. Critiques argue that the nature of many industrial innovation projects are not actually innovative. Scholars argue that many intents to create an innovation resulte in improvement projects (Frank et al., 2016; Zimmer et al., 2016). Some explanations emerge as rationales for this reality. Firstly, the misuse of the firm's own financial resources and the public instruments for innovation. These resources are applied incorrectly or in projects that will not generate a original or potential innovation. The measures of many Brazilian innovation surveys are rather subjective. In this sense, technologies that are simply acquired or updated are classified as innovative (Mendonça et al., 2009; Frank et al., 2016). Consequently, it may not bring a clear understanding about the real situation of innovation in the country. Secondly, the projects brought by multinationals also influence the conception of innovation. Many of these innovation projects are not created in Brazil, but simply adapted to meet regulatory standards (Moralles e Rebelatto, 2016).

Another crucial point that touches the theme of innovation in Brazil is public policies. Several debates criticize the excessive bureaucracy and the lack of information about

the use of these incentives (Fabiani and Sbragia, 2014; Lopes and Barbosa, 2014; Melo et al., 2015; Ciarini et al., 2016). This fact may inhibit firms to look for governmental support. It can be inferred that the information about how to use public instruments is not entirely clear and not efficiently spread. Therefore, a possible cause for the majority of firms not to fully enjoy the governmental support for innovation is its lack of transparency Studies indicated that for emerging countries public investment is an important innovation driver either directly or processed by science (Pereira and Plonsky, 2009; Fabiani and Sbragia, 2014; Moralles e Rebelatto, 2016; Yigitcanlar et al., 2016). Indeed, results from firms registered in the São Paulo stock exchange – BOVESPA indicate that firms aware of the utilization of public instruments have successful innovation results (Moralles e Rebelatto, 2016). Firms in Brazil need governmental support due to the high innovation costs and risks (Melo et al., 2015; Ciarini et al., 2016; Yigitcanlar et al., 2016).

Furthermore, other features related to the Brazilian panorama of innovation also emerge from specialized literature. Studies mention a multitude of strategies that firms could adopt in order to get better results in innovation. For instance, many authors point to partnerships with universities and research centers as successful to innovation (Rocha et al., 2012; Chaves et al., 2012; Andreassi, 2013), although it is still lacking in Brazil (Zawislak et al., 2008; Esteves and Feldmann, 2016). In short, cooperation is pointed out as a key strategy for the Brazilian industry (Schwartz and Bar-El, 2015; Melo et al., 2015). Other scholars defend the industry´s need to focus on the organizational culture (Nagano et al., 2014). Finally, a more general research stream recommends both managers and policy makers to understand the strengths and weaknesses of the strategic orientation of the industry (Goedhuys and Veugelers, 2012; Frank et al., 2016; Zimmer et al., 2016).

Brazil is a promising country in terms of innovation due to its growing entrepreneurship (Chu and Andreassi, 2013; da Silva et al., 2016). Besides, the country has a favorable environment for the development of specific types of innovation, such as the agriculture and renewable energy (de Araújo e de Freitas, 2008; Hall et al., 2011; Bambini et al., 2014; Emodi et al., 2015; Figueiredo, 2016; Bradshaw, 2017). These reasons may justify why many scholars and practitioners have focused on Brazil as an object of study for innovation Therefore, it is worth noting the need of a more accurate analysis of these studies, since much has been published.

2.3 REVIEW METHOD

Based on the literature on how to conduct systematic reviews (Higgins and Green, 2011), we undertook distinct but complimentary stages in our procedure. We first started with the development of a research protocol, followed by the inclusion and exclusion criteria, the definition of a search strategy, critical appraisal, data extraction and, finally, the synthesis of the studies.

2.3.1 Protocol development

The protocol we developed for this systematic review followed the general recommendations of the Cochrane Handbook for Systematic Reviews of Interventions (Higgins and Green, 2011).

2.3.2 Inclusion and exclusion criteria

Papers were excluded if their focus was not related to the macro aspects of the Brazilian industrial innovation activity or when it was not exclusively related to it. This means that papers addressing business cases were excluded. Also, papers whose aim was to compare Brazil to other countries, for instance, the 'BRICS' block and Latin American countries, were not included in this review, since we understand that in such cases they treat Brazil with a secondary degree of importance and, therefore, we could not fully explore the nuances of the country and its relation with its own innovation system. Moreover, only research papers were considered eligible for this review, hence, we did not incorporate firm reports, consultancy reports or any other kind of publication that did not have the reliability of a peer-review process. Finally, only studies written in English or in Portuguese languages were included.

2.3.3 Data source and search strategy

The following databases were searched: (i) Web of Science; (ii) Science Direct, and (iii) Periódicos CAPES. The first two in the list are online subscription-based scientific service databases that provides a comprehensive citation search. The last one, in turn, is a Brazilian database of the Coordination for the Improvement of Higher Education Personnel (CAPES) that includes most of the Brazilian scientific journals. We included 'Periódicos CAPES' platform with the purpose of enhancing our chances of finding

more articles related to the Brazilian industrial innovation scenario.

Figure 1 clarifies the systematic review process and the number of papers identified in each stage. In stage one, the titles, abstracts and keywords of the articles in the included electronic databases were searched using the combination of terms 'Innovation AND Brazil'. We only searched for this single combination of terms in order to be as broad as possible in our search. Thus, after gathering all the articles related to innovation and Brazil from the three database, we applied a filtering process based on the research objectives and what was identified as relevant to the review.

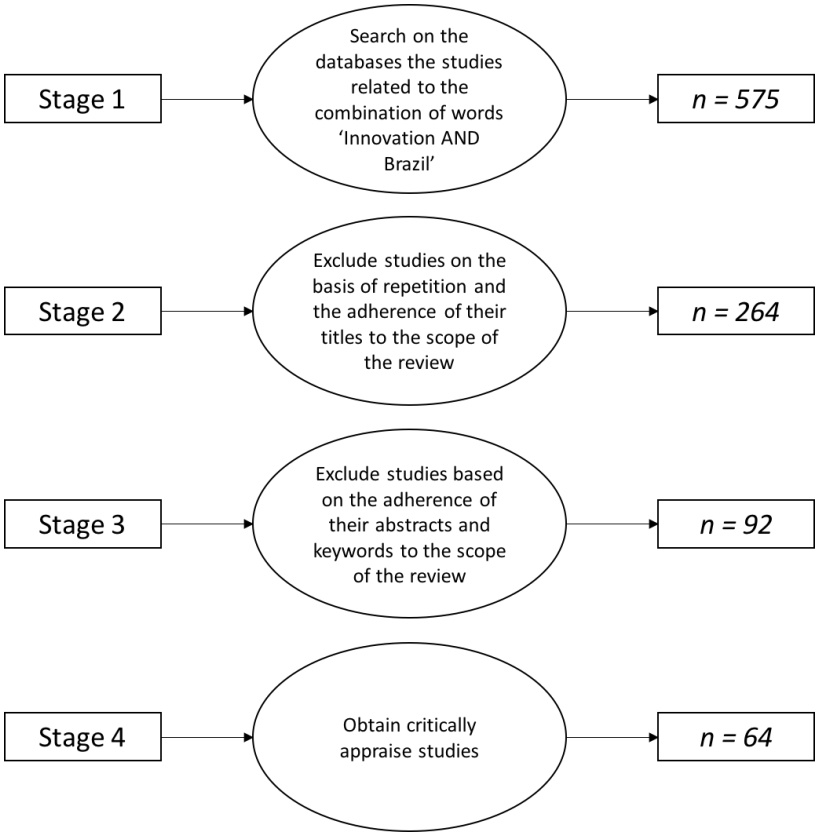

Figure 1 – Stages of the systematic literature review

2.3.4 Citation management, filtering and inclusion decisions

The studies we gathered from Stage 1 were grouped using the software Mendeley®. Also, an Excel spreadsheet was created to record and manage information about the articles. In this first step, we recorded information about: the research landscape; the stages of our search; the search strategy; the database from which the citations came from; retrieval and inclusion decisions and the quality assessment.

In the second stage of Figure 1, after duplicated papers were eliminated, we reviewed the titles of each study in order to determine the relevance of the article to the

systematic review. Hence, articles that were not exclusively about the Brazilian industrial innovation activity were excluded, independently of whether they were about the Brazilian industry or if they featured innovation (in a generic way). We excluded papers that discussed technical aspects about the development of a specific type of innovation. For instance, we got several hits of articles related to innovation in a specific type of pharmaceutical product that is sold in Brazil or the discovery of a certain type of plant, which represented an innovation to some agricultural businesses. In short, specialized technical articles, whose understanding would be little for business management researchers. Also, we got several hits on social innovation in Brazil and innovation in the Brazilian public service. Finally, we excluded papers about specific businesses, for instance "Understanding innovation at industry 'X'". This strategy allowed us focusing more on empirical studies instead of business cases. Summarizing, articles whose titles clearly indicated that they were outside the scope of this review were eliminated. Notwithstanding, titles are not always completely clear about their research subject. In such cases, we considered not only reading the titles, which led us to the third stage of our review process.

After we excluded 311 articles we began Stage 3 of our review. It consisted in reading and assessing the abstracts of the 264 remaining articles that we could retrieve from Stage 2 in order to check their adherence to the scope of our study. Hence, in Stage 3 we excluded papers whose focuses or main focuses were not associated to innovation in the Brazilian industry. This resulted in 92 articles that we deemed as relevant based on their titles, abstracts and keywords. To be more objective in evaluating whether these 92 retrieved articles were relevant to our review or not, we adopted a quality assessment approach (CASP)[1] (NATIONAL CASP COLLABORATION, 2006).

2.3.5 Quality assessment

Each of the 92 articles that remained from Stage 3 were assessed by the authors in accordance to 7 quality criteria. These criteria are proposed by the Critical Appraisal Skills program (CASP)[1] (NATIONAL CASP COLLABORATION, 2006). This program aims to guide researchers to a more critical evaluation regarding the quality of the articles. We adapted these criteria to the scope of our research and we performed the

[1] http://www.casp-uk.net

quality analysis. The seven criteria aim to cover in detail 3 main issues regarding the articles' quality:

- *Rigor*. Is the research approach thorough and has it been applied to key research methods in the study?
- *Credibility*. Are the findings meaningful, well-presented and pertinent to both academic and industrial community?
- *Relevance*. Are the findings useful to both industry and academic community?

Figure 3 – Quality assessment criteria

Item	Quality assessment Criteria
1	Does the study provide a trustworthy empirical research or is it a merely lessons learned based on an expert´s opinion or a single-case evidence that does not represent the industrial sector as a whole?
2	Were the aims and objectives of the study clearly reported?
3	Was the context in which the research was carried out clearly and adequate described?
4	For research that presented data analysis, were the description of the sample as well as the methods for the identification and recruitment of the sample adequate?
5	Were appropriate data collection methods used and described?
6	Were method used to analyze data appropriate and clearly described?
7	Does the study provide clear findings with credible results and justified conclusions?

2.3.6 Data extraction

During this stage, we extracted data from the 64 articles we classified as contributive from the critical appraise assessment. This form (Appendix C) enabled us to record key information and full details of the articles under review. It allowed us to organize articles with the same scope in order to provide more comprehensive conclusions. We managed this data extraction process in an Excel spreadsheet, in which we took notes aspects we deemed importat, such as: (i) research objectives; (ii) research methods; (iii) findings and (iv) important citations. These aspects allowed us to related the articles.

2.3.7 Synthesis of findings

To synthesize our data, we used an approach based on meta-ethnographic methods (Noblit and Hare, 1988; Atkins et al., 2008; France et al., 2016). Although largely used in healthcare qualitative research, studies recommend the use of meta-ethnographic synthesis in other areas (Atkins et al., 2008; France et al., 2016). Meta-ethnography is

one of the several methods for synthesizing research. This approach is relevant for the purpose of this study, since it has the potential to provide a higher level of analysis and generate new research questions. Also, a meta-ethnography usually provides more information on the methods of the review than is the case in traditional narrative reviews (Atkins et al., 2008).

In the first stage of this method we analyzed the main aspects of the topic under study. For instance, we categorized articles that were about public investment in innovation and articles about the relation between innovation activities and innovation performance. This characterization was made through the analysis of the papers´main focus. In the sequence, we linked papers in accordance to their findings. The key concepts and key findings were organized in an Excel spreadsheet and compared. In a meta-ethnographic synthesis, studies can be related to one another in three different forms. Firstly, they can be equivalent or directly comparable. Secondly, they can refute each other on their respective translations, that is, they can be opposites. Finally, they may not represent a line of argument. It is worth noting that by translations, we do not intend to approach the literal interpretation of it. Translation on the scope of a meta-ethnographic synthesis means the explanation of a phenomenon (France et al., 2016). In Figure 4 we present the seven steps of a meta-ethnographic synthesis of Noblit and Hare (1988) with a brief description of them.

The use of the meta-ethnographic method provided an organized manner for managing citations and create streams of discussion for the review. Moreover, it also supported us on answering the three questions we established in our objective. The process allowed us to identify the set of higher-order themes. Secondly, it helped on the identification of strengths and weaknesses reported in the articles regarding the Brazilian industrial innovation system. Finally, we could also highlight the implications of our findings for both academia and industry.

Figure 4 – Meta-ethnographic synthesis stages (Noblit and Hare, 1988)

Stage	Name	Description
Stage 1	Getting started	Choosing the topic of focus.
Stage 2	Deciding what is relevant to the initial interest	Identifying and selecting studies that will account for the synthesis.
Stage 3	Reading the studies	Readership of the studies. It also involves note taking about concepts, themes and findings.
Stage 4	Determining how the studies are related	Compare studies and relate the ones that discuss the same thematic. Organize them in categories “reciprocal”, “refutational” or “line of argument

		synthesis”
Stage 5	Translating studies into one another	Systematically compare themes, concepts and findings across the studies.
Stage 6	Synthesizing translations	If stage 5 results in many translations, these can be compared to evaluate if there are common types of translations or if some translations or concepts encompass those from other study to reach new interpretations.
Stage 7	Expressing the synthesis	Conveying the findings syntheses to a particular in a way to inform a particular audience.

2.4 RESULTS

From the methodological steps described in Section 3 we identified 64 relevant articles for the review. These articles are represented by codes from S1 to S64. The complete list of references is available in Appendix A, while a table with a brief overview about the articles is presented in Appendix B. In the following subsections, we bring an overview on the research questions and the quality assessment of these papers (Sections 2.4.1. and 2.4.2, respectively). Finally, we present the main analysis of their findings (Section 2.4.3).

2.4.1 Methodological classification

We present in Table 1 the number and the percentage of publications with the methodological approach they used. The detailed information about each study and the method that was adopted is in Appendix B.

Table 1 – Studies by research methods

Research Method	Number	Percentage
Single-case study	2	3
Multiple-case study	10	16
Econometric/quantitative analysis	31	48
Mixed methods	11	17
Survey/interview	10	16

Only 2 of the 64 studies were are single-case studies. Study S14 presented a study about the adoption of open innovation in the Brazilian aerospace industry. The article S58 by Quandt (2012), in turn, investigates how the collaboration among different agents in a local productive arrangement contributes to the development of innovation. Ten studies

were conducted using various industrial examples. Four of these articles converge to the same goal: understand the obstacles that inhibit firms to innovate.

Thirty-one of the sixty-four papers use some type of econometric or quantitative approach as method. Fifteen articles used variables from the Brazilian innovation survey (PINTEC) on their analysis and other two recommend PINTEC for future studies industrial innovation in Brazil. This result highlights the importance of PINTEC as a source of data in Brazil regarding industrial and innovation.

The majority of the studies used the mixed method approach, that is a survey or an interview combined with a quantitative analysis. Therefore, besides presenting the findings of the quantitative analysis, these studies usually discussed about the interviews and the surveys conducted.

Lastly, few studies used only a survey or an interview to draw conclusions. Six of these articles investigated the role of external actors for the innovation process (S10, S11, S15, S60, S62, S64). They differ in terms of industrial sector under analysis. Moreover, the articles also differ in terms of which kind of actors are being investigated. However, they all converge to the same conclusion: cooperation is beneficial for firms. In accordance to the articles, cooperation may enhance the capacity of firms to produce more substantial innovations (S11, S62), to enhance the time to market of innovations (S10), to conquer new markets (S15) and to support firms with their limitations (S58, S64). The other studies have particular focuses and because they do not follow the same stream of analysis they will not be mentioned here.

2.4.2 Quality assessment

As we mentioned in section 2.3.5, we conducted a quality assessment of the 92 articles selected from Stage 3 of the review. We assessed each of the 92 articles according to seven quality criteria based on the Critical Appraise Skills Program (CASP) (see Figure 3 above for a review of the criteria). From the 92 articles analyzed, 64 were selected for our review, based on their contributions as empirical research studies.

Taken together, these seven criteria provide a sense on the extent that we can be confident about the real contribution of the study's findings for the review. We used a binary or dichotomous scale (1/ "yes", 0/ "no") to select and rank the articles. The results of the grading process for the 64 selected studies are presented in Table 2.

Table 2 – Quality assessment results

Article	1	2	3	4	5	6	7	Total

	R. type	Objective	R. cont.	Sampling	Dt. coll.	Dt. analysis	Findings	
S1	1	1	1	1	0	0	1	5
S2	1	1	1	0	0	0	1	4
S3	1	1	1	0	1	0	1	5
S4	1	1	1	1	1	1	0	6
S5	1	1	1	1	1	0	0	5
S6	1	1	1	0	0	0	1	4
S7	1	1	1	1	1	1	1	7
S8	1	1	1	1	1	1	1	7
S9	1	1	1	1	1	1	1	7
S10	1	0	1	1	0	0	1	4
S11	1	0	1	0	1	1	0	4
S12	1	1	1	1	1	1	1	7
S13	1	1	1	1	1	1	1	7
S14	1	1	1	1	1	1	0	6
S15	1	0	1	1	1	0	1	5
S16	1	1	1	1	1	1	1	7
S17	1	1	1	1	1	1	1	7
S18	1	1	1	1	1	1	1	7
S19	1	1	1	0	0	0	1	4
S20	1	1	1	1	1	0	1	6
S21	1	1	1	0	1	1	1	6
S22	1	1	1	1	1	1	1	7
S23	1	1	1	1	1	0	1	6
S24	1	1	1	1	1	1	1	7
S25	1	1	1	0	1	1	1	6
S26	1	1	1	1	1	1	1	7
S27	1	1	1	1	1	1	1	7
S28	1	1	1	0	1	1	1	6
S29	1	0	1	1	1	1	1	6
S30	1	1	1	1	1	1	1	7
S31	1	1	1	1	1	1	1	7
S32	1	1	1	1	1	0	1	6
S33	1	1	1	0	1	1	1	6
S34	1	1	1	1	1	1	1	7
S35	1	1	1	0	0	1	1	5
S36	1	1	1	1	1	1	1	7
S37	1	1	1	0	1	0	1	5
S38	1	1	1	1	1	1	1	7
S39	1	1	0	0	1	1	1	5
S40	1	1	1	1	1	0	1	6
S41	1	1	1	1	1	1	1	7
S42	1	1	1	1	1	1	1	7
S43	1	1	0	1	0	1	1	5

S44	1	1	1	1	1	0	1	6
S45	1	1	1	1	1	1	1	7
S46	1	1	1	1	1	1	1	7
S47	1	1	1	1	1	1	1	7
S48	1	1	1	1	1	1	1	7
S49	1	1	1	1	1	1	1	7
S50	1	1	1	1	0	1	1	6
S51	1	1	1	0	1	1	1	6
S52	1	1	1	0	0	0	1	4
S53	1	1	1	1	1	0	1	6
S54	1	1	1	1	1	0	1	6
S55	1	1	1	1	1	0	1	6
S56	1	1	1	0	1	1	1	6
S57	1	1	1	1	1	1	1	7
S58	1	1	1	1	0	1	1	6
S59	1	1	1	1	1	1	1	7
S60	1	1	1	1	1	1	1	7
S61	1	1	1	1	1	1	1	7
S62	1	1	1	1	1	1	1	7
S63	1	1	1	1	1	1	1	7
S64	1	0	1	0	1	1	1	5
Total	64	59	62	48	54	46	60	

All studies ranked in Table 2 were classified as acceptable based on the first criterion: the study must be a research paper and present trustworthy empirical evidence. The readership and analysis of the articles allowed identifying clear objectives expressed in 59 of the 64 articles. In only 2 articles, the context of the research was not clearly defined. The definition of the sample used to conduct the analysis is also an important aspect for analysis, since it highlights the trustworthiness of the study. Our quality assessment shows that 48 out of 64 articles present an accurate description of the sample used. The same mindset of analysis is extended to the data collection process. For 18 articles, we identified that the strategy used to conduct analysis was not appropriate. Only 4 papers did not present any conclusive findings from the study.

We often found articles with not clear objectives, sampling and data collection not well described and data analysis incongruent with the objectives of the research. Moreover, we also encounter articles without accurate findings and without valuable contributions for research. Thirty articles (S7, S8, S9, S12, S13 S16, S17, S18, S22, S24, S26, S27, S30, S31, S34, S36, S38, S41, S42, S45, S46, S47, S48, S49, S57, S59, S60, S61, S62,

S63) received the maximum score of 8 (1/ “yes”), indicating that more than a half of the articles present lack of rigorous research in the dataset.

2.4.3 The CDM Model

We categorized the articles into four main groups following Crepón et al. (1998) model of innovation process (named as CDM model): innovation inputs, innovation process, innovation outputs and innovation performance. This helped us to organize the findings and to describe the results in a clearer manner. In some of the articles it was not possible to create a direct link with one of the four groups of the CDM model. Such cases will be discussed in two other sections.

2.4.3.1 Innovation Inputs (innovation activities)

Several studies approach innovation activities. Figure 5 brings the studies we found that focus on how firms manage their activities and how they orient themselves towards innovation. Innovation activities are usually associated to strategies in these papers. Innovation activities stand for the strategic orientation of firms towards innovation. In this way, we bring here a synthesis of articles that discuss innovation activities and their role for the formation of innovation strategies.

Figure 5 – Study aims for studies on industrial innovation inputs

Study	Study aim
S11	Investigate the role of Brazilian universities as strategic partners for innovation in the pharmaceutical industry.
S14	Presenting the ‘Open innovation’ concept as a strategy for the aerospace industry to conduct innovations.
S15	Characterize the relationships in innovation and business clustering processes in the productive chain of small and medium enterprises (SME) of Brazil.
S18	Investigate whether knowledge management (KM) contributes to the development of strategic orientation and to enhance innovativeness, and whether these three factors contribute to improve business performance.
S21	Characterize innovation stages and organizational resources in midsized Brazilian firms.
S25	Analyze the interactions between firms, universities and research institutes based in Minas Gerais, Brazil.
S32	Evaluate the main intersectoral R&D flows in the Brazilian economy and determine their direction and magnitude.
S35	Address some of the new challenges for indigenous public research organizations, in light of the increasing food demand and greater complexity of agricultural innovation management.
S47	Perform a quantitative evaluation of the cooperative relations developed between the Brazilian productive structure involved with innovative activity, universities and technological centers.
S48	Verify among the innovation activities related to the transformation industry, which are more

	efficient in relation to their financial return in the State of Paraná.
S51	Investigate if a R&D sector influences the development of innovation in the Brazilian sector of agricultural machines.
S52	Identify which variables define innovation in Brazilian firms in the light of the contingency theory.
S54	Analyze a theoretical model that establishes relationships between resources for innovation and performance and, specifically, to verify if the model is stable over time.
S56	Analyze R&D expenditures in Brazil and assess the impact of these expenditures on national patent applications and on the country´s Gross Domestic Product (GDP).
S61	Identify the ranking of the Brazilian innovation index of the industrial and extractive activities in southern Brazil.

Five of the articles presented in Figure 5 aim to study cooperation as a strategy. Although cooperation does not naturally fall into the innovation 'activities' classification, it is associated to how firms will manage their innovation efforts. The articles of Rocha et al. (2012) (S11), Chaves et al. (2012) (S25) and Bastos and Britto (2016) (S47) focus on the interaction between firms and universities/research institutes. The three articles point out the benefits of cooperation with research institutes and universities for innovation. According to Rocha et al. (2015) (S11), there is a fertile ground for universities as strategic partners. This type of partnership is beneficial for both firms and universities in the long-term, since it enriches research and attracts investments for the universities (Rocha et al., 2015) (S11). However, this type of collaboration has to be adapted to the objectives of both actors, since it is a multifaceted partnership (Bastos e Britto, 2016) (S47).

Dewes et al. (2010) (S14) argue that collaboration with customers and suppliers, also known by the term 'open innovation' enhances the outcomes of innovation in the aerospace Brazilian industry. Finally, Tristão et al. (2013) (S15) investigated the combined efforts of a cluster of the footwear industry in Franca, a city located in São Paulo State. The article found that there is a lack of development inside the cluster. Firms should combine their efforts and enjoy the use of more advanced technologies for product development. Overcoming this barrier will raise the competitiveness of the cluster and bring benefits such as the conquering of new markets (Tristão et al., 2013) (S15).

Other stream of research that stands out among the articles on innovation inputs is the importance of R&D activities for innovation. Three of the articles in Table 5 bring this issue for analysis. Gonçalves et al. (2017) (S32) calculate R&D flows based on the total expenditure of in-house R&D. The authors provide a map of this intersectoral flow as a

main deliver of their study. Also, it is noteworthy that they used the Brazilian innovation survey (PINTEC) for analysis. Castro (2011) (S50) discusses about the relation between R&D departments and specific features of firms. For instance, large firms have large R&D department. Moreover, it also shows that the firm´s innovation performance is dependent on the way that internal R&D departments are structured. The study also shows that firms with a structured internal R&D center have better financial results. These results are important for firms to understand the influence of a structured R&D department as part of the firm´s innovation strategy. Lastly, Oliveira et al. (2015) (S56) investigated the influence of R&D expenditures for patent registration and also on the Brazilian GDP. Results highlight that both public and private R&D investments are important for the growth of the Brazilian GDP as well as for the number of patents registered.

Some particular findings and discussions are worth mentioning here. For instance, Lazzarotti et al. (2015) (S54) brings a theoretical model that assesses the relation between innovation resources and innovation performance. Their findings indicated that measuring innovation is a complex task. There is a diversity of factors related to socioeconomic and many technological uncertainties that inhibit an accurate measurement of the innovation process, even in the long term. Theiss et al. (2014) (S61), analyzed the landscape of extractive and industrial activities in the south of Brazil. According to their findings, the most innovative industrial activities of this Brazilian region are food, followed by machine and equipment fabrication. This study is important because it highlights the most promising industrial activities of an industrialized Brazilian region. Similarly, Brunheira (2015) (S48) brings an analysis regarding the financial return of innovation activities of firms in Parana, another southern Brazilian state.

The other studies (S18, S21, S35, S52) are not related to the ones previously mentioned. However, they are focused on innovation inputs. For instance, da Costa and Porto (2012) (21) focused on characterizing the different stages and resources of innovation. Ferraresi et al. (2012) (S18) investigated the role of knowledge management to the strategic orientation of firms. Figueiredo (2016) (S35) addressed the challenges of indigenous public research organizations in promoting agricultural innovation. Lastly, dos Santos et al. (2016) (S51) analyzed the innovation activities that mostly motivate opened capital firms.

2.4.3.2 Innovation Process

We identified that 14 articles were about the innovation process. Six of these fourteen articles specifically discuss about the management of the innovation process (S5, S9, S17, S38, S58, S60). Two of the fourteen articles study cooperation and its role on the innovation process (S10, S63). Three focus on the importance of knowledge and intellectual capital for the innovation process (S34, S39, S60). The remaining four articles (S42, S55, S62, S64) have specific aims that do not present convergence with the other articles mentioned. We present in Figure 6 the studies and their aims.

Figure 6 – Study aims for studies on industrial innovation process

Study	Study aim
S5	Discuss the main theoretical and conceptual approaches to innovation, especially management and organizational innovation, based on data from the official innovation survey in Brazil (PINTEC).
S9	Analyze the relationships between internal organizational elements and the influence of contextual factors related to innovation management and its challenges.
S10	Investigate the role of industrial associations as a catalyst element for an innovation ecosystem.
S17	Develop a model to measure organizational performance with a focus on knowledge management and innovation management.
S34	Study the influence of intellectual capital on a firm's absorptive capacity (ACAP), and of ACAP on product innovation.
S38	Identify the most critical factors in the innovation process of the enterprises; analyze the dynamics of the sector and the contribution of the universities and incubators to the innovation process and also evaluates how these elements affect the management process of the technological innovation within and outside the organization.
S39	Characterize the knowledge flow between firms and universities based on national and sectoral systems of innovation perspective.
S42	Study how the technological innovation process occurs in small and medium technology-based firms located in the metropolitan region of the Paraíba Valley and North Coast – Brazil.
S55	Measure the impacts of the adoption of information technology on the productivity of workers in the Brazilian manufacturing industry.
S58	Diagnose the interrelationship between the main performance variables and the innovative capacity of firms working in the red ceramic sector.
S60	Understand the relationship between the company's absorptive capacity (AC), labor qualification, internal R&D and the innovative performance of firms that interact with universities.
S62	Investigate if the innovative performance of Brazilian firms has a direct relationship with external actors, such as: universities, research centers, suppliers, customers and consultants.
S63	Describe and analyze the challenges of open innovation in technology-based startups through the potential and restrictive factors present in the search for external sources of knowledge.
S64	Investigate strategies and practices of technological innovation management.

As we mentioned, six of the fourteen articles in Figure 6 dissertate about innovation process from a managerial perspective. Lopes and Barbosa (2014) (S5) study the

management of organizational innovation and its role to process innovation. The authors highlight the difficulty in obtaining appropriate data to study organizational innovation. The article used data from the Brazilian innovation survey (PINTEC). Although PINTEC was not originally designed to capture detailed data, the authors adapted the information available on the dataset to create relationships among variables. Their results show that innovation is a complex phenomenon and that innovation of products and processes depends on how firms manage their organizational innovations. Furthermore, the article indicates future studies to explore a measurement system capable of capturing information on organizational innovation. Similarly, the study of Nagano et al. (2014) (S9) focused on internal factors of a firm and its influence to innovation from a managerial perspective. Moreover, the authors also considered external factors, such as the context of the sector and the national innovation system. According to the authors, the lack of understanding about this issue is one of the weakest points of the Brazilian industry. (Nagano et al., 2014) (S9). The conclusions of the article corroborate the critiques presented by the authors. Their results prove a high interdependence between organizational context and consistency of the innovation processes. Finally, the article of Dickel and Moura (2016) (S17) also falls into the same scope of these research. The authors also studied the managerial perspective of the innovation process through organizational innovation. The aim of their article is to develop a model focused on knowledge management. The model was constructed based on a multi-case study in the Brazilian metal-mechanic industrial sector. Similarly to Lopes and Barbosa (2014) (S5) and Nagano et al. (2014) (S9), Dickel and Moura (2016) (S17) also mention the complexity in assessing the relation between process management and organizational innovation.

Three other papers also approach the management of the innovation processes. Through interviews conducted in Brazilian biotechnology firms, the study of Chu and Andreassi (2013) (S38) investigates the most critical factors for innovation. Also, the article analyzes the interaction between firms and universities and incubators. The article also identified the elements involved in this interaction and how they affect innovation process within and outside the organization. The results of the study indicate that access to finance is the most critical factor. Because of this, firms end up establishing strategies to compensate this deficiency, such as: creating flexible organizations and making the internal process of innovation more agile. Furthermore, the article indicates that partnerships have been adversely affected by the lack of clear rules and laws regarding

intellectual property. This problem inhibits firms from the biotechnological sector to partner with universities and incubators. Similarly, the article of Rocha e Palma (2012) (S58) conducted case studies to diagnose the most critical factors of the innovation process. The study used the innovation outputs from the red ceramic sector to investigate the lack of innovative capacity. The authors conclude that the lack of qualified labor, lack of cooperation and the lack of programs and incentives for innovation are the main obstacles that hamper the innovative capacity of firms from the red ceramic sector. Results from Teixeira et al. (2015) (S60) corroborate these findings. Although these three articles focus on particular industrial sectors, they discuss about an important aspect of innovation, which are the obstacles of the innovation process.

The articles S58 and S60 highlight knowledge as important to be managed for a successful innovation process. In light with that, other articles we analyzed also emphasize the same topic. Engelmand et al. (2017) (S34) study the influence of intellectual capital for product performance. Zawislak et al. (2008) (S39) investigated how the knowledge flows in a university-industry partnership is characterized. Their results indicated that firms from high-tech sectors establish knowledge flows essentially based on scientific research, while low-tech firms prefer to establish more technical partnerships. Three of the articles we analyzed point out to cooperation as a possible way for firms to acquire resources to innovation, including knowledge (Schwartz and Bar-El, 2015; Vieira et al., 2015; Torres-Freyre and Henriques, 2016) (S10, S63, S62 respectively).

The articles S42, S55 and S64 do not converge to a specific issue. However, they focus on the study of the innovation process. The article of da Silva et al. (2016) (S42) studies how the innovation process is managed in small and medium technology-based firms. Mendonça et al. (2009) (55) investigate the adoption of Information and Communication Technologies (ICT) and its impact throughout the innovation process. Finally, the study of Vilha and Quadros (2012) (S64) analyzed the implications of an innovation trajectory based on sustainable products to the innovation process.

2.4.3.3 Innovation Outputs (innovation results)

One of the most discussed topics about innovation is the results generated from innovative activities. We highlight though, that the results or the outputs of innovation are not equal to innovation performance. The innovation outputs are usually related to measures such as improvements in product quality, safety and environmental standards

and innovation costs, while innovation performance measures aspects such as firm growth (IBGE, 2013; Frank et al., 2016) (S22). We found out in our review 10 articles related to innovation outputs; see Figure 7.

Figure 7 – Study aims for studies on industrial innovation outputs

Study	Study Aim
S2	Explain the link between willingness to change and innovation in services.
S13	Identify the main types of recent innovation in low-tech industries of emerging markets.
S22	Understand how innovation activities are conducted in Brazilian industrial sectors and how they affect innovation results (innovation output).
S26	Study the influence of innovation activities on product and service innovation.
S31	Demonstrate which are the factors that influence innovation in Brazil more significantly and which of them demand for more investments in order to boost technology and innovation.
S40	Assess the differences in rates, directions, sources and efforts of innovations between low-tech and high-tech industries in Brazil.
S44	Analyze the influence of competitive priorities in the practices and adoption of innovations considering the context of small businesses of the metal-mechanic sector of the Sorocaba area (State of São Paulo, Brazil).
S46	Advances current understanding of patent behavior by exploring the effects of manufacturing firms' innovation partnerships, foreign ownership, and adoption of new management practices on the likelihood of patenting.
S57	Investigate how the interactions of the various agents working in LPAs contribute to the development of their innovation and, consequently, innovations in products and processes, and to increase competitiveness and local economic development.
S59	Identify and verify how the main elements that make up the innovative capacity of Brazilian firms are organized.

Two of the papers analyzed (S22 and S26) focused on the understanding of the relation between innovation inputs and innovation outputs in Brazil. The first study published was the one of Goedhuys and Veugelers (2012) (S26). This article provides a significant contribution to the study of industrial innovation in Brazil. The study analyzes which are the industrial innovation activities in Brazil and how they converge to the strategic orientation of the industry. The authors found the existence of two opposite innovation strategies. One of them is based on the acquisition of technologies, while the other focuses on the internal development of products. Furthermore, this article indicates that the former strategy provides better innovation outcomes than the latter. Frank et al. (2016) (S22) corroborates Goedguys and Veugelers (2012) (S26) in what regards the existence of two opposite innovation strategies in the Brazilian industry. Frank et al. (2016) (S22) used econometric techniques to study the Brazilian innovation survey dataset (PINTEC-2011), which led them to different conclusions from the ones of Goedguys and Veugelers (2012) (S26). According to their results, the strategy based on

technology acquisition leads firms to negative innovation outcomes. On the other hand, the internal product development strategy, called by the authors as 'Market-Orientation', positively impacts the results of innovation. Frank et al. (2016) (S22) justify such a different conclusion by the use of different data sources and periods. While Frank et al. (2016) (S22) used data from PINTEC released in 2011, Goedguys and Veugelers (2012) (S26) used data from the World Bank ICS survey released in 2002. De Lara and Guimarães (2014) (S44), in turn, corroborate the findings of Frank et al. (2016) (S22). The authors argue that innovation does not occur only through heavy investments in technology. Moreover, the article suggests a redirection of the current public innovation policy programs, since most part of them motivate a strategy towards technology acquisitions.

Two of the articles we classified for this section focus on identifying key elements that contribute for the innovative capacity of firms. According to Santos et al. (2012) (S59) the main elements are human capital (skilled labor), relational capital (external R&D, and external knowledge) and internal capital (training, internal R&D, new innovations and technology acquisition). In fact, these elements cover a multitude of assets that firms should have in order to succeed on innovation. Esteves and Feldmann (2016) (S31) also found other similar aspects on their research. Their results show that lack of public investment inhibits firms from getting better innovation outcomes. Also, the lack of commitment of firms to innovate and the bad integration between firms and universities/research centers are mentioned as deficiencies in the Brazilian industrial innovation scenario.

One of the points mentioned by Esteves and Feldmann (2016) (S31) is the establishment of better collaborations with universities and research centers. This allowed us to infer that these actors may be helpful in providing knowledge and technical skilled labor for firms. Such type of partnership may be beneficial for both sides. Also, Costa et al. (2016) (S40), whose study focused on the partners of the innovation process, indicated that cooperation may be beneficial for low-tech firms. Finally, Barros et al. (2015) (S46) found that engagement in innovative collaboration is a critical determinant for patenting in a strong institutional context, even if property rights are difficult to enforce.

Interestingly, however, the study of Quandt (2012) (S57) found that firms participating of a LPA did not have expressive improvements in their innovation outcomes. The paper studied the influence of a Local Productive Arrangement (LPA) for the performance of firms inside the network. In fact, the impact of the LPA within each

organization was classified as “very limited”. This results stands out in this review, since it was the first not to point cooperation as a significant strategy.

The articles S2 and S13 do not follow the same research streams of the studies mentioned above. However, they are also focused on innovation outputs. Article S2 from Moreira et al. (2016) studies change as a predictor of innovation in services. Based on an econometric model generated from a survey of 351 software development firms the authors show that willingness to change has little to do with innovation in services. This variable, thus, may not be considered an accurate measure to forecast innovation in services. The authors point to other factors that might have a higher correlation that is worth to be objects of future research. Lastly, Zawislak et al. (2013) (S13) conducted a study among 14 low-tech industries to identify their main types of innovation in the Brazilian emerging market. Among four main types of innovation: technology development, operations, management and transactions, this last one is the focus of low-tech industries, followed by technology development. They innovate, especially, in terms of optimizing their processes and commercializing their products.

2.4.3.4 Innovation Performance

The last aspect of the CDM model we analyze is innovation performance. Fifteen of the studies we classified fall into this category (see Figure 8). This fact indicates the interest of researchers to understand and explore the features related to innovation performance.

Figure 8 – Study aims for studies on industrial innovation performance

Study	Study aim
S1	Verify the correlation between the focus on innovation and relative economic efficiency.
S3	Examine what problems were hampering or inhibiting the improvement and increasing of the level of country´s innovativeness from the perspective of micro and small technology-based firms.
S4	Calculate the spillover effects throughout the industry that result from public investment in innovation, and also the R&D and management investment spillovers of the capital goods industry for the rest of the manufacturing sector.
S6	Shed some light on the question of why technology-intensive businesses often fail in less-developed countries and under what circumstances they are likely to be a success from the perspective of both domestic and export markets.
S7	Investigate the impact of innovation capacity and international experience on the export performance of small and medium-sized enterprises (SMEs) located in an emerging country and to identify which factor is more significant.
S12	Tests whether innovation efforts have a positive influence on firm performance.
S16	Examine the important moderating influences of supplier involvement and foreignness on the relationship between innovation ambidexterity and performance.
S20	Examine the competitiveness of firms operating in the emerging economy of Brazil.

S23	Investigate the relationship between innovation and sustainability strategies in the mining sector in Brazil.
S24	1 – extend existing studies about innovation and trade; 2 – improve our understanding of the role that innovation plays in supporting export diversification of firms from less advanced countries.
S28	Analyze the relationship between innovation and resilience from the financial performance analysis with EBITDA, ROE and ROA indicators.
S30	Measure the relation between product innovation, resources and organizational performance.
S36	Examine the relationship between innovation and sustainable performance.
S41	Verify the relationships that may exist between knowledge absorptive capacity (ACAP), innovation performance, and organizational performance in Brazilian firms.
S43	Evaluates whether firms that invest in research and development (R&D) have better future performance and if the stock market fully value such intangible investment.

Three studies focus on the relation between innovation and firm´s financial performance (S1, S12, S28). Santos et al. (2014) (S12) analyzed the relationship between innovation efforts and innovation performance using a structure equation model based on PINTEC data. Surprisingly, the authors conclude that variables associated to innovation investments do not explain firm´s financial performance significantly. Zorzo et al. (2017) (S1) found similar results. Their research investigated the relationship between innovation and economic efficiency in the context of electric power distribution companies. The authors suggest that the low correlation between innovation and economic efficiency in these companies is explained by the incipient innovation efforts. Moreover, the authors argue that most of the investments in innovation are not genuinely made to obtain benefits from innovation, but rather to comply with the legislation.

Oppositely, the study of de Carvalho et al. (2016) (S26) drew different conclusions. The authors compared the financial results of innovative and non-innovative firms in an international economic post-crisis period. The results were obtained from the analysis of EBITDA, ROE and ROA indexes. When both types of firms were compared, the indexes were a clear indicative of the higher financial performance of innovative firms.

The results among the articles are opposite, not allowing, therefore, an absolute conclusion about the relationship between innovation efforts and financial performance. However, the articles differ in terms of objectives and research designs. For instance, the study of Zorzo et al. (2017) (S1) were specifically for the context of electric power distribution firms. The article of de Carvalho et al. (2016) (S26), in turn, had a limited sample of 10 firms for analysis. Due to these reasons, we may conclude that the article provide the most general information is the one of Santos et al. (2014) (S12), since it

presents a quantitative analysis of a national innovation survey. However, based on this juxtaposition of evidences, an update research on this topic for the Brazilian context is necessary.

Two of the papers mentioned in Figure 8 focuses on the analysis of the problems that hamper innovation activities. Pereira and Plonsky (2009) (S6) shed light on why less developed countries face obstacles to innovate in technology-intensive businesses. The authors identified two spheres in which the problems reside: (i) weakness of institutions that affect the incentives to innovate; (ii) inadequacy of social and organizational demography to carry out innovation activities. The first sphere comprehends issues such as the patent system, the lack of efficiency and transparency of the public administration in promoting incentives to innovation. The authors also point to the lack of solid institutions. In Brazil and in many developed countries, the financial sources of innovation have excessive relied on angel investors, venture capitalists, equity markets, and alliance partners, instead of traditional lenders (banks). In the second sphere, education is the main problem. The authors deepened in the analysis of the theme in Brazil. The low school attendance in the country is the main reason for the incapability of preparing workers with proper skills. Lastly, in addition to these two main spheres, the lack of continuity and long-term commitment due to political and economic issues are one of the main obstacles the country has to face in order to sustain industrial development. Melo et al. (2015) and Cyrino et al. (2017) (S3, S20) corroborates these arguments. The authors mention the lack of governmental support, solid funds and financing mechanisms as the main innovation problems in Brazil. According to Moralles and Rebelatto (2016) (S4), governmental investment is one of the main drivers for innovation in emerging countries. Innovation costs are high and, therefore, firms need financial support to develop their innovation activities (Melo et al., 2015) (S3). Moreover, Cyrino et al. (2017) (S20) advanced that governmental policies are excessively bureaucratic, bearing a negative impact on the nature of the country´s business environment.

Organizational performance was another point that stood out among the papers in the innovation performance category. De guimarães et al. (2016) (S30) investigated whether organizational resource contribute for product innovation and organizational performance, under the context of the Brazilian furniture industry. The authors suggest firms to invest in a senior management commitment and the use of multidisciplinary NPD teams for a better organizational management. Their results show that these

aspects may lead firms to an enhanced product innovation and organizational performance. Moreover, Dávila et al. (2017) (S41) highlight the importance of knowledge management to organizational performance improvements.

Sustainability was another factor related to innovation performance that we could identify form the articles analyzed. In this sense, from a sample of 112 Brazilian firms from the electric and electronics industry, Kuhl el al. (2016) (S36) identified a positive relation between sustainability and innovation performance. The authors found that firms categorized as more sustainable were more prone to innovate. Moreover, it was also found that sustainability affects the willingness of firms to engage in collaborations. Although this last finding is not strictly related to innovation performance, it may be a strategy for firms to achieve better innovation results. The article of Barbieri et al. (2016) (S23) corroborate these findings for the Brazilian mining sector.

The articles S16 and S43 highlight other features that also contribute to the innovative performance of firms. Dunlap et al. (2016) (S16) studied the role of customer and suppliers to the innovation process. Their findings show that these two external actors positively contribute to higher innovation performance. Article S43 from da Silva et al. (2015) investigated whether firms that invest in R&D have better future performance. Specifically, the authors analyzed if firm´s investment in R&D are better evaluated on the stock market. Firstly, theirs results show a strong correlation among the investment in R&D and firm´s future performance. However, after controlling for factors such as firm characteristics and risk factors, the results surprisingly changed. The final model indicated that R&D is not a useful measure for predicting firm´s future returns. Therefore, R&D intensity may not be considered a useful variable for valuating firms in Brazil.

Lastly, export diversification was another convergent issue among the studies. Oura et al. (2016) (S7) investigated the role of both innovation capacity and international experience in firm´s export performance. The context of analysis was small and medium firms in Brazil. Interestingly, the study points out a possible over emphasis on innovative capacity. Based on the quantitative analysis results, the authors point out to a possible bias on export performance literature. Those studies have excessively study innovative capacity as a motor of export performance, neglecting other aspects, such as international experience. Finally, Oura et al. (2016) (S7) conclude that international experience has greater impact on firm´s export performance than innovation. Cirera et

al. (2015) (S24), in turn, explored the capacity of firms to introduce new products for exports. The authors evidence that export diversification is more important than the focus on export performance if firms aim to conquer new markets through product diversification. Moreover, the authors highlight the need of firms to manage their internal knowledge and the importance to focus on foreign innovation policies.

2.4.4 The role of public policies to innovation

Among the papers we classified as part of the CDM model, several of them highlight the role of the government in supporting innovation. Since they are more focused on the operational aspect of innovation we decided to approach them in one of the four dimensions of the CDM model. However, we identified other articles strictly focused on discussing the role of public institutions for innovation. These studies were not discussed in the previous subsections and, therefore, they will be addressed here.

Figure 9 – Study aims for studies on the role of government to innovation

Study	Study aim
S8	Measure the effects of government support for innovative activities on manufacturing firms' R&D investments in Brazil.
S19	Analyze the use of tax incentives for technological innovation by private companies in the Brazilian market, as well as the main benefits perceived by them and suggested improvements.
S37	Present a brief description of the main public instruments for innovation support in Brazil.
S45	Verify the innovation management practices used by these companies, as well as the main obstacles encountered by them to make use of tax incentives of the Good Law.

Two of the articles presented in Figure 9 discuss the use of the Law 11.196/2005, also known in the Brazil as the "Good Law". This law creates the concession of fiscal incentives to legal entities that carry out research and development of technological innovation[2]. The articles of Fabiani and Sbragia (2014) and Zimmer et al. (2016) (S19, S45) analyzed the use of the Good Law for R&D and point out to its benefits and obstacles. Firstly, the articles highlighted the importance of the good law to promote R&D investments in private firms. Secondly, the authors deepened in the discussion of the many obstacles that hamper firms to fully enjoy its benefits. Through an analysis of 26 firms in the private sector, Fabiani and Sbragia (2014) (S19) indicated that the deduction of R&D expenditures only occurs in firms that are considered profitable. Another problem associated to the use of the Good Law is the profile of the innovation projects. Many projects are improvement projects rather than innovation projects. Zimmer et al. (2016) (S45) highlight that firms need more knowledge about the law itself in order correctly separate improvement projects from innovation projects. Fabiani and Sbragia (2014) share the same recommendation. The authors argue that the percentage of firms that benefit from the Good Law is still very small and the lack of knowledge of Brazilian businessmen may help explain this phenomenon.

The articles of Rocha et al. (2015) (S8) and Cirani et al. (2016) (S37) promote insights about the use of public incentives to innovation. For instance, the study of Rocha et al. (2015) (S8) measured the effects of government support to innovative activities. The study used secondary data from PINTEC 2005 and 2008 with a sample of 243 firms. Surprisingly, their results do not give support for the hypothesis that firm's R&D intensity was affected by governmental support. This finding casts doubts about the

[2] http://www.leidobem.com/lei-do-bem-inovacao/

complementary role of the government for the provision of resources for R&D. According to the authors, this finding is contrary to other studies that found a positive effect for some of public instruments. Therefore, an updated analysis should bring additional understanding on this issue. Cirani et al. (2016) (S37) highlight that the two most important Brazilian institutions for the promotion of investments for innovation are the Brazilian Innovation Agency (FINEP) and the National Bank for Social Development (BNDES). The authors point out, however, to a lack of integration among these institutions. Furthermore, the firms surveyed mentioned problems such as: excessive bureaucracy, slowness for project´s approval and legal uncertainty. According to the firms, these problems hamper the use of such public instruments.

All the articles defended the role of the government or public incentives to innovation in Brazil. As seen there are specific institutions and laws created to support the Brazilian industry. However, the lack of knowledge on how to use them and the excessive bureaucracy inherent to the public sphere of the country may exert a negative effect on the capacity of firms to fully enjoy the benefits of such instruments.

2.4.5 Uncliassified articles

This last topic aims to present the articles that did not fit into any of the categories previously discussed. We understand that these works have specific objectives. In this sense, although they fit into our research protocol, they do not converge to the main points of discussion (the CDM model and the role of public policies to innovation). However, we will present their main features.

Figure 10 – Study aims for not related studies

Study	Study aim
S27	Examine whether a causal relation exists between ethanol related innovation and fuel market variables in Brazil.
S29	Understand the pathways of discontinuous capability building of firms in natural resource-processing industries.
S33	Explore how technological, commercial and social uncertainties shaped the development of Brazilian biofuels.
S49	Map and compare in an exploratory way the interests and research priorities of the nascent community of Service Science and service innovation in Brazil.
S52	Carry out a technological prospection about the use of nanotechnology in drugs.
S53	Examine the role of intercompany knowledge flows in the construction of production and innovation capacities in subsidiary companies of multinationals in the Brazilian ICT sector, from 1996 to 2007.

The articles mentioned in Figure 10 bring contributions about specific aspects of specific industries. For instance, de Freitas and Kaneko (2012) (S27) examined if there is a causal relation between the implementation of innovation in ethanol and the increase in the consumption of this type of fuel. Hall et al. (2011) (S33) addressed the development of biofuels in Brazil and points out to the social issues and uncertainties that were created afterwards. Figueiredo (2010) (S29) analyzed the pathways of innovation that natural resource firms have adopted. From an analysis of the pulp and paper Brazilian industries, the authors highlighted that the pathways of these natural resource based industries were characterized by high variability. Furthermore, firms that have attained progressively higher levels of innovative performance have more rapidly developed a combination of internal and external research-based arrangements in order to undertake increasingly complex, but firm-centered innovation efforts (Figueiredo, 2010) (S29). Fialho et al. (2016) (S52), in turn, analyzed the Brazilian nanotechnology sector. The study focused on the patents published in Brazil to assess how the country is inserted in this industrial sector. The authors noted that the sector reached a maturation level in Brazil and the number of patents published is starting to decrease. However, this finding does not mean that the nanotechnology sector is becoming less important in Brazil. Contrarily, it evinces a new position of the industry towards studies of new applications. The last two papers in Figure 10 bring information about intercompany knowledge flows in the ICT sector (Figueiredo et al., 2009) (S53) and a research agenda for innovation in services in Brazil (Calabria et al., 2013) (S49).

2.5 IMPLICATIONS OF THE STUDY AND SUGGESTIONS FOR RESEARCH AND PRACTICE

Our study comprised a systematic review about previous articles on industrial innovation in Brazil. Several implications for research and practice emerged from the multitude of aspects that these articles addressed. Furthermore, one point of convergence is that innovation was treated as a differential in terms of firm competitiveness.

This review also shows that a range of methodological approaches have been applied. For a more comprehensive understanding it is necessary to apply both fixed and flexible methodologies. Accordingly to Edmondson and McManus (2007), the state of research falls into three types: nascent, intermediate and mature. Three different aspects are used

as basis for the assessment: (i) research questions, (ii) type of data collected and (iii) theoretical contribution. For the theme of industrial innovation in Brazil, we believe the current state of theory is mature. This state is characterized by research questions focused on hypothesis associated to existing constructs, meaningful amount of data available for collection and supported theory that may add specificity, new mechanisms or new boundaries to an existing theory (Edmondson and McManus, 2007).

There are areas on topics such as organizational engineering, innovation obstacles and public incentives that still characterize fruitful fields of research in Brazil. These areas might be in a nascent or intermediate stage. Hence, it suggests a need for more qualitative and quantitative studies on these issues. In Brazil there is a survey focused on industrial innovation, the Brazilian Innovation Survey (PINTEC). It brings information about several variables, including innovation obstacles and governmental incentives. We believe that this data source is relevant to be used in future studies about the points we mentioned.

In order to increase the usefulness of this review and to provide a continuity of research in the field, we present a list of suggestions for future research (see Figure 11). Our intention is to help academics interested in the theme to find avenues in which they may drive their research in. For practitioners, this review shows that many promising studies of industrial innovation in Brazil have been reported. Although serious limitations have been mentioned, this review suggest that better results can be achieved based on additional understanding about organizational features, the use of public instruments and how partnerships should be established.

Due to the limited number of articles reviewed and the scope of this research, it is impossible to present more details and to be more definitive in our findings. Rather, this work presents a synthesis of the studies carried out to date, which must be critically assessed by industries so as they can generate their own identification. Hence, firms can use this synthesis to improve their reality. This review clearly indicates the need for more research in order to fulfill the gaps here presented. We would like to urge both academics and practitioners to partner in projects and to engage in the development of the weak spots of industrial innovation in Brazil. Such action could not only improve the industry, but generate spillovers in a way that other aspects of the country can also benefit.

Figure 11 – Research agenda

Item #	Name	Synthesis	Suggestion for future research	CDM classification	Authors
1	Cooperation	Cooperation has been pointed out as an alternative strategy for innovation. Some external actors cited for cooperation: universities and research institutes, suppliers, customers, other firms.	1. Investigate ways to strength the partnerships between universities, incubators and research institutes. 2. Study how cooperation can be adapted to the reality of different industrial sectors and external actors. 3. Find ways of a safer knowledge transfer among the industry and its partners.	Inputs; Process; Outputs; Performance	S10, S11, S14, S15, S25, S31, S38, S39, S40, S47, S62, S63
2	R&D	The articles analyzed bring evidences about the benefits of R&D for innovation. However, two studies diverge regarding R&D as a variable to predict firm´s future returns.	4. Investigate how companies can better implement R&D as an innovation activity. 5. Update research about the influence of R&D to the generation of financial returns.	Inputs; Performance	S8, S32, S37, S43, S51, S56
3	Managerial Perspective	Several articles point to a lack of appropriate data. Therefore, the use of process management for improvements of organizational innovation has been an obstacle for researchers. Furthermore, lack of qualified labor, lack of cooperation and lack of programs and incentives for innovation were cited as main obstacles for innovation.	6. Foment of surveys and instruments to collect data from the managerial level. 7. Research that addresses the issue of innovation obstacles in a more comprehensive way. 8. As cooperation has been lacking in the Brazilian industry, we reinforce #1.	Process	S5, S9, S17, S38, S58, S60
4	Public Policies	The articles point out to lack of information about the use of public incentives for innovation. Moreover, it is also highlighted the excessive bureaucracy of public instruments towards industrial innovation.	9. More research about the use of public instruments for innovation, such as the Good Law (11.196/2005). 10. Studies that focus on differentiate improvement projects from actual innovation projects. Such studies may shed light on a better use of the Good Law (11.196/2005). 11. Investigate alternatives that help to de-bureaucratize public instruments for innovation.	Process; Outputs	S3, S6, S8, S20, S22, S26, S31, S37, S44, S58, S60
5	Innovation obstacles	Studies mention obstacles to innovation. However, the specific way in which they were addressed do not provide a deep comprehension on the topic.	12. Studies should focus on a broader analysis of the innovation obstacles in the Brazilian industry.	Outputs	S3, S6, S20
6	Organizational Performance	Organizational assets were pointed out as important for innovation performance, such as knowledge management.	13. Research should focus on developing knowledge management in innovative companies.	Performance	S30, S41
7	Sustainability	Two articles indicated a positive relation between sustainability and innovation performance.	14. Investigate the attributes of sustainability that are related to innovativeness.	Performance	S23, S36

2.6 CONCLUSIONS

Through the search strategies applied in the first step of our review, we identified 575 articles. From these articles, we found 64 useful for the aim of this paper, due to their rigor, credibility and relevance.

To organize the results and deliver accurate insights, we categorized the 64 articles into four groups: innovation inputs, innovation outputs, innovation process and innovation performance. This categorization can be found in the study of Crepón et al. (1998). Furthermore, we extended our comments for articles related to the role of public policies to innovation and for articles that we did not find relation to these previous classifications. We identified a number of weaknesses regarding the Brazilian innovation industry. These weaknesses open up avenues for future research. We offer a research agenda with several suggestions for further studies. We advise readers from both academia and industry to utilize this article as well as the research agenda as a map of findings. Both communities can make our insights useful by comparing them to their own situation.

2.7 REFERENCES

ATKINS, Salla et al. Conducting a meta-ethnography of qualitative literature: lessons learnt. **BMC medical research methodology**, v. 8, n. 1, p. 21, 2008.

BAMBINI, Martha D., et al. Collaborative Innovation in Agrometeorology: Coordination Strategies to Develop a Monitoring IT System for Brazil. Journal of technology management & innovation, 9.1: 119-130,2014.

BARROS, Henrique M. Exploring the use of patents in a weak institutional environment: The effects of innovation partnerships, firm ownership, and new management practices. **Technovation**, v. 45, p. 63-77, 2015.

BASTOS, Carlos Pinkusfeld; BRITTO, Jorge. **Inovação e geração de conhecimento científico e tecnológico no Brasil: uma análise dos dados de cooperação da Pintec segundo porte e origem de capital**. Revista Brasileira de Inovação, v. 16, n. 1, p. 35-62, 2017.

BRADSHAW, Amanda. Regulatory change and innovation in Latin America: The case of renewable energy in Brazil. **Utilities Policy**, 49: 156-164, 2017.

BRUNHERA, Diandra Carla Uncini; BAÇO, Fernanda Mendes Bezerra; CROTTI, Poliana Cristina. **A eficiência dos processos de inovação na indústria de transformação: uma análise no estado do Paraná**. RAI Revista de Administração e Inovação, v. 12, n. 4, p. 187-204, 2015.

CALABRIA, Paulo Cesar et al. **A ciência da inovação em serviços: estudo exploratório sobre os interesses e prioridades para uma agenda de pesquisa no Brasil**. RAI Revista de Administração e Inovação, v. 10, n. 4, p. 110-135, 2013.

CASTRO, Bernardo Hauch Ribeiro. **Influência da estruturação de departamentos de P&D na inovação: um estudo na indústria de máquinas e implementos agrícolas no Brasil**. RAI Revista de Administração e Inovação, v. 8, n. 1, p. 196-220, 2011.

CAVALCANTE, Pedro; CAMÕES, Marizaura. Do the Brazilian innovations in public management constitute a new model? **RAI Revista de Administracao e Inovacao**, 14.1: 90-96, 2017.

CHAVES, Catari Vilela et al. The point of view of firms in Minas Gerais about the contribution of universities and research institutes to R&D activities. **Research Policy**, v. 41, n. 9, p. 1683-1695, 2012.

CHEN, Ching-Pu; CHIEN, Chen-Fu; LAI, Chih-Tsung. Cluster policies and industry development in the Hsinchu Science Park: A retrospective review after 30 years. **Innovation**, 15.4: 416-436, 2013.

CHU, Daniel; ANDREASSI, Tales. Management of technological innovation: Case studies in biotechnology companies in Brazil. **Management Research: Journal of the Iberoamerican Academy of Management**, v. 9, n. 1, p. 7-31, 2011.

CIRANI, Cláudia Brito Silva et al. The role of public institutions for innovation support in Brazil. **BBR. Brazilian Business Review**, v. 13, n. 6, p. 210-230, 2016.

CIRERA, Xavier; MARIN, Anabel; MARKWALD, Ricardo. Explaining export diversification through firm innovation decisions: The case of Brazil. **Research Policy**, v. 44, n. 10, p. 1962-1973, 2015.

COSTA, Priscila Rezende; PORTO, Geciane Silveira. Innovation stages and organizational resources at midsized companies in Brazil. **Future Studies Research Journal: Trends and Strategies**, v. 4, n. 2, p. 217-247, 2012.

CRÉPON, Bruno; DUGUET, Emmanuel; MAIRESSEC, Jacques. Research, Innovation And Productivi [Ty: An Econometric Analysis At The Firm Level. **Economics of Innovation and new Technology**, v. 7, n. 2, p. 115-158, 1998.

CYRINO, Alvaro Bruno et al. A critical assessment of Brazilian manufacturing competitiveness in foreign markets. **Competitiveness Review: An International Business Journal**, v. 27, n. 3, p. 253-274, 2017.

DA ROSA, Luciana Aparecida Barbieri et al. The Power of Innovation and Strategic Sustainability Positioning: A Survey of the Mining Sector in Brazil. **Environmental Quality Management**, v. 25, n. 2, p. 47-62, 2015.

DA SILVA ALVES, Alex; BOTELHO, Antonio José Junqueira; MENDES, Luciano. An exploratory assessment of the gaps for health innovation in Brazil: challenges and a proposed research agenda. **RAI Revista de Administração e Inovação**, 14.2: 98-108, 2017.

DA SILVA TEIXEIRA, André Luiz et al. **Dimensões da capacidade de absorção, qualificação da mão de obra, P&D e desempenho inovativo**. Revista Brasileira de Inovação, v. 15, n. 1, p. 139-163, 2016.

DA SILVA, Fabiana Matos; OLIVEIRA, Edson Aparecida de Araujo Querido; DE MORAES, Marcela Barbosa. Innovation development process in small and medium technology-based companies. **RAI Revista de Administração e Inovação**, v. 13, n. 3, p. 176-189, 2016.

DA SILVA, Raphael Braga et al. Innovative intensity and its impact on the performance of firms in Brazil. **Research in International Business and Finance**, v. 34, p. 1-16, 2015.

DALMARCO, Gustavo et al. How knowledge flows in university-industry relations: An overview from two economic sectors in Brazil. **European Business Review**, v. 27, n. 2, p. 148-160, 2015.

DÁVILA, Guillermo Antonio; DURST, Susanne; VARVAKIS, Gregorio. Knowledge Absorptive Capacity, Innovation, and Firm's Performance: Insights From the South of Brazil. **International Journal of Innovation Management**, p. 1850013, 2018.

DE ARAÚJO, Maria Silvia Muylaert; DE FREITAS, Marcos Aurélio Vasconcelos. Acceptance of renewable energy innovation in Brazil—case study of wind energy. **Renewable and Sustainable Energy Reviews**, 12.2: 584-591, 2008.

DE CARVALHO, Antonio Oliveira et al. Organizational resilience: a comparative study between innovative and non-innovative companies based on the financial performance analysis. **International Journal of Innovation**, v. 4, n. 1, p. 58, 2016.

DE FREITAS, Luciano Charlita; KANEKO, Shinji. Is there a causal relation between ethanol innovation and the market characteristics of fuels in Brazil? **Ecological Economics**, v. 74, p. 161-168, 2012.

DE GUIMARÃES, Julio Cesar Ferro et al. The use of organisational resources for product innovation and organisational performance: A survey of the Brazilian furniture industry. **International Journal of Production Economics**, v. 180, p. 135-147, 2016.

DE MEDEIROS ROCHA, Michele et al. Innovation as a Critical Success Factor: an Exploratory Study about the Partnership among University with Pharmaceutical Industry in Brazil. **Journal of technology management & innovation**, v. 7, n. 3, p. 148-160, 2012.

DE MENDONÇA, Marco Aurélio Alves; DE ALMEIDA FREITAS, Fernando; DE SOUZA, Jano Moreira. Tecnologia **da informação e produtividade na indústria brasileira**. RAE-Revista de Administração de Empresas, v. 49, n. 1, p. 74-85, 2009.

DE OLIVEIRA COSTA, Eduardo et al. Patterns of Technological Innovation: A Comparative Analysis between Low-tech and High-tech Industries in Brazil. **International Journal of Innovation** (iji), v. 4, n. 2, p. 97-105, 2016.

DEWES, Mariana de Freitas et al. Open innovation as an alternative for strategic development in the aerospace industry in Brazil. **Journal of Aerospace Technology and Management**, v. 2, n. 3, p. 349-360, 2010.

DICKEL, Deise Graziele; DE MOURA, Gilnei Luiz. Organizational performance evaluation in intangible criteria: a model based on knowledge management and innovation management. **RAI Revista de Administração e Inovação**, v. 13, n. 3, p. 211-220, 2016.

DOS SANTOS, José Glauber Cavalcante; CALÍOPE, Thalita Silva; DA SILVA FILHO, José Carlos Lázaro. **Analisando as diferenças entre investimentos em atividades de inovação conforme variáveis estratégicas contingenciais em empresas de capital aberto no Brasil**. Revista Gestão & Tecnologia, v. 16, n. 3, p. 31-57, 2016.

DUNLAP, Denise et al. Organizing for Innovation Ambidexterity in Emerging Markets: Taking Advantage of Supplier Involvement and Foreignness. **Journal of Leadership & Organizational Studies**, v. 23, n. 2, p. 175-190, 2016.

DYBÅ, Tore; DINGSØYR, Torgeir. Empirical studies of agile software development: A systematic review. **Information and software technology**, v. 50, n. 9-10, p. 833-859, 2008.

EDMONDSON, Amy C.; MCMANUS, Stacy E. Methodological fit in management field research. **Academy of management review**, v. 32, n. 4, p. 1246-1264, 2007.

EMODI, Nnaemeka Vincent; BAYARAA, Zorig; YUSUF, Samson D. Energy technology innovation in Brazil. **International Journal of Energy Economics and Policy**, 5.1: 263, 2015.

ENGELMAN, Raquel Machado et al. Intellectual capital, absorptive capacity and product innovation. **Management Decision**, v. 55, n. 3, p. 474-490, 2017.

ESTEVES, Karen; FELDMANN, Paulo Roberto. Why Brazil does not innovate: a comparison among nations. **RAI Revista de Administração e Inovação**, v. 13, n. 1, p. 29-38, 2016.

EVANGELISTA, Rinaldo; VEZZANI, Antonio. The economic impact of technological and organizational innovations. A firm-level analysis. **Research Policy**, 39.10: 1253-1263, 2010.

FABIANI, Sidirley; SBRAGIA, Roberto. Tax Incentives for Technological Business Innovation in Brazil: The Use of the Good Law-Lei do Bem (Law No. 11196/2005). **Journal of technology management & innovation**, v. 9, n. 4, p. 53-63, 2014.

FERRARESI, Alex A. et al. Knowledge management and strategic orientation: leveraging innovativeness and performance. **Journal of knowledge management**, v. 16, n. 5, p. 688-701, 2012.

FERREIRA DE LARA, Felipe; NEVES GUIMARÃES, Márcia Regina. Competitive priorities and innovation in SMEs: A Brazil multi-case study. **Journal of technology management & innovation**, v. 9, n. 3, p. 51-64, 2014.

FIALHO, Bruno Germani; DALLE NOGARE, Gelson Eduardo; RUPPENTHAL, Janis Elisa. **A INSERÇÃO DO BRASIL NO PANORAMA GLOBAL DE INOVAÇÃO EM NANOFARMACÊUTICOS**. Revista GEINTEC-Gestão, Inovação e Tecnologias, v. 6, n. 3, p. 3257-3263, 2016.

FIGUEIREDO, Paulo N. Discontinuous innovation capability accumulation in latecomer natural resource-processing firms. **Technological Forecasting and Social Change**, v. 77, n. 7, p. 1090-1108, 2010.

FIGUEIREDO, Paulo N. New challenges for public research organisations in agricultural innovation in developing economies: Evidence from Embrapa in Brazil's soybean industry. **The Quarterly Review of Economics and Finance**, v. 62, p. 21-32, 2016.

FIGUEIREDO, Paulo N.; DE ANDRADE, Rosilene F.; BRITO, Klauber N. **Aprendizagem tecnológica e acumulação de capacidades de inovação: evidências de contract manufacturers no Brasil**. Revista de Administração, v. 45, n. 2, p. 156-171, 2010.

FILIPPETTI, Andrea; ARCHIBUGI, Daniele. Innovation in times of crisis: National Systems of Innovation, structure, and demand. **Research Policy**, 40.2: 179-192, 2011.

FRANCE, Emma F. et al. Why, when and how to update a meta-ethnography qualitative synthesis. **Systematic reviews**, v. 5, n. 1, p. 44, 2016.

FRANK, Alejandro Germán et al. The effect of innovation activities on innovation outputs in the Brazilian industry: Market-orientation vs. technology-acquisition strategies. **Research Policy**, v. 45, n. 3, p. 577-592, 2016.

GODOI-DE-SOUSA, Edileusa, et al. Redes Organizacionais: **Perspectiva Para Sustentabilidade de Uma ONG**. Revista de Administração da Unimep, 8.1, 2010.

GOEDHUYS, Micheline; VEUGELERS, Reinhilde. Innovation strategies, process and product innovations and growth: Firm-level evidence from Brazil. **Structural change and economic dynamics**, v. 23, n. 4, p. 516-529, 2012.

GONÇALVES, Eduardo; PEROBELLI, Fernando Salgueiro; DE ARAÚJO, Inácio Fernandes. Estimating intersectoral technology spillovers for Brazil. **The Journal of Technology Transfer**, v. 42, n. 6, p. 1377-1406, 2017.

HALL, Jeremy et al. Managing technological and social uncertainties of innovation: the evolution of Brazilian energy and agriculture. **Technological Forecasting and Social Change**, v. 78, n. 7, p. 1147-1157, 2011.

HIGGINS, Julian PT; GREEN, Sally. Cochrane Handbook for Systematic Reviewsof Interventions Version 5.1. 0 (updated March 2011). **The Cochrane Collaboration**, 2011. Available from www. cochrane-handbook. org, 2011.

IBGE, 2016. Pintec 2014, Estatísticas do registro civil 2014. ISSN 0101-4234.

IRELAND, R. Duane; WEBB, Justin W. A multi-theoretic perspective on trust and power in strategic supply chains. **Journal of Operations Management**, v. 25, n. 2, p. 482-497, 2007.

KANNEBLEY JR, Sergio; PORTO, Geciane S.; PAZELLO, Elaine Toldo. Characteristics of Brazilian innovative firms: An empirical analysis based on PINTEC—industrial research on technological innovation. **Research Policy**, 34.6: 872-893, 2005.

KUHL, Marcos Roberto et al. Relationship between innovation and sustainable performance. **International Journal of Innovation Management**, v. 20, n. 06, p. 1650047, 2016.

LAWSON, Benn; SAMSON, Danny. Developing innovation capability in organisations: a dynamic capabilities approach. **International journal of innovation management**, v. 5, n. 03, p. 377-400, 2001.

LAZZAROTTI, Fábio; MARCON, Rosilene; BANDEIRA-DE-MELLO, Rodrigo. **Recursos para inovação e desempenho: uma análise da invariância de mensuração em firmas de setores de alta intensidade tecnológica no Brasil**. RAI Revista de Administração e Inovação, v. 11, n. 4, p. 33-57, 2014.

LEI do Bem. 2018. Elaborada por F. Iniciativas. Disponível em: <http://www.leidobem.com/lei-do-bem-inovacao/>. Acesso em: 21 fev. 2018.

LOPES, Daniel Paulino Teixeira; BARBOSA, Allan Claudius Queiroz. Management and organizational innovation in Brazil: evidence from technology innovation surveys. **Production**, v. 24, n. 4, p. 872-886, 2014.

MARTINS TRISTÃO, Hélcio et al. Innovation in industrial clusters: a survey of footwear companies in Brazil. **Journal of technology management & innovation**, v. 8, n. 3, p. 45-56, 2013.

MELO, Paulo et al. Innovation Performance in Brazil–What is Missing? From the Perspective of Micro and Small Technology-Based Firms. **Journal on Innovation and Sustainability**. RISUS ISSN 2179-3565, v. 6, n. 2, p. 73-96, 2015.

MELO, Tatiana Massaroli; FUCIDJI, José Ricardo; POSSAS, Mario Luiz. **Política industrial como política de inovação: notas sobre hiato tecnológico, políticas, recursos e atividades inovativas no Brasil**. Revista Brasileira de Inovação, v. 14, p. 11-36, 2015.

MIOZZO, Marcela; WALSH, Vivien. International competitiveness and technological change. **Oxford University Press on Demand**, 2006.

MORALLES, Herick Fernando; DO NASCIMENTO REBELATTO, Daisy Aparecida. The effects and time lags of R&D spillovers in Brazil. **Technology in Society**, v. 47, p. 148-155, 2016.

NAGANO, Marcelo Seido; STEFANOVITZ, Juliano Pavanelli; VICK, Thais Elaine. Innovation management processes, their internal organizational elements and contextual factors: An investigation in Brazil. **Journal of Engineering and Technology Management**, v. 33, p. 63-92, 2014.

NATIONAL CASP COLLABORATION, et al. 10 Questions to Help You Make Sense of Qualitative Research, Critical Appraisal Skills Program (CASP). **Milton Keynes Primary Care Trust**, 2006.

OLIVEIRA, Michel Angelo Constantino et al. **Análise econométrica dos dispêndios em Pesquisa & Desenvolvimento (P&D) no Brasil**. RAI Revista de Administração e Inovação, v. 12, n. 3, p. 268-286, 2015.

OURA, Mauricio Massao; ZILBER, Silvia Novaes; LOPES, Evandro Luiz. Innovation capacity, international experience and export performance of SMEs in Brazil**. International Business Review**, v. 25, n. 4, p. 921-932, 2016.

PEREIRA, Luciana; PLONSKI, Guilherme Ary. Shedding light on technological development in Brazil. **Technovation**, v. 29, n. 6-7, p. 451-464, 2009.

PHILIPPE, Jean; FIGUEIREDO-MOREIRA, Marina; DE AQUINO, Tomas Guimaraes. Change and innovation: An observable relationship in services? **Revista de Administração e Inovação (RAI)**, v. 13, n. 2, p. 135-144, 2016.

QUANDT, Carlos Olavo. **Redes de cooperação e inovação localizada: estudo de caso de um arranjo produtivo local**. RAI Revista de Administração e Inovação, v. 9, n. 1, p. 141-166, 2012.

QUEIROZ, Sérgio; CARVALHO, Ruy de Quadros. **Empresas multinacionais e inovação tecnológica no Brasil**. São Paulo em Perspectiva, 19.2: 51-59, 2005.

ROCHA, A. F.; PALMA, M. A. M. **Gestão da inovação e capacidade competitiva: uma análise não paramétrica no setor cerâmico de Campos dos Goytacazes, RJ** (Innovation management and competitive capacity: a non-parametric analysis in the red ceramic sector of Campos dos Goytacazes, RJ, Brazil). Cerâmica, v. 58, p. 244-252, 2012.

ROCHA, Frederico. Does governmental support to innovation have positive effect on R&D investments? Evidence from Brazil. **Revista Brasileira de Inovação**, v. 14, p. 37-60, 2014.

RUIZ, Ana Urraca; DE AMORIM, Renata Bhawan. **Diferenças de comportamento inovador entre empresas nacionais e estrangeiras no Brasil**. RBI-Revista Brasileira de Inovação, 9.1: 29-68, 2010.

SALERNO, Mario Sergio. **Inovação tecnológica e trajetória recente da política industrial**. Revista USP, 93: 45-58, 2012.

SANTOS, David Ferreira Lopes et al. Innovation efforts and performances of Brazilian firms. **Journal of Business Research**, v. 67, n. 4, p. 527-535, 2014.

SANTOS, David Ferreira Lopes; BASSO, Leonardo Fernando Cruz; KIMURA, Herbert. **A estrutura da capacidade de inovar das empresas brasileiras: uma proposta de construto**. RAI Revista de Administração e Inovação, v. 9, n. 3, p. 103-128, 2012.

SCHWARTZ, Dafna; BAR-EL, Raphael. The role of a local industry association as a catalyst for building an innovation ecosystem: An experiment in the State of Ceara in Brazil. **Innovation**, v. 17, n. 3, p. 383-399, 2015.

THEISS, Viviane et al. **Ranking do Índice Brasil de Inovação (IBI) nas atividades industriais e extrativas da região sul do Brasil**. RAI Revista de Administração e Inovação, v. 11, n. 3, p. 79-100, 2014.

TORRES-FREIRE, Carlos; HENRIQUES, Frederico. **As empresas olham além de seus muros para inovar?**. RAI Revista de Administração e Inovação, v. 10, n. 3, p. 143-164, 2013.

VIEIRA, Kelly Carvalho et al. External Sources in the process of Open Innovation: Reinforcing and Restrictive Factors in Tech Startups. **Journal on Innovation and Sustainability**. RISUS ISSN 2179-3565, v. 6, n. 3, p. 3-28, 2015.

VILHA, Anapatricia Morales; QUADROS, Ruy. **Gestão da inovação sob a perspectiva do desenvolvimento sustentável: lições das estratégias e práticas na indústria de higiene pessoal, perfumaria e cosméticos**. RAI Revista de Administração e Inovação, v. 9, n. 3, p. 28-52, 2012.

YIGITCANLAR, Tan et al. Stimulating technological innovation through incentives: Perceptions of Australian and Brazilian firms. **Technological Forecasting and Social Change**, 2017.

ZAWISLAK, Paulo Antônio et al. Types of innovation in low-technology firms of emerging markets: an empirical study in Brazilian Industry. **RAI Revista de Administração e Inovação**, v. 10, n. 1, p. 212-231, 2013.

ZIMMER, Paloma et al. Tax Incentives for Innovation in Brazil: Obstacles for Use of the Good Law (Law 11.196/2005). **Journal of technology management & innovation**, v. 11, n. 4, p. 38-46, 2016.

ZORZO, Lucas Seffrin et al. The relationship between the focus on innovation and economic efficiency: a study on Brazilian electric power distribution companies. **RAI Revista de Administração e Inovação**, v. 14, n. 3, p. 235-249, 2017.

Appendix A. Studies included in the review

[S1] ZORZO, Lucas Seffrin et al. The relationship between the focus on innovation and economic efficiency: a study on Brazilian electric power distribution companies. **RAI Revista de Administração e Inovação**, v. 14, n. 3, p. 235-249, 2017.

[S2] PHILIPPE, Jean; FIGUEIREDO-MOREIRA, Marina; DE AQUINO, Tomas Guimaraes. Change and innovation: An observable relationship in services?. **Revista de Administração e Inovação (RAI)**, v. 13, n. 2, p. 135-144, 2016.

[S3] MELO, Paulo et al. Innovation Performance in Brazil–What is Missing? From the Perspective of Micro and Small Technology-Based Firms. **Journal on Innovation and Sustainability. RISUS ISSN 2179-3565**, v. 6, n. 2, p. 73-96, 2015.

[S4] MORALLES, Herick Fernando; DO NASCIMENTO REBELATTO, Daisy Aparecida. The effects and time lags of R&D spillovers in Brazil. **Technology in Society**, v. 47, p. 148-155, 2016.

[S5] LOPES, Daniel Paulino Teixeira; BARBOSA, Allan Claudius Queiroz. Management and organizational innovation in Brazil: evidence from technology innovation surveys. **Production**, v. 24, n. 4, p. 872-886, 2014.

[S6] PEREIRA, Luciana; PLONSKI, Guilherme Ary. Shedding light on technological development in Brazil. **Technovation**, v. 29, n. 6-7, p. 451-464, 2009.

[S7] OURA, Mauricio Massao; ZILBER, Silvia Novaes; LOPES, Evandro Luiz. Innovation capacity, international experience and export performance of SMEs in Brazil. **International Business Review**, v. 25, n. 4, p. 921-932, 2016.

[S8] ROCHA, Frederico. Does governmental support to innovation have positive effect on R&D investments? Evidence from Brazil. **Revista Brasileira de Inovação**, v. 14, p. 37-60, 2014.

[S9] NAGANO, Marcelo Seido; STEFANOVITZ, Juliano Pavanelli; VICK, Thais Elaine. Innovation management processes, their internal organizational elements and contextual factors: An investigation in Brazil. **Journal of Engineering and Technology Management**, v. 33, p. 63-92, 2014.

[S10] SCHWARTZ, Dafna; BAR-EL, Raphael. The role of a local industry association as a catalyst for building an innovation ecosystem: An experiment in the State of Ceara in Brazil. **Innovation**, v. 17, n. 3, p. 383-399, 2015.

[S11] DE MEDEIROS ROCHA, Michele et al. Innovation as a Critical Success Factor: an Exploratory Study about the Partnership among University with Pharmaceutical Industry in Brazil. **Journal of technology management & innovation**, v. 7, n. 3, p. 148-160, 2012.

[S12] SANTOS, David Ferreira Lopes et al. Innovation efforts and performances of Brazilian firms. **Journal of Business Research**, v. 67, n. 4, p. 527-535, 2014.

[S13] ZAWISLAK, Paulo Antônio et al. Types of innovation in low-technology firms of emerging markets: an empirical study in Brazilian Industry. **RAI Revista de Administração e Inovação**, v. 10, n. 1, p. 212-231, 2013.

[S14] DEWES, Mariana de Freitas et al. Open innovation as an alternative for strategic development in the aerospace industry in Brazil. **Journal of Aerospace Technology and Management**, v. 2, n. 3, p. 349-360, 2010.

[S15] MARTINS TRISTÃO, Hélcio et al. Innovation in industrial clusters: a survey of footwear companies in Brazil. **Journal of technology management & innovation**, v. 8, n. 3, p. 45-56, 2013.

[S16] DUNLAP, Denise et al. Organizing for Innovation Ambidexterity in Emerging Markets: Taking Advantage of Supplier Involvement and Foreignness. **Journal of Leadership & Organizational Studies**, v. 23, n. 2, p. 175-190, 2016.

[S17] DICKEL, Deise Graziele; DE MOURA, Gilnei Luiz. Organizational performance evaluation in intangible criteria: a model based on knowledge management and innovation management. **RAI Revista de Administração e Inovação**, v. 13, n. 3, p. 211-220, 2016.

[S18] FERRARESI, Alex A. et al. Knowledge management and strategic orientation: leveraging innovativeness and performance. **Journal of knowledge management**, v. 16, n. 5, p. 688-701, 2012.

[S19] FABIANI, Sidirley; SBRAGIA, Roberto. Tax Incentives for Technological Business Innovation in Brazil: The Use of the Good Law-Lei do Bem (Law No. 11196/2005). **Journal of technology management & innovation**, v. 9, n. 4, p. 53-63, 2014.

[S20] CYRINO, Alvaro Bruno et al. A critical assessment of Brazilian manufacturing competitiveness in foreign markets. **Competitiveness Review: An International Business Journal**, v. 27, n. 3, p. 253-274, 2017.

[S21] COSTA, Priscila Rezende; PORTO, Geciane Silveira. Innovation stages and organizational resources at midsized companies in Brazil. **Future Studies Research Journal: Trends and Strategies**, v. 4, n. 2, p. 217-247, 2012.

[S22] FRANK, Alejandro Germán et al. The effect of innovation activities on innovation outputs in the Brazilian industry: Market-orientation vs. technology-acquisition strategies. **Research Policy**, v. 45, n. 3, p. 577-592, 2016.

[S23] DA ROSA, Luciana Aparecida Barbieri et al. The Power of Innovation and Strategic Sustainability Positioning: A Survey of the Mining Sector in Brazil. **Environmental Quality Management**, v. 25, n. 2, p. 47-62, 2015.

[S24] CIRERA, Xavier; MARIN, Anabel; MARKWALD, Ricardo. Explaining export diversification through firm innovation decisions: The case of Brazil. **Research Policy**, v. 44, n. 10, p. 1962-1973, 2015.

[S25] CHAVES, Catari Vilela et al. The point of view of firms in Minas Gerais about the contribution of universities and research institutes to R&D activities. **Research Policy**, v. 41, n. 9, p. 1683-1695, 2012.

[S26] GOEDHUYS, Micheline; VEUGELERS, Reinhilde. Innovation strategies, process and product innovations and growth: Firm-level evidence from Brazil. **Structural change and economic dynamics**, v. 23, n. 4, p. 516-529, 2012.

[S27] DE FREITAS, Luciano Charlita; KANEKO, Shinji. Is there a causal relation between ethanol innovation and the market characteristics of fuels in Brazil?. **Ecological Economics**, v. 74, p. 161-168, 2012.

[S28] DE CARVALHO, Antonio Oliveira et al. Organizational resilience: a comparative study between innovative and non-innovative companies based on the financial performance analysis. **International Journal of Innovation**, v. 4, n. 1, p. 58, 2016.

[S29] FIGUEIREDO, Paulo N. Discontinuous innovation capability accumulation in latecomer natural resource-processing firms. **Technological Forecasting and Social Change**, v. 77, n. 7, p. 1090-1108, 2010.

[S30] DE GUIMARÃES, Julio Cesar Ferro et al. The use of organisational resources for product innovation and organisational performance: A survey of the Brazilian furniture industry. **International Journal of Production Economics**, v. 180, p. 135-147, 2016.

[S31] ESTEVES, Karen; FELDMANN, Paulo Roberto. Why Brazil does not innovate: a comparison among nations. **RAI Revista de Administração e Inovação**, v. 13, n. 1, p. 29-38, 2016.

[S32] GONÇALVES, Eduardo; PEROBELLI, Fernando Salgueiro; DE ARAÚJO, Inácio Fernandes. Estimating intersectoral technology spillovers for Brazil. **The Journal of Technology Transfer**, v. 42, n. 6, p. 1377-1406, 2017.

[S33] HALL, Jeremy et al. Managing technological and social uncertainties of innovation: the evolution of Brazilian energy and agriculture. **Technological Forecasting and Social Change**, v. 78, n. 7, p. 1147-1157, 2011.

[S34] ENGELMAN, Raquel Machado et al. Intellectual capital, absorptive capacity and product innovation. **Management Decision**, v. 55, n. 3, p. 474-490, 2017.

[S35] FIGUEIREDO, Paulo N. New challenges for public research organisations in agricultural innovation in developing economies: Evidence from Embrapa in Brazil's soybean industry. **The Quarterly Review of Economics and Finance**, v. 62, p. 21-32, 2016.

[S36] KUHL, Marcos Roberto et al. Relationship between innovation and sustainable performance. **International Journal of Innovation Management**, v. 20, n. 06, p. 1650047, 2016.

[S37] CIRANI, Cláudia Brito Silva et al. The role of public institutions for innovation support in Brazil. **BBR. Brazilian Business Review**, v. 13, n. 6, p. 210-230, 2016.

[S38] CHU, Daniel; ANDREASSI, Tales. Management of technological innovation: Case studies in biotechnology companies in Brazil. **Management Research: Journal of the Iberoamerican Academy of Management**, v. 9, n. 1, p. 7-31, 2011.

[S39] DALMARCO, Gustavo et al. How knowledge flows in university-industry relations: An overview from two economic sectors in Brazil. **European Business Review**, v. 27, n. 2, p. 148-160, 2015.

[S40] DE OLIVEIRA COSTA, Eduardo et al. Patterns of Technological Innovation: A Comparative Analysis between Low-tech and High-tech Industries in Brazil. **International Journal of Innovation (iji)**, v. 4, n. 2, p. 97-105, 2016.

[S41] DÁVILA, Guillermo Antonio; DURST, Susanne; VARVAKIS, Gregorio. Knowledge Absorptive Capacity, Innovation, and Firm's Performance: Insights From the South of Brazil. **International Journal of Innovation Management**, p. 1850013, 2018.

[S42] DA SILVA, Fabiana Matos; OLIVEIRA, Edson Aparecida de Araujo Querido; DE MORAES, Marcela Barbosa. Innovation development process in small and medium technology-based companies. **RAI Revista de Administração e Inovação**, v. 13, n. 3, p. 176-189, 2016.

[S43] DA SILVA, Raphael Braga et al. Innovative intensity and its impact on the performance of firms in Brazil. **Research in International Business and Finance**, v. 34, p. 1-16, 2015.

[S44] FERREIRA DE LARA, Felipe; NEVES GUIMARÃES, Márcia Regina. Competitive priorities and innovation in SMEs: A Brazil multi-case study. **Journal of technology management & innovation**, v. 9, n. 3, p. 51-64, 2014.

[S45] ZIMMER, Paloma et al. Tax Incentives for Innovation in Brazil: Obstacles for Use of the Good Law (Law 11.196/2005). **Journal of technology management & innovation**, v. 11, n. 4, p. 38-46, 2016.

[S46] BARROS, Henrique M. Exploring the use of patents in a weak institutional environment: The effects of innovation partnerships, firm ownership, and new management practices. **Technovation**, v. 45, p. 63-77, 2015.

[S47] BASTOS, Carlos Pinkusfeld; BRITTO, Jorge. Inovação e geração de conhecimento científico e tecnológico no Brasil: uma análise dos dados de cooperação da Pintec segundo porte e origem de capital. **Revista Brasileira de Inovação**, v. 16, n. 1, p. 35-62, 2017.

[S48] BRUNHERA, Diandra Carla Uncini; BAÇO, Fernanda Mendes Bezerra; CROTTI, Poliana Cristina. A eficiência dos processos de inovação na indústria de transformação: uma análise no estado do Paraná. **RAI Revista de Administração e Inovação**, v. 12, n. 4, p. 187-204, 2015.

[S49] CALABRIA, Paulo Cesar et al. A ciência da inovação em serviços: estudo exploratório sobre os interesses e prioridades para uma agenda de pesquisa no Brasil. **RAI Revista de Administração e Inovação**, v. 10, n. 4, p. 110-135, 2013.

[S50] CASTRO, Bernardo Hauch Ribeiro. Influência da estruturação de departamentos de P&D na inovação: um estudo na indústria de máquinas e implementos agrícolas no Brasil. **RAI Revista de Administração e Inovação**, v. 8, n. 1, p. 196-220, 2011.

[S51] DOS SANTOS, José Glauber Cavalcante; CALÍOPE, Thalita Silva; DA SILVA FILHO, José Carlos Lázaro. Analisando as diferenças entre investimentos em atividades de inovação conforme variáveis estratégicas contingenciais em empresas de capital aberto no Brasil. **Revista Gestão & Tecnologia**, v. 16, n. 3, p. 31-57, 2016.

[S52] FIALHO, Bruno Germani; DALLE NOGARE, Gelson Eduardo; RUPPENTHAL, Janis Elisa. A INSERÇÃO DO BRASIL NO PANORAMA GLOBAL DE INOVAÇÃO EM NANOFARMACÊUTICOS. **Revista GEINTEC-Gestão, Inovação e Tecnologias**, v. 6, n. 3, p. 3257-3263, 2016.

[S53] FIGUEIREDO, Paulo N.; DE ANDRADE, Rosilene F.; BRITO, Klauber N. Aprendizagem tecnológica e acumulação de capacidades de inovação: evidências de contract manufacturers no Brasil. **Revista de Administração**, v. 45, n. 2, p. 156-171, 2010.

[S54] LAZZAROTTI, Fábio; MARCON, Rosilene; BANDEIRA-DE-MELLO, Rodrigo. Recursos para inovação e desempenho: uma análise da invariância de mensuração em firmas de setores de alta intensidade tecnológica no Brasil. **RAI Revista de Administração e Inovação**, v. 11, n. 4, p. 33-57, 2014.

[S55] DE MENDONÇA, Marco Aurélio Alves; DE ALMEIDA FREITAS, Fernando; DE SOUZA, Jano Moreira. Tecnologia da informação e produtividade na indústria brasileira. **RAE-Revista de Administração de Empresas**, v. 49, n. 1, p. 74-85, 2009.

[S56] OLIVEIRA, Michel Angelo Constantino et al. Análise econométrica dos dispêndios em Pesquisa & Desenvolvimento (P&D) no Brasil. **RAI Revista de Administração e Inovação**, v. 12, n. 3, p. 268-286, 2015.

[S57] QUANDT, Carlos Olavo. Redes de cooperação e inovação localizada: estudo de caso de um arranjo produtivo local. **RAI Revista de Administração e Inovação**, v. 9, n. 1, p. 141-166, 2012.

[S58] ROCHA, A. F.; PALMA, M. A. M. Gestão da inovação e capacidade competitiva: uma análise não paramétrica no setor cerâmico de Campos dos Goytacazes, RJ (Innovation management and competitive capacity: a non-parametric analysis in the red ceramic sector of Campos dos Goytacazes, RJ, Brazil). **Cerâmica**, v. 58, p. 244-252, 2012.

[S59] SANTOS, David Ferreira Lopes; BASSO, Leonardo Fernando Cruz; KIMURA, Herbert. A estrutura da capacidade de inovar das empresas brasileiras: uma proposta de construto. **RAI Revista de Administração e Inovação**, v. 9, n. 3, p. 103-128, 2012.

[S60] DA SILVA TEIXEIRA, André Luiz et al. Dimensões da capacidade de absorção, qualificação da mão de obra, P&D e desempenho inovativo. **Revista Brasileira de Inovação**, v. 15, n. 1, p. 139-163, 2016.

[S61] THEISS, Viviane et al. Ranking do Índice Brasil de Inovação (IBI) nas atividades industriais e extrativas da região sul do Brasil. **RAI Revista de Administração e Inovação**, v. 11, n. 3, p. 79-100, 2014.

[S62] TORRES-FREIRE, Carlos; HENRIQUES, Frederico. As empresas olham além de seus muros para inovar?. **RAI Revista de Administração e Inovação**, v. 10, n. 3, p. 143-164, 2013.

[S63] VIEIRA, Kelly Carvalho et al. External Sources in the process of Open Innovation: Reinforcing and Restrictive Factors in Tech Startups. **Journal on Innovation and Sustainability. RISUS ISSN 2179-3565**, v. 6, n. 3, p. 3-28, 2015.

[S64] VILHA, Anapatricia Morales; QUADROS, Ruy. Gestão da inovação sob a perspectiva do desenvolvimento sustentável: lições das estratégias e práticas na indústria de higiene pessoal, perfumaria e cosméticos. **RAI Revista de Administração e Inovação**, v. 9, n. 3, p. 28-52, 2012.

Appendix B. Overview of primary studies

ID	Research Method	CDM focus	Used PINTEC as data source
S1	Survey/Interview	Performance	
S2	Econometric or other quantitative analysis	Outputs	
S3	Multiple-case	Performance	
S4	Econometric or other quantitative analysis	Performance	
S5	Econometric or other quantitative analysis	Process	X
S6	Multiple-case	Performance	
S7	Econometric or other quantitative analysis	Performance	X
S8	Econometric or other quantitative analysis	Inputs (Government)	X
S9	Multiple-case	Process	X
S10	Survey/Interview	Process	
S11	Survey/Interview	Input	X
S12	Econometric or other quantitative analysis	Performance	X
S13	Multiple-case	Outputs	
S14	Single-case	Input	
S15	Survey/Interview	Input	X
S16	Econometric or other quantitative analysis	Performance	X
S17	Mixed methods	Process	
S18	Mixed methods	Input	
S19	Econometric or other quantitative analysis	Inputs (Government)	
S20	Survey/Interview	Performance	
S21	Mixed methods	Input	
S22	Econometric or other quantitative analysis	Outputs	X
S23	Mixed methods	Performance	
S24	Econometric or other quantitative analysis	Performance	X
S25	Econometric or other quantitative analysis	Input	X
S26	Econometric or other quantitative analysis	Outputs	
S27	Econometric or other quantitative analysis	Not related article	
S28	Mixed methods	Performance	
S29	Multiple-case	Not related article	
S30	Econometric or other quantitative analysis	Performance	X
S31	Econometric or other quantitative analysis	Outputs	
S32	Econometric or other quantitative analysis	Input	X
S33	Multiple-case	Not related article	
S34	Econometric or other quantitative analysis	Process	
S35	Mixed methods	Input	
S36	Mixed methods	Performance	X
S37	Mixed methods	Inputs (Government)	X
S38	Multiple-case	Process	
S39	Mixed methods	Process	
S40	Econometric or other quantitative analysis	Outputs	
S41	Econometric or other quantitative analysis	Performance	

S42	Multiple-case	Process	
S43	Econometric or other quantitative analysis	Performance	
S44	Multiple-case	Outputs	
S45	Mixed methods	Inputs (Government)	X
S46	Econometric or other quantitative analysis	Outputs	X
S47	Econometric or other quantitative analysis	Input	X
S48	Econometric or other quantitative analysis	Input	X
S49	Survey/Interview	Not related article	
S50	Econometric or other quantitative analysis	Input	
S51	Econometric or other quantitative analysis	Input	
S52	Econometric or other quantitative analysis	Not related article	
S53	Mixed methods	Not related article	
S54	Econometric or other quantitative analysis	Input	X
S55	Econometric or other quantitative analysis	Process	X
S56	Econometric or other quantitative analysis	Input	X
S57	Single-case	Outputs	X
S58	Survey/Interview	Process	
S59	Econometric or other quantitative analysis	Outputs	X
S60	Survey/Interview	Process	X
S61	Econometric or other quantitative analysis	Input	X
S62	Survey/Interview	Process	
S63	Multiple-case	Process	
S64	Survey/Interview	Process	

Appendix C. Data extraction form

Study description	Item	Item Description
1.	Id	Number of the article on the citation manager
2.	Bibliographic reference	Tittles, authors, journal, year
3.	Study objectives	What is/are the objective(s) of the study?
4.	Research design	Qualitative, quantitative (single-case, multiple-case, econometric or other quantitative analysis, mixed-methods, survey/interview)
5.	CDM classification	Categorization in accordance to the CDM model
6.	Data source	Did the article used PINTEC as data source?
7.	Data analysis	How was the data analyzed?
Study contribution	**Item**	**Item Description**
8.	Findings and conclusions	What are the main findings and conclusions?
9.	Limitations pointed by the authors	What are the main limitations pointed by the authors?
10.	Future research	What are the suggestions for future research?

3 ARTICLE 2 - Innovation barriers in industrial markets: are they an obstacle or an opportunity for cooperation?

Mateus José do Rêgo Ferreira Lima[1]

Arthur Marcon[1]

Isadora Marques Castiglio[1]

Susan K. Cohen[2]

Alejandro Germán Frank[1 **]

This paper is under submission at Research Policy (Elsevier).

Abstract

Innovation efforts are not always successful, since a variety of barriers may be present in the industrial activities. Cooperating with partners is proposed as a possible way to overcome such barriers. However, some barriers may actually discourage cooperation. The literature does not make clear which innovation barriers are, in fact, triggers or obstacles to industrial cooperation for R&D. In this paper, we examine the impact of innovation barriers on industrial cooperation intensity using secondary data from the 2014 Brazilian Industrial Innovation Survey (PINTEC - 2014), which represents more than 40,000 innovative companies of this country analyzed over three years (2011-2014). Using an econometric model based on instrumental variables regression, we show that industrial sectors tend to cooperate when they face cost barriers. On the other hand, industrial sectors cooperate less when knowledge and market barriers are present. This means that industries may be willing to share financial risks with partners, but they also want to keep independency, avoiding partnerships before having their own innovation knowledge capacities. Therefore, we show a conservative and opportunistic industrial behavior on cooperation for innovation. Policy makers should explore opportunities to build long-term industrial cooperation based on shared knowledge capacities.

Keywords*:* Industrial innovation; innovation barriers; cooperation; large-scale survey; emerging countries.

3.1 INTRODUCTION

Innovation is widely acknowledged as a key driver of welfare and sustainable social and economic growth for countries (Tourigny and Le, 2004; Hölzl and Janger, 2014; Santos et al, 2014; Watkins et al., 2015). However, the path traced by industry to innovate is rarely clear and it is not always successful. A variety of barriers (or obstacles) affect industries and can hinder innovation activities (Ferriani et al., 2008; Madrid-Guijarro et al., 2009; D'este et al., 2012; Leoncini, 2016). Whether such barriers prevent a country from realizing the full potential of innovation to raise economic and social welfare depends upon how firms and policy makers respond to them.

An important industrial response is cooperation to circumvent barriers to innovation (Luzzini et al., 2015; Robin and Schubert, 2013; Lewandowska et al., 2016), such as by

forming alliances to share the risks and costs of R&D (Kale and Singh, 2007; Sheth and Parvatiyar, 1992; Stanek, 2004) or to access knowledge and resources a firm lacks (Gudergan et al., 2012, Tsou et al., 2016). However, barriers have many origins and characteristics (Blanchard et al, 2013), and it is unclear which tend to trigger cooperative responses and which are more likely to simply deter aspiring innovators.

In this study, we specifically focus on the influence of innovation barriers for cooperation. We extend prior work on innovation barriers by exploring when barriers trigger industrial cooperation for innovation – defined as engaging in joint R&D projects (Lustosa, 2011) – between firms and their customers, suppliers, universities, competitors, and consultants. We adopt an exploratory approach because the implications of innovation barriers for industrial innovation activities as a whole are still a maturing topic among scholars (Blanchard et al., 2013; Hadjimanolis, 1999; Baldwin and Lin, 2002; Galia and Legros, 2004; Hölzl and Janger, 2014). The literature has mostly been concerned with financial barriers, as exemplified by the studies of Iammarino et al. (2009) and Savignac (2005). We propose a more comprehensive exploration of different types of barriers commonly associated with the innovation process. Specifically, we draw on the OECD (2005) categorization of barriers into cost, market, knowledge and regulatory categories. This categorization was also used in large-scale innovation surveys and in other innovation studies, such as the one of D'Este et al. (2012). Although some evidence suggests that barriers can open opportunities for cooperation among partners (Greis et al., 1995; Resende et al., 2014), it is unclear which barriers have this effect. Hence, we explore *which innovation barriers trigger or which affect industrial cooperation for R&D.*

The main objective of this paper is to examine the impact of innovation barriers on industrial cooperation intensity in Brazil. To this end, we analyze secondary data from the 2014 Brazilian Industrial Innovation Survey (PINTEC - 2014) which represents more than 30,000 innovative companies of this country analyzed over three years (2011-2014). We used an econometric approach based on instrumental variables regression method to address these antecedent effects of innovation barriers on industrial cooperation and we show that certain barriers trigger greater cooperation while others reduce the intensity of industrial cooperation for innovation. The main contribution of our findings is that we show how industrial sectors are motivated to cooperate for innovation when they face different types of barriers.

3.2 THEORETICAL BACKGROUND

3.2.1 Innovation barriers and the context of developing countries

Inherent risk and uncertainty can deter industrial innovation, and additional obstacles, such as lack of access to capital or regulatory constraint, can further quell industries' emphases on innovation (Pavitt, 1984; Zander, 1997; Klevorick et al, 1997; Galia and Legros, 2004; Blanchard et al., 2013; Hölzl and Janger, 2014). However, obstacles can also trigger creative responses, shaping innovation in characteristic ways (Porter, 1990; Ruttan, 1997). For instance, Ruttan (2001) portrayed labor saving innovation as an industrial response to scarce human capital and land-saving innovation as a response to limited supply of fertile fields. It is not clear from prior studies when barriers to innovation trigger creative responses or dampen interest in innovation altogether.

To advance our understanding in this area, we explore a behavioral response to innovation barriers: cooperation for innovation. We draw on a novel database that records industrial research and development (R&D) activities for Brazilian industries, and defines cooperation for innovation as "the active participation of the company in joint R&D projects and other innovation projects with any other organization (company or institution), which does not imply that the involved parties would gain immediate benefits. The simple hiring of services from other organizations without their active collaboration is not considered to be cooperation (IBGE, 2016, p.24)." Building on work by D'este et al., (2012), we categorize innovation barriers as pertaining primarily to challenges financing innovation (cost), discerning and acting on opportunities (knowledge), lack of demand for novel products (market), and the imposition of norms, standards, and laws that constrain innovative activities (regulation). These four categories cover both technology push and market pull perspectives (Dosi, 1982), as well as institutional and organizational enablers (Kamien and Schwartz, 1982).

D'Este et al., (2012) provide a broad theoretical understanding of these barriers by proposing that they can be classified into two differing main categories: *revealed barriers* (i) *and deterring barriers* (ii). This classification was built on the studies from Hadjimanolis (1999), and Baldwin and Lin (2002), and comprises advancement in the theoretical thought of innovation barriers. Conceptually, *revealed barriers* reflect the degree of difficulty encountered during the innovation process and learning through engagement in innovation activities (e.g. research and development, technology

acquisition). *Deterring barriers*, in turn, encompass the obstacles that limit industries' engagement in innovation, causing withdrawal and a phenomenon called "failure without learning". While D'Este et al, (2012) and Hadjimanolis (1999) suggest that the costs of innovation activities and excessive perceived economic risks might act as deterring barriers, empirical evidence regarding their effects across industries, and the implications for cooperative innovation, is lacking.

Other authors have proposed ways to classify innovation barriers (e.g. Piatier, 1984; Hadjimanolis, 1999; Blanchard et al., 2013; Hölzl and Janger, 2014; Sandberg and Aarikka-Stenroos, 2014; Uyarra et al., 2014). For example, Piatier (1984) and Hadjimanolis (1999) differentiate barriers based on their origin. Hence, internal barriers to innovation comprise supply and demand, environmental obstacles or organizational routine. External barriers are related to resources, the market, governmental, cultural or systemic obstacles (Hölzl and Janger, 2014; Uyarra et al., 2014). Blanchard et al., (2013), on the other hand, propose that barriers can be divided into financial and non-financial barriers. Financial barriers focus on R&D expenditures and other innovation inputs, such as external funding. Non-financial barriers encompass lack of cooperation, lack of specialized personnel, market uncertainty, among others. We integrate the D'Este et al. (2012) framework and insights from these studies, to propose four categories of barriers: cost, knowledge, market, and regulatory.

The effect of any given type of barrier on industrial innovation may differ across countries. Thus, some general features that move industries towards innovation may differ when considering the boundaries of a less developed country, and as consequence, the perception of barriers. According to Crespi and Zuniga et al. (2012), there is strong evidence from Latin American countries that the stimulus for innovation is strongly associated with gains in productivity while the scientific and market sources of information are considered secondary reasons for innovation, illustrating weak linkages that characterize national innovation systems in those countries. In line with this performance-oriented behavior and this information gap, Costa and Queiroz (2002) and Nagano et al. (2014) observed that in the Brazilian context companies are traditionally considered unlikely to innovate, often experiencing difficulties in managing and developing new technologies.

In the socioeconomic context of developing economies, lack of knowledge to support innovation is a pervasive weakness. In developing countries, innovation to develop new products is often thwarted by the shortage of specialized technical labor in the supply of

technical services (Hadjimanolis, 1999; Doruk and Söylemezoğlu, 2014). Bureaucratic barriers may predominate in less developed economies (Doruk and Söylemezoğlu, 2014), as well as a lack of market readiness to accept novel products (Cardoza et al., 2016). Industrial orientation to innovation may reflect immaturity of the national innovation systems (Frank et al., 2016), and present an additional knowledge-based barrier to innovation.

3.2.2 Industrial cooperation as a consequence of innovation barriers

Emphasis on cooperative R&D may vary by industry, in accordance with their different technological opportunities, demand conditions, and mechanisms for appropriating the benefits of innovation (Klevorick et al, 1997). However, we know little about when financial, knowledge, market and regulatory barriers hinder rather than trigger such cooperation (e.g. Agnetis et al., 2016; Bouncken and Fredrich, 2016; De Faria et al., 2010; Mention, 2011); Gallego et al., 2013). In this sense, we hypothesize that innovation barriers are antecedents of the industrial cooperation intensity, and that they can trigger or hinder such cooperation. Some reasons for such hypothesis are given next.

Cooperation is an alternative to engaging in an activity alone and is often chosen to share risks and costs, and to combine complementary resources and capabilities (Hagedoorn, Link, and Vonortas, 2000). Following this line, cooperation could exist as a reaction to innovation barriers. On the other hand, other authors argue that instead of being a major reason for firms to collaborate with external parties, innovation barriers may, actually, represent a difficulty for firms to adopt this strategy (Mention, 2011; Trigo and Vence, 2012). Therefore, there are basically two distinct interpretations about the role of innovation barriers as antecedents of cooperation. Understanding when barriers trigger cooperation and when they discourage it is important for policy makers to better anticipate how they affect the context for industrial innovation in their country.

From the literature that defends the role of innovation barriers as stimuli for a collaborative engagement, there are different perspectives, which mostly indicate how companies establish their partnerships and in which direction they are mostly focused. For instance, Tomlinson and Fai (2013) state that an increased number of firms, usually small and medium-sized enterprises, encourage networks and close relationships in order to improve both knowledge transfer and organizational learning. De Faria (2010) also maintains that for certain innovative companies the obstacles stemming from the

scarcity of proper knowledge are usually the ones that motivate the search for external sources (De Faria et al., 2010). Both of these findings highlight the role of cooperation as a response to the lack of internal specialized knowledge. In addition, other authors, such as Trigo and Vence (2012) and Galego et al (2013) present a different perspective emphasizing that highly innovative firms as well as firms with intense R&D activities are the ones most favorable to exploit new knowledge. These findings add an interesting avenue for discussion once they imply that, in certain scenarios, it is not only the need to fill knowledge gaps that accounts for the decision whether or not to cooperate but also the capacity of firms to enjoy the advantages of being involved in cooperation networks.

Along the same line, cost, as well as market barriers, as seen in the previous section, are obstacles highlighted as very critical to innovation (e.g. D'Este et al., 2012; Baldwin and Lin, 2002; Galia and Legros, 2004; Doruk and Söylemezoğlu, 2014). Even more, authors usually recognize these two barriers as having a deterring effect on innovation (D'este et al., 2012; Pellegrino and Savona, 2017), which means that they may not only jeopardize innovation activities of innovative firms but also completely hamper firms that are trying to innovate. Literature, in turn, maintains that from a wide range of possible alternatives to surmount these obstacles, a strong one relies on external collaboration. For instance, studies of De Faria (2010), Zen et al. (2010) and Pekkarinen and Harmaakorpi (2006) have shown that the role of cooperation networks on innovation generate benefits by decreasing innovation costs and investment risks, as well as promoting market failure corrections. Hence, through industrial cooperation these companies establish a mutual support based on cost sharing mechanisms for innovation, allowing them not only to afford the costs involved with the innovation process itself but also to deal with their financial risks. Moreover, other authors provide evidence that cooperation is also a mean for firms to obtain information for a better market behavior assessment (Mention, 2011; Gallego et al., 2013). In this way, these cooperation networks may provide support to identify when an innovation should be introduced into the market and how this market is most likely to react.

Another way to study the relationship of innovation barriers and industrial cooperation is to focus on the parties involved on the network and how they may vary according to the environment and orientation characteristic of different industries. In this way, depending on which type of innovation barriers are prevalent, the environment in which they are inserted and how they seek to improve their innovation processes they may

establish different kinds of partnership. For instance, Liefner et al. (2006) found that, for the context of developing economies, cooperation with research organizations, such as universities and research institutions, is an important source of new knowledge, especially for small and medium sized enterprises. This may be understandable by the fact that in these countries knowledge creation is usually centered in these organizations and companies may not find an easy way to access knowledge from outside this context. On the other hand, when analyzing the scenario of a developed country, collaboration with customer, suppliers and other enterprises is considered the best mean to achieve innovative gains in products and processes, especially if compared to the partnerships with research institutes, universities and government agencies (Zeng et al., 2010; Robin and Schubert, 2013). According to Schwartz et al. (2012) and Tomlinson and Fai (2013), this can be explained by the fact that both supplier and customer collaboration offer more benefits in terms of innovation process inputs, information exchange and generation of new ideas. Thus, whereas in developed economies, networks may enhance innovation performance by providing knowledge and information, in developing economies they may be established primarily to fill knowledge gaps in certain domains relevant to innovation (i.e., to overcome knowledge barriers) (Bouncken and Fredrich, 2016; Cohen and Levinthal, 1990; De Faria et al., 2010).

Other authors who also studied about innovation obstacles and the influence of external partners on the innovation process may help to provide a better understanding of these different relationships. For instance, in what are regarded as financial barriers, previous works identified cooperation with other enterprises, essentially competitors (coopetition) as an effective way to establish cost-sharing mechanisms and thereby surmount obstacles associated with excessive innovation costs and risks (Gudergan et al., 2012; Roma and Perone, 2016; Bouncken and Fredrich, 2016; Tsou et al., 2016). Furthermore, Belderbos et al. (2004) addressed how companies overcome barriers to explore new segments and reduce uncertainty when approaching a new market and concluded that cooperation with research organizations is the most effective way to be successful in a new environment. Their findings provide insight on how companies can surmount innovation market barriers. Finally, and in addition to these previous findings, there is a strong indication that cooperation with external partners such as consultants, customers and other actors who are closer to the company's production system itself may help them to overcome innovation barriers associated to regulations. Then, when exposed to a new scenario, companies not only may find a solution for such a

constrained environment, relying on external collaboration but also improve their approach when implementing innovations in a new market (Trigo and Vence, 2011; De Faria et al., 2010; Mention, 2010; Tomlinson, 2012).

In summary, the literature does not make clear which barriers are likely to trigger industrial cooperation for innovation and which will tend to discourage it. Next, we explore how the four categories of barriers suggested by prior work relate to industrial cooperation for innovation, in Brazil.

3.3 RESEARCH METHODS

3.3.1 Data source

We used secondary data obtained from the 2014 Brazilian Industrial Innovation Research report (PINTEC-2014), which provides information on firms' cooperative innovative investments, activities, achievements, and challenges in Brazil from 2011 to 2014. Since 2000, the Brazilian Institute of Statistics and Geography (IBGE) has collected this data from Brazilian firms, using face-to-face and over-the-phone structured interviews with professionals from R&D or industrial production areas, and by administering surveys (Lustosa, 2011). This process takes from five to nine months (Lustosa, 2011). IBGE follows the guidelines provided by the third edition of the *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data*, which allows for comparisons of innovation data for countries using this guide (IBGE, 2016; OECD, 2005).

The unit of analysis for the PINTEC survey is the enterprise – a legal unit, established in Brazil, with at least ten employees in December 31 of the reference year. IBGE identifies active enterprises on the Central Register of Enterprises (Cempre - *Cadastro Central de Empresas*) of IBGE, which contains the organizations registered in the National Directory of Legal Entities (CNPJ - *Cadastro Nacional da Pessoa Jurídica*) maintained by the Department of the Treasury. When the legal unit (i.e., the firm or enterprise) encompasses separate physical units, IBGE captures innovation data at each geographic location and from each subsidiary with independent management. IBGE then verifies these data with the central unit administration and consolidates it, so that measured variables represent the firm as a whole (corporation). The main economic activity of each enterprise is classified according to which sector provides the primary

source of revenue, as represented by National Classification of Economic Activities (CNAE - *Classificação Nacional de Atividades Econômicas*).

IGBE employs a stratified disproportional sampling to select a sample of enterprises covering each major geographic region and industrial sector. One stratification seeks to capture a high proportion of potential innovators from each sector or region. IBGE creates a number of indicators of potential to innovate, using surveys and registry entries, and classifies firms into three strata: large enterprises (with at least 500 employees in the extractive industry and with at least 100 in the service industry) and several indications that they are likely to innovate, enterprises with moderate indication that they will innovate, and enterprises with no indication that they will innovate. The third, 'no indication they will innovate' group comprises 20% of the sample, with 80% comprised by firms deemed highly or moderately likely to innovate (Lustosa, 2011). A second stratification seeks to include a desired representation across geographic regions, of sectors that represent at least 1% of the national value of industrial transformation and particular percentages of regional value. For the report released in 2014, the final effective sample comprises a total of 17,171 companies represented by 55 different industrial sectors. Using the Horvitz Thompson estimator (Horvitz and Thompson, 1952)[3], IBGE estimates that this sample is representative of 47,693 innovative firms from a universe of 132,529 industrial businesses (IBGE, 2014) from four main industries: extractive, processing, energy (electricity and gas) and services, subdivided in 55 industrial sectors as shown in Table 3. For this study, we focused only on the extractive and processing industries, represented by 42 different industrial sectors. This consists in a subgroup of 17,171 surveyed companies (85.78% of the sample) representing a total estimated universe of 42,988 innovative firms. We choose to exclude the Energy (electricity and gas - 1 sector) and Services (12 sectors) industries from our analysis because both tend to present a different innovation nature, mainly focused on the service quality provision to the customers. This decision follows PINTEC's (2014) reporting criteria, which groups Extractive and Processing activities as a single cluster of industrial activities while Energy and Services are treated separately from each other. Thus, our final sample comprises 42 industrial sectors

[3] This estimator was proposed by Horvitz and Thompson (1952) to estimate the population of stratified samples. The method is based on inverse probability weighting to account for different proportions of observations in the stratified sample of a target population. The PINTEC (2014) report provides this procedure for the considered sample.

analyzed at an aggregate data level (i.e. individual firms' data is not provided in this dataset).

Table 3 – Sample characteristics of PINTEC 2014

Main industries	Universe of firms represented by the sample	Surveyed companies	Universe of innovative firms estimated from the sample	Number of industrial sectors represented in the industry
Extractive	2,708	14,387 [a]	1,137	1
Processing	108,057		41,851	41
Electricity and gas [b]	468	96	136	1
Services [b]	21,295	2,688	4,569	12
Total	**132,529**	**17,171**	**47,693**	**55** [c]

Table notes: [a] This data is not discriminated in PINTEC report; [b]Excluded for the final sample of this research; [c] Final sample after exclusion: n= 42 industrial sectors.

3.3.2 Data source

3.3.2.1 Variable selection

The PINTEC report is released every three years, for the most part (2000, 2003, 2005, 2008, 2011, 2014). It provides qualitative and quantitative data in nine areas, aggregated by industry or region: (i) efforts devoted to various innovative activities; (ii) sources of financing for innovation; (iii) purchase of R&D services; (iv) internal R&D activities; (v) achievements and impact of innovations; (vi) information sources used for innovation; (vii) cooperation for innovation; (viii) government support received for innovation; and (ix) use of patents and other innovation methods (IBGE, 2016). Respondents are asked to consider a three-year window (focal year plus the two preceding years) when assessing qualitative variables, such as for the importance of internal R&D or acquisition of external knowledge. Quantitative responses, such as percentage of sales invested in various innovation activities, are for the focal year (Lustosa, 2011). Several variables are captured both quantitatively and qualitatively (e.g. effort devoted to various innovation activities is measured using an importance scale – high, medium, low, not done - and monetarily in Brazilian *Reais*). Variables of particular relevance to this study pertained to the characteristics of innovative firms, such as: description and types of innovation adopted, governmental support, innovation

results, engagement in various types of collaboration, and obstacles to innovation (IBGE, 2016).

The PINTEC report devotes a specific section to the discussion of innovation barriers. This section aims to identify the reasons why the company did not develop innovative activities or did not obtain the expected results. During the data gathering phase, a list of factors responsible for hindering their innovative activities is presented and companies are asked to position themselves according to the perceived importance of each of these barriers. Similarly, companies are asked to indicate how important several modes of cooperation are to their innovation efforts. Cooperation for innovation is defined as "the active participation in joint R&D projects and other innovation projects with any other organization (company or institution), which does not imply that the involved parties would gain immediate benefits. The simple hiring of services from other organizations without their active collaboration is not considered to be cooperation (IBGE, 2016). The PINTEC report indicates the intensity of cooperation between companies and different stakeholders. The reported data indicate whether companies that have declared themselves to be innovative have faced any type of obstacle, what type of obstacle, and the impact of the obstacle in the innovation activities and outcomes. Figure 12 presents a description of the innovation barriers and cooperation variables used from PINTEC 2014.

Figure 12 - PINTEC variables selected for the analysis

Innovation barriers	Description according to PINTEC 2014
Excessive economic risks [RISKS]	This barrier includes the risks associated with a certain innovation, specifically when this innovation is seen as radical to the market. Although the company has all the information needed, the market response to that innovation cannot be forecasted.
High innovation costs [COSTS]	This barrier affects the company when the amount of money the company has access to is not sufficient to carry out the innovation effort, and even if the company has the necessary requirements, it cannot proceed to innovate.
Lack of financial sources [SOURCES]	This barrier relates to the lack of interest or possibilities of collaboration with third parties, specifically in terms of financing.
Organizational rigidity [INFLEXIBILITY]	This barrier addresses the company's ability to adapt itself to organizational changes. Sometimes, organization and structural changes are necessary to facilitate the innovation process and if the company is unwilling to adapt, this may be an obstacle to the innovation process.

Lack of qualified personnel [UNQUALI_PERSONNEL]	This barrier is associated with the impossibility of finding qualified workforce to work in a certain innovation project. It is worth mentioning that this can happen even if the company is capable of affording it.
Lack of information on technology [TECH_INFO]	This barrier represents an impossibility of finding information regarding the technology applied to a certain innovation project. As with the [UNQUALI_PERSONNEL] barrier, this obstacle can exist even if the company can afford to search for the required information.
Lack of information on markets [MARKET_INFO]	This obstacle relates to the difficulty of finding enough information to support decision making along the innovation process. Similar to the previous barriers [UNQUALI_PERSONNEL] and [TECH_INFO] this barrier can occur even if the company has capital to support the pursuit of this information.
Scarce possibilities of cooperation with other companies/institutions [LACK_OF_COOPJ]	This barrier relates to the difficulty of finding capable partners for the company to cooperate with. This barrier may exist due to certain reasons such as the environment and the maturity stage of innovation in which the company is. Thus, specific aspects as lack of interested parties, knowledge protection and the capability of being involved in networks may represent an obstacle for companies to move their innovation efforts further.
Difficulty adjusting to standards, norms and regulations [REGULATIONS]	This barrier represents the misunderstanding and difficulties for companies to adjust their innovation proposals to the norms and regulations of a given environment. This may be due to the lack of information or very restricted policies.
Weak consumer response to new products [MARKET_BEHAVIOR]	This barrier is associated to consumer behavior. In some cases, the targeted market is used to deal with a certain technology or product type and may be resistant to adopting alternative ones.
Scarcity of appropriate external services [LACK_OF_SERVICES]	This barrier is related to the scarcity of external sources that can enhance the potential of the innovation, such as: research, repairing and remanufacturing, for example.
Centralization of the innovation activity [CENTRALIZATION]	This barrier relates to how the company structures the decisions related to innovation, especially when this innovation is developed in an environment outside the company.

Cooperation configurations	**Description according to PINTEC 2014**	
Types of cooperation	1.Customers	5.Consulting firms
	2.Suppliers	6.Universities and research institutes
	3.Competitors	7.Testing and certification

	4.Another company unit	institutions 8. Training and technical centers

As we aim to analyze innovation barriers as an antecedent of cooperation intensity, we decided not to include the innovation barrier variable [LACK_OF_COOP] in the analysis due to its overlapping characteristic with our dependent variable. We also excluded the innovation barrier [CENTRALIZATION], which may also overlap with the dependent variable, since its represents a contrary effect to cooperation intensity. We grouped the remaining 10 innovation barriers variables into constructs according to the previous work of D'Este et.al, (2012), as explained later (Section 3.3.2.2). Cooperation with each of the eight organization types (customers, consultants, etc.) was defined as a single construct, as we further describe in Section 3.3.2.2.

The data used to assess innovation barriers and cooperation was measured by IBGE using a Likert scale with three points (low, medium and high) to indicate the importance of a particular barrier or of a particular partnership to a firm's innovation activities. The PINTEC report presents these data in aggregated categorical form, in which each industrial sector has a single value. In order to calculate a unique score for the innovation barriers and for cooperation, for each of the 42 industrial sectors, we used the following equation proposed by Frank et al. (2016) in their analysis of PINTEC 2011:

$$T_{ij\%} = \frac{1.00 \times th_j + 0.50 \times tm_j}{T_j} \quad (1)$$

According to this equation, $T_{ij\%}$ is calculated for a specific industrial sector *j* regarding a qualitative aspect *i* of innovation barriers (the 10 types of barriers) or industrial cooperation variables (the 8 types of cooperation). A weight of 1.00 is attributed to an industrial sector *j* that indicated a high importance (th_j) to a variable *i*, while a weight of 0.50 is given for an industrial sector *j* that attributed a moderate importance (tm_j) for variables *i*. The objective of calculating this formula is to have a weighted sum for the two partial totals (Frank et al., 2016). Thus, all companies that reported high or middle importance to a variable (th_j and tm_j) were calculated based on the Eq. (1) and included in our analysis. The results are expressed in terms of relative percentages in which the weighted sum is divided by the total quantity of companies related to a specific industrial sector. In this way, Eq. (1) provides a unique score ($T_{ij\%}$) for each of the

industrial sectors comprehended in this study that reflects the perceived importance that companies have according to each variable.

3.3.2.2 Construct definition

Since PINTEC comprises many variables regarding innovation barriers (10) and industrial cooperation types (8), we explored whether aggregating these variables into constructs would help to avoid multicollinearity problems as well as to enhance interpretability by capturing hidden structures in the data (Hair 2009; Treiblmaier and Filzmoser, 2010). Toward this end, we followed two different procedures, one for the barriers (based on theoretical considerations) and one for the cooperation types (based on data analysis procedures).

For the synthesis of the innovation barriers variables, we classified them according to D'Este et al. (2012) innovation barriers framework, which provides a categorization of barriers into four relevant areas: Costs; Knowledge; Market and Regulation. D'Este et al. (2012) propose a list of variables classified into these main four groups that are very similar to those used in PINTEC. Thus, we adapted such classification to the PINTEC barriers as shown in Figure 13. Secondly, we synthesized the variables into constructs by taking the average of the components in each group.

Figure 13 - Innovation Barriers classification based on the framework of D'Este et al. (2012)

Detailed barriers according to PINTEC 2014	**Barrier factors**			
	COST	**KNOWLEDGE**	**MARKET**	**REGULATION**
Excessive economic risks [RISKS] *	X			
High innovation costs [COSTS] *	X			
Lack of financial sources [SOURCES] *	X			
Organizational rigidity [INFLEXIBILITY]		X		
Lack of qualified personnel [UNQUALI_PERSONNEL] *		X		
Lack of information on technology [TECH_INFO] *		X		
Lack of information on market [MARKET_INFO] *		X		
Scarcity of appropriate external services [LACK_OF_SERVICES]		X		
Weak consumer response to new products [MARKET_BEHAVIOR] +			X	
Difficulty adjusting to Standards, norms and regulations [REGULATIONS] +				X

Notes: * Barrier considered in D'Este et al. (2012) framework; + Similar variable to the one considered in D'Este et al. (2012) framework.

For the cooperation variables, we proceeded differently since we did not have previous theoretical background. In this case, we performed an Exploratory Factor Analysis (EFA) using the Principal Component Analysis (PCA) technique to organize the variables in set subgroups of cooperation activities. Before obtaining the PCA results, we first corroborated whether the technique was appropriate or not to treat our data. In this sense, the indexes considered for the assessment of this analysis were all satisfactory and allowed us to validate the construct (Bartlett's test of sphericity: $p<0.001$ and KMO's test index = 0.89). As observed in Table 4, we obtained a single component called COOPERATION in which all factor loadings were higher than 0.70. The total variance explained by this single component was 77.97% which exceeds the minimum of 70% suggested by (Hair et al., 2009). This result indicates that those industrial sectors that collaborate more are more prone to present higher values than other industrial sectors in all the different types of collaboration and not in one specific, even when they invest more effort in a specific type of collaboration, as shown after in Table 5. To obtain the final scale of the COOPERATION variable, we used the standardized factorial scores generated using Thurstones' regression technique.

Table 4 - Factorial matrix for Cooperation intensity

Variable	**Factor Loadings**	
	COOPERATION	**Communality**
Customers	0.907	0.823
Suppliers	0.951	0.904
Competitors	0.751	0.564
Another company's unit	0.884	0.782
Consulting firms	0.830	0.689
Universities and research institutes	0.874	0.763
Testing and certifications institutions	0.917	0.842
Training and technical centers	0.933	0.871
Sum of squares (eigenvalue)	6.238	6.238
Total variance explained	77.97%	77.97%

3.3.2.3 Construct definition

We include some potential control variables obtained from the PINTEC database by following previous work (Frank et al., 2016) using the PINTEC 2011 database. The first aspect we considered was that industrial sectors with larger firms are more likely to invest in innovation activities (Resende et al., 2014; Chudnovsky et al., 2006;

Evangelista and Vezzani, 2010; De Backer et al., 2008). For this reason, we included a dummy control variable called firm size [Firm_size] (0 = small/medium; 1 = large), that categorizes companies according to the number of employees in each industrial sector. All small and medium sized sectors were included into the same dummy variable because of the limited access to information about sectoral features (Frank et al., 2016). Moreover, we also included three dummies (k-1) as control variables of the four (k) industrial activities characteristics used in Chudnovsky et al. (2006) and Frank et al. (2016): labor, scale, R&D and natural resources intensive [Dummy_Natural; Dummy_Labor and Dummy_Scale].

3.3.3 Econometric procedures

The econometric model proposed in our study is graphically represented in Figure 14. As shown in this figure, there are four main innovation barriers: Costs barriers [COSTS], Knowledge barriers [KNOWLEDGE], Market barriers [MARKET] and Regulation barriers [REGULATION], which might impact industrial cooperation for innovation [COOPERATION]. As we discussed earlier, certain barriers might encourage collaboration while others discourage it. Moreover, as shown in Figure 14, our econometric model considers, based on prior evidence from the literature, that innovation barriers, are contextually-dependent and should be instrumented in order to avoid biased outcomes. The instrumental variables are discussed next (Section 3.3.3.1).

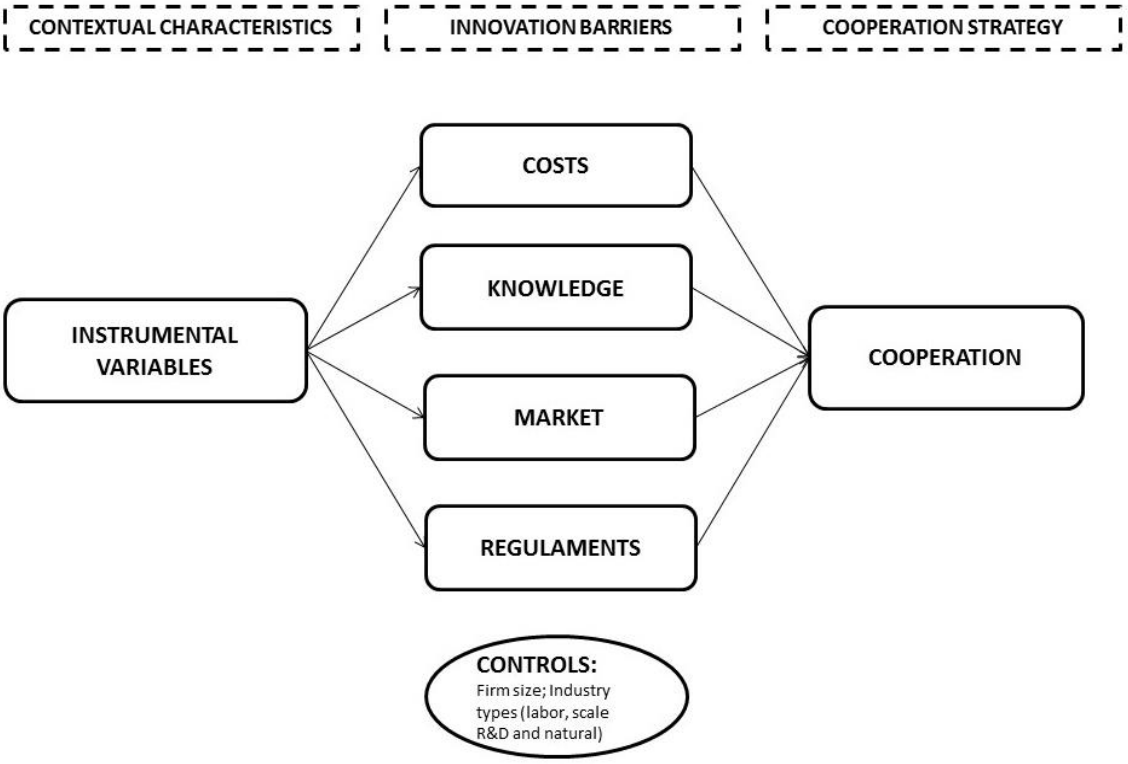

Figure 14 - Econometric model

3.3.3.1 Endogeneity and Self-selection bias

Data analysis from large scale innovation surveys is usually undermined by two potential problems: endogeneity and self-selection bias (Chudnovsky et al., 2006; Hashi & Stojcic, 2013; Crespi and Suniga, 2012; Tiwari et al., 2008; Blanchard et al., 2013; Leoncini; 2016). Then, given the structure of the model proposed in Figure 14, it should be verified whether these problems are present or not (Wooldridge, 2010; Heckman, 1979). The endogeneity problem arises when the regressor is correlated with the error term, violating the OLS estimation assumption that the independent variables are exogenous (Bascle, 2008). According to Bascle (2008), endogeneity can be present due to errors-in-variables, omitted variables and simultaneous causality. The three causes are important for our study. First, since we are using secondary data sources, the possibility of errors-in-variables cannot be controlled for and should be treated in our econometric model. Secondly, omitted variables can also affect our model, since innovation barriers can be present due to other contextual conditions, which may turn them endogenous and not exogenous variables. Finally, simultaneous causality is also very important in our sample since the inverse effect of industrial cooperation on the innovation barriers, for their reduction, is also viable, i.e. the model can be cyclical. In

such a case, the use of a simple regression, based on ordinary least squares (OLS) is not considered to be the most appropriate method for analysis, once results can be overestimated due to the existence of bias in the assessment limits (Shaver, 1998; Guide et al., 2015). On the other hand, the self-selection bias is also considered another major problem of innovation surveys due to the lack of precision in respect to the company's self-classification as innovator or non-innovator. This negative aspect of most innovation surveys jeopardizes the clarity of the analysis, once it may yield biased results for the parameters utilized on the analysis (Tavassoli and Carbonara, 2014; Chudnovsky et al., 2006; Hashi & Stojcic, 2013).

Then, as recommended by several authors, a possible way to address both problems is to consider the use of instrumental variables (Bascle, 2008; Wooldridge, 2010). These variables are accessed by using the two-stage least squares (2SLS) regression method. Furthermore, since we are studying a small sample size (42 industrial sectors), we used the limited-information maximum likelihood (LIML) estimator for the 2SLS regression, as recommended by Bascle (2008). We performed these tests in Stata 13.0®. The instrumental variables used to regress the independent variables of innovation barriers in the first model of the 2SLS regression were obtained from PINTEC 2014. We defined these instruments based on prior works of the literature (e.g. Frank et al., 2016, Resende et al., 2014; Hashi and Stojcic, 2013; Crespi and Zuniga, 2012; Stiebale and Reize, 2011) that can be divided into four categories as follows: a) degree of innovation project's failure present in the industrial sector, which represents risk to a innovation project of a particular industrial sector (i.e. higher innovation risks in a sector may lead to a higher presence and perception of innovation barriers): (i) organizational related failures [IV_ORGAN_FAILURE], (ii) market related failures [IV_MARKET_FAILURE], (iii) product/process related failures [IV_P&P_FAILURE]; b) information sources used to innovate: (i) internal information sources [IV_R&D_SOURCES], (ii) market information sources [IV_MARKET_SOURCES], (iii) institutional sources [IV_INST_SOURCES], (iv) other sources [IV_OTHER_SOURCES]; c) public subsidies: (i) subsidies for R&D activities [IV_R&D_FUNDS], (ii) other subsidies (generic and specific programs like tariffs and taxation) [IV_OTHER_FUNDS]; d) governmental policies for innovation [IV_POLICIES].

Following estimation of the 2SLS regression model using the LIML estimator, we followed a set of post-estimation procedures to verify the adequacy of the 2SLS

regression model used[4]. We first tested the Durbin and Wu-Hausman statistical test to verify if the independent variables are endogenous, justifying the use of 2SLS regression rather than ordinary least square (OLS) regression. The results showed that the null-hypothesis which considers that the independent variables are exogenous can be rejected (Durbin-Wu-Hausman test= 3.30; $p< 0.01$), indicating the possible presence of endogenous independent variables. Then, we verified the strength of the instruments by analyzing the F-statistics from the first regression stage. Two of the instruments (COST: F-value = 9.71, $p<0.01$; KNOWLEDGE: F-value 9.57; $p<0.01$) were near the reference F-value of 10.0 for strong instruments (Bascle, 2008), while one was much lower (MARKET: F-value = 6.60, $p<0.01$). However, the LIML estimator we used for small sample size is also the most reliable estimation when there is a presence of relative weak instrumentation (Blomquist and Dahlberg, 1999), allowing us to proceed with our study. Finally, we considered the estimation of the Sargan's overidentification test. This procedure tests the null hypothesis that instrumental variables are uncorrelated to the residual term, indicating that they are exogenous and then appropriate for the model. The results obtained for the Sargan's test were X^2 test = 9.7337 and p = 0.2042, rejecting the null hypothesis and evincing that the instruments can be considered valid. These tests indicated that the use of LIML for the econometric model proposed with instrumentation will provide more reliable results than the OLS regression approach. (Wooldridge, 2010).

3.4 RESULTS

3.4.1 Descriptive analysis

Our first analysis (Table 5) consists in a general descriptive statistic about innovation barriers and innovation investments using the four PINTEC databases available (2005, 2008, 2011 and 2014), covering 12 years of analysis from 2003 to 2014 and for the four main industries considered in the dataset. This panorama provides a better comprehension regarding how the innovation barriers have evolved over time and how those industrial sectors perceived the impact of such obstacles on their innovation

[4] For the 2SLS procedures we used the Stata® extension *ivreg2* and the complementary set of tools (e.g. LIML, overid, ffirst, etc.). A detailed list of these commands can be found in Bascle's (2008) Appendix I.

activities. After, we focus in Section 4.2 on the results of the last PINTEC period, which considers the most recent results of the Brazilian innovation panorama.

According to the descriptive results shown in Table 5, in a general sense, ther perception of innovation barriers in the Brazilian industry have decreased during the last 12 years covered by the PINTEC report. This means that innovation has become more viable in the Brazilian market. In the last PINTEC period (2011-2014), some barriers witnessed a slight growth, which can be due to the recent economic crisis both globally and in this country. However, most of the barriers that have grown again are still much lower than ten years ago. When considered the general picture of this table, it is clear that the COST barriers (i.e. excessive economic risks; high innovation costs; and lack of financial sources) exert the greatest impact on the innovation activities of the industrial sectors analyzed by PINTEC. The economic risks barrier has significantly grown in the last period, which shows that even other costs barriers are still low when comparing to the past the future scenario of the Brazilian market was very unclear for the companies participating in PINTEC.

Table 5 - Descriptive analysis of the evolution of Brazilian industrial efforts on innovation activities (inputs) and innovation barriers

			Investments in innovation		**Barriers** (% of innovative firms)									
PINTEC period	**Number of firms (universe)**	**Net revenue[1] (1,000 US$)**	**Number of innovative firms**	**Aggregated investment[1] (1,000 US$)**	Excessive economic risks	High innovation costs	Lack of financial sources	Organizational rigidity	Lack of qualified personnel	Lack of information on technology	Lack of information on market	Difficulty adjusting to Standards, norms and regulations	Weak consumer response to new products	Scarcity of appropriate external services
2003-2005	95,301	758,282,885	30,400	23,066,598	42.2%	44%	36.5%	18.8%	30.8%	20.3%	17.5%	19.8%	16.3%	17.4%
2006-2008	106,862	1,059,293,877	41,300	30,225,486	33.6%	39.5%	31.5%	15.6%	36%	17.7%	14.5%	19%	14.3%	20%
2009-2011	128,699	1,416,210,689	45,950	36,236,718	29.2%	33.6%	24.9%	12.7%	26.7%	14%	11.6%	12.8%	11.2%	14.9%
2012-2014	132,529	3,210,686,455	47,693	26,119,117	39.1%	34.5%	27.2%	9.5%	18.5%	11.7%	10.7%	13.4%	10.3%	12.9%

[1]Monetary values transformed to American Dollar (US$ 1.00 = Brazilian R$ 3.12 in March of 2017). N/A: data not available for this period of PINTEC report.

3.4.2 Regresion analysis

In accordance with the econometric model proposed in Figure 14, we performed a 2SLS regression using LIML to analyze the impact of innovation barriers on the industrial cooperation intensity. This analysis used data from two of the four main industries considered in PINTEC (2014) (extractive and processing industries, representing 42 industrial sectors). In the first step, we analyzed the effect of the instrumental variables (IV_ORGAN_FAILURE, IV_MARKET_FAILURE, IV_P&P_FAILURE, IV_R&D_SOURCES, IV_MARKET_SOURCES, IV_INST_SOURCES, IV_OTHER_SOURCES, IV_R&D_FUNDS, IV_OTHER_FUNDS, IV_POLICIES) on the four main innovation barriers (COST, KNOWLEDGE, MARKET and REGULATION). For the second step, in turn, we tested the direct effect of these four constructs of innovation barriers (already corrected by the first-step of the regression) on the industrial cooperation intensity [COOPERATION] of the industrial sectors considered in our sample. Control variables were introduced in both steps. These results are shown in Table 6.

Table 6 - Results for LIML estimation - The impact of innovation barriers on cooperation intensity

	First-stage			Second-stage
Variables	**COSTS**	**KNOWLEDGE**	**MARKET**	**COOPERATION**
COSTS				74.13**
KNOWLEDGE				-79.31*
MARKET				-44.477*
REGULATION				-21.77
Dummy_Natural (Control)	-0.019	-0.014	-0.011	0.367
Dummy_Labor (Control)	-0.034	-0.010	-0.033*	0.612
Dummy_Scale (Control)	-0.025	-0.013	-0.031**	-0.250
Firms_Size (Control)	-0.005	0.010	-0.007	1.045
IV_ORGAN_FAILURE	0.229	0.090	0.187	
IV_MARK_FAILURE	-0.889	-0.322	-0.772**	
IV_PRODUCT_FAILURE	0.067	-0.129	0.319	
IV_R&D_SOURCES	0.003	0.047	-0.091*	
IV_MARKET_SOURCES	0.062	0.028	0.096**	
IV_INST_SOURCES	-0.03	0.004	-0.158***	
IV_OTHER_SOURCES	0.132	0.104**	0.094	
IV_R&D_FUNDS	0.253**	0.013	0.228***	
IV_OTHER_FOUNDS	-0.311	-0.177*	-0.05	
IV_POLICIES	-0.073***	-0.026**	-0.036**	

*p<0.1; **p < 0.05; ***p < 0.01; n = 42 industrial sectors

According to the results of Table 6, from the four innovation barriers (COSTS, KNOWLEDGE, MARKET and REGULATION), three of them showed significant effects on COOPERATION. The innovation barrier COST was the only with positive impact (B = 74.13, p < 0.05) on COOPERATION, while KNOWLEDGE (B = -79.31, p < 0.05) and MARKET (B = -44.477, p < 0.1) were negative. The innovation barrier REGULATION did not present significant effects. Therefore, our results verified that three of the four innovation barriers constructs are antecedents of the industrial cooperation intensity, while the type of effect (positive or negative) is not the same for the different barriers considered in our study.

The positive effect of COSTS on COOPERATION indicate that the industrial sectors that are facing innovation barriers such as economic risks, innovation costs or lack of financial sources, tend to pursue cooperation with external partners as a way to reduce such kind of obstacles. Thus, the more costs barriers the industry faces, the more prone it is to cooperate for innovation. Moreover, our results also indicate that a second important aspect regarding the decision of companies to cooperate is related to

KNOWLEDGE, which showed a negative effect on COOPERATION. This means that industrial sectors with more knowledge constraints (represented by organizational rigidity and lack of several characteristics such as qualified personnel, information on technology and information on market) surprisingly tend to cooperate less instead of more. In other words, having prior information and understanding on innovation leads to pursuing cooperation and not the contrary in our findings. Finally, our results revealed that MARKET has also a negative effect on COOPERATION. This means that the Brazilian industrial sectors cooperate when there is a strong consumer response to new products and not when there is weak consume. In this sense, industrial cooperation is used as an opportunistic strategy when market is growing and not as a crisis strategy to overcome weak market demands.

3.5 DISCUSSIONS

Our descriptive analysis showed that the effect of innovation barriers in the Brazilian industry has considerably decreased over time. The general improvement of the Brazilian scenario and the reduction of the innovation barriers are in accordance with the industrial policy trends of the last decades, which have had innovation as one of the main goals of this industry (Cirera et al., 2015). Several industrial policies have been enacted to promote industrial innovation and to reduce the existing barriers. Some examples are: the establishment and growth of new technology parks and the development of incubation programs (Ruiz et al, 2016), the creation of funding programs and agencies (Cirera et al., 2015), as well as a stronger investment in technology transference from universities and research institutions to the private sector (Olavarrieta and Villena, 2014; Frank et al., 2016).

On the other hand, as also shown in our descriptive results, while several barriers have decreased, those related to the costs and economic aspects have increased again in the last triennial (2012-2014). This may be due to the economic and political contingencies both in the international and in the national scenario during this period. At the international level, the Euro crisis and the decrease of the Chinese GDP in 2012 where some of the main factors that indirectly affected the Brazilian growing perspectives (World Bank Group, 2017). Additionally, during this period, Brazil underwent a scenario of political instability and uncertainty that triggered the retraction of the economy and, consequently, the reduction of public expenditures and investments

(Ministério da Fazenda, 2016). Our statistical analysis of this period showed that such an economic effect forced several industrial sectors to pursue innovation partners in order to reduce some of the financial problems and risks. This result is also aligned with the prior studies that indicated that cooperation can be adopted by firms as a strategy to transpose cost barriers by the establishment of cost sharing mechanisms among the partners (e.g. Cassiman and Veugelers, 2002; Roma and Perronen, 2016; Gnyawali and Park, 2011; Savignac, 2005) and by accessing to complementary resources among them (De Faria et al., 2010; Gudergan et al., 2012).

For the set of barriers represented by the construct KNOWLEDGE, in turn, we observed a significant and negative effect on cooperation intensity. This means that Brazilian industrial sectors are more prone to cooperate when they find themselves in a favorable ecosystem which allows accessing to information on new technology and market strategies as well as when they can hire qualified professionals and access appropriate services. For instance, Gallego et al. (2013) argued that the level of industrial cooperation between firms depends on how able they are to benefit from internal and external knowledge already present in the partnership, which is reinforced by our results. Such a finding may be counterintuitive for the assumption that the industry will pursue higher levels of cooperation as a reaction to surmount barriers. However, considering the context of developing countries, which are more conservative regarding innovation due to market and economic uncertainties, this could be understandable. Companies may want to keep independency regarding their partners and therefore, they may avoid the risk of establishing such partnerships before having their own innovation knowledge capacities.

Moreover, cooperation activities in Brazil happen mainly with customers and suppliers and few activities are conducted with universities and research institutions (PINTEC, 2016). Given this fact, it is understandable that the industrial sectors cooperate when there is a mutual level of KNOWLEDGE regarding information, qualified personnel and organizational conditions. On the other hand, partners that could be valuable when knowledge barriers are present, given their knowledge transfer role – e.g. universities, technical centers and public institutions – are the less considered in the cooperation activities of the Brazilian industry (PINTEC, 2016) and, therefore, they may not allow the detection of an expressive positive output when such barriers are present. Additionally, Hölzl and Janger, (2014) suggested that knowledge barriers have a deterring effect in countries that have more access to new technologies, due to their

increasingly need to focus on the creation of own knowledge and the adoption of innovation-based growth strategies to stay competitive. Consequently, for these countries, this may be the biggest reason to pursue different types of collaboration. As most part of the Brazilian industry has limited access to leading technology, this industry is more distant from the technological frontier. Hence, we interpret that for Brazil, as an emerging economy, the innovation barriers associated to knowledge are still not a main concern and, therefore, they are not evidencing a deterring effect for innovation. Cooperation is, therefore, not a positive reaction strategy of the Brazilian industry to overcome existing knowledge barriers, but an option considered when the obtaining of knowledge does not represent an obstacle.

We also found a significant and negative effect of MARKET on COOPERATION. This construct represents the innovation barrier associated to customer response to new products. Thus, our findings suggest that the less the industry perceives market barriers, the more likely it is to cooperate in order to find innovation opportunities. D'Este et al. (2012) have provided prior evidences that market barriers have a deterring effect on innovation, since the risk of not meeting the expectations of the demand can inhibit firms to innovate. We found a similar pattern, since innovation based on cooperation, in the Brazilian industry, is seen as an opportunistic strategy when market is growing, instead of a reactive strategy to overcome market diminution.

Finally, the variable REGULATION was the only construct of innovation barriers that did not evince a significant impact on the development of industrial cooperation [COOPERATION]. A possible explanation could be simply that factors such as the difficulty to adjust to standards, norms and regulations are not a major driver for companies to pursue cooperation with other partners; industrial sectors may follow their own independent way to face this kind of problem. In this sense, those institutions that could be partners to overcome such a barrier, like technical institutions for calibration, standardization, etc., might be considered only by their auditory role instead of as a potential partner. Since this barrier considers difficulties of adaptation to new market standards, this could be a starting point for research related to how industries adapt to new contexts, such as new markets or the implementation of radical innovations within the context of developing countries. In other words, an empirical study regarding the innovation strategies adopted when companies face this barrier could shed light on this point, since we could not demonstrate that cooperation is the way. One last possible explanation resides in the bureaucracy inherent to the Brazilian context. Since

bureaucracy is generally related to the governmental regulations and licenses, cooperation with other companies and research institutes would not yield the reduction of regulations and bureaucracy, therefore, companies may not perceive cooperation as an effective strategy for such end.

3.6 CONCLUSIONS

This paper presented the results of a large-scale survey from the Brazilian industry about the influence of innovation barriers on industrial cooperation. Our results revealed that innovation barriers are antecedents of the strategic decision to cooperate or not with external partners for innovation activities. Our findings suggest that some barriers trigger the pursuing of cooperation activities while other barriers discourage such cooperation. More specifically, we found that Brazilian industrial sectors tend to cooperate when innovation costs are higher, when market is growing and when the industry has prior knowledge and organizational conditions to innovate. In other words, Brazilian industry is more conservative regarding industrial cooperation, since this is more likely to happen when internal and external conditions are favorable and costs and risks need to be reduced.

3.6.1 Contributions for scholars and pratitioners

Our findings present contributions for both practitioners and scholars. From one side, practitioners such as managers and consultants can be able to understand how Brazilian industry behaves and, based on this, they can develop strategic innovation planning to deal with the existing innovation barriers. For instance, we demonstrated that industrial cooperation is pursued when cost barriers are stronger. In this sense, our study encourages managers to find appropriate partners who allow them to share financial risks associated with the innovation process. We also demonstrated that this industry is conservative and cooperates more when knowledge barriers are lower. However, in our study we explain that this may be due to Brazilian industry cooperation, which is more focused on customers and suppliers while universities and research centers are still very weak partners in the industry. We believe this is a potential point of exploration for practitioners who should consider academic institutions as a way to share innovation costs based by means of public incentive programs or as a manner to acquire advanced knowledge and new technology. Also, policy-makers can use our findings to promote

public policies focused on reducing barriers with greater impact for the development of innovation in firms, and to promote other initiatives aiming to facilitate industrial cooperation as both a way to improve the country's innovative capabilities and to enable greater knowledge and technology absorption.

Finally, from a different perspective, academics can use the findings provided in this study to base future research on innovation barriers in developing countries and to further advance the understanding of the innovative dynamics that affect developing economies. In addition, since our descriptive analysis indicated that, in general, the effects of innovation barriers on firms are being increasingly smoothed following the economic development of this country, while recently the current Brazilian crisis increased again some of this barrier, we propose a deeper investigation regarding what other strategies are followed by the industry in order to overcome such barriers in times of economic crisis.

3.6.2 Limitations and opportunities for future research

In terms of the methodological approach used, we identified limitations that may indicate opportunities for future research. For instance, due to PINTEC sectorial aggregate data reported, our conclusions cannot be drawn for company-level details, because of the natural differences among industrial sectors that our research was not capable of identifying. In addition, future studies could also assess the perception of barriers to innovation based on similarities between the industrial sectors, which can be done through clustering sectors. Lastly, we could have also evaluated company-level effects by examining companies as a unit of analysis. Therefore, future research can greatly enhance the understanding of how innovation barriers impact industrial cooperation by analyzing the different types of cooperation and targeting the detail-levels aforementioned. A last limitation of our study is that we considered a cross-sectional dataset, PINTEC 2014, and consequently, we did not evaluate the temporal effects of the variables analyzed. Future studies can consider the temporal effects of innovation barriers along different periods of the PINTEC dataset.

3.7 REFERENCES

AGNETIS, Alessandro; ALOULOU, Mohamed Ali; FU, Liang-Liang. Production and interplant batch delivery scheduling: Dominance and cooperation. **International Journal of Production Economics**, v. 182, p. 38-49, 2016.

BALDWIN, John; LIN, Zhengxi. Impediments to advanced technology adoption for Canadian manufacturers. **Research policy**, v. 31, n. 1, p. 1-18, 2002.
BASCLE, Guilhem. Controlling for endogeneity with instrumental variables in strategic management research. **Strategic organization**, v. 6, n. 3, p. 285-327, 2008.
BECHEIKH, Nizar; LANDRY, Rejean; AMARA, Nabil. Lessons from innovation empirical studies in the manufacturing sector: A systematic review of the literature from 1993–2003. **Technovation**, v. 26, n. 5-6, p. 644-664, 2006.
BETH STANEK, Mary. Measuring alliance value and risk: a model approach to prioritizing alliance projects. **Management Decision**, v. 42, n. 2, p. 182-204, 2004.
BLANCHARD, Pierre et al. Where there is a will, there is a way? Assessing the impact of obstacles to innovation. **Industrial and Corporate Change**, v. 22, n. 3, p. 679-710, 2012.
BLOMQUIST, Sören; DAHLBERG, Matz. Small sample properties of LIML and jackknife IV estimators: Experiments with weak instruments. **Journal of Applied Econometrics**, p. 69-88, 1999.
BOUNCKEN, Ricarda B.; FREDRICH, Viktor. Learning in coopetition: Alliance orientation, network size, and firm types. **Journal of Business Research**, v. 69, n. 5, p. 1753-1758, 2016.
CARDOZA, Guillermo et al. Barriers and public policies affecting the international expansion of Latin American SMEs: Evidence from Brazil, Colombia, and Peru. **Journal of Business Research**, v. 69, n. 6, p. 2030-2039, 2016.
CASSIMAN, Bruno; VEUGELERS, Reinhilde. Complementarity in the innovation strategy: internal R&D, external technology acquisition, and cooperation in R&D. 2002.
CIRERA, Xavier; MARIN, Anabel; MARKWALD, Ricardo. Explaining export diversification through firm innovation decisions: The case of Brazil. **Research Policy**, v. 44, n. 10, p. 1962-1973, 2015.
CHEN, Chung-Jen; HUANG, Yi-Fen. Creative workforce density, organizational slack, and innovation performance. **Journal of Business Research**, v. 63, n. 4, p. 411-417, 2010.
CHUDNOVSKY, Daniel; LÓPEZ, Andrés; PUPATO, Germán. Innovation and productivity in developing countries: A study of Argentine manufacturing firms' behavior (1992–2001). **Research policy**, v. 35, n. 2, p. 266-288, 2006.
COHEN, Wesley M.; LEVINTHAL, Daniel A. Absorptive capacity: A new perspective on learning and innovation. In: **Strategic Learning in a Knowledge economy**. 2000. p. 39-67.
COSTA, Ionara; DE QUEIROZ, Sérgio Robles Reis. Foreign direct investment and technological capabilities in Brazilian industry. **Research Policy**, v. 31, n. 8-9, p. 1431-1443, 2002.
CRESPI, Gustavo; ZUNIGA, Pluvia. Innovation and productivity: evidence from six Latin American countries. **World development**, v. 40, n. 2, p. 273-290, 2012.
DE BACKER, Koen; LOPEZ-BASSOLS, Vladimir; MARTINEZ, Catalina. Open Innovation in a Global Perspective. 2008.
D'ESTE, Pablo et al. What hampers innovation? Revealed barriers versus deterring barriers. **Research policy**, v. 41, n. 2, p. 482-488, 2012.
DE FARIA, Pedro; LIMA, Francisco; SANTOS, Rui. Cooperation in innovation activities: The importance of partners. **Research Policy**, v. 39, n. 8, p. 1082-1092, 2010.
DORUK, Ömer Tuğsal; SÖYLEMEZOĞLU, Ergül. The Constraints of Innovation in Developing Countries: Too Many Barriers to Start Ups?. **Procedia-Social and Behavioral Sciences**, v. 150, p. 944-949, 2014.
DOSI, Giovanni. Technological paradigms and technological trajectories: a suggested interpretation of the determinants and directions of technical change. **Research policy**, v. 11, n. 3, p. 147-162, 1982.
EVANGELISTA, Rinaldo; VEZZANI, Antonio. The economic impact of technological and organizational innovations. A firm-level analysis. **Research Policy**, v. 39, n. 10, p. 1253-1263, 2010.
FAGERBERG, Jan. Innovation: a guide to the literature. **Georgia Institute of Technology**, 2004.
FAGERBERG, Jan; VERSPAGEN, Bart. Innovation studies—The emerging structure of a new scientific field. **Research policy**, v. 38, n. 2, p. 218-233, 2009.
FERRIANI, Simone; GARNSEY, Elizabeth; PROBERT, David. **Sustaining breakthrough innovation in large established firms: learning traps and counteracting strategies**. Edward Elgar Publishing, 2008.
FRANK, Alejandro Germán et al. The effect of innovation activities on innovation outputs in the Brazilian industry: Market-orientation vs. technology-acquisition strategies. **Research Policy**, v. 45, n. 3, p. 577-592, 2016.
GALLEGO, Jorge; RUBALCABA, Luis; SUÁREZ, Cristina. Knowledge for innovation in Europe: The role of external knowledge on firms' cooperation strategies. **Journal of Business Research**, v. 66, n. 10, p. 2034-2041, 2013.
GALIA, Fabrice; LEGROS, Diego. Complementarities between obstacles to innovation: evidence from France. **Research policy**, v. 33, n. 8, p. 1185-1199, 2004.

GOEDHUYS, Micheline; VEUGELERS, Reinhilde. Innovation strategies, process and product innovations and growth: Firm-level evidence from Brazil. **Structural change and economic dynamics**, v. 23, n. 4, p. 516-529, 2012.
GNYAWALI, Devi R.; PARK, Byung-Jin Robert. Co-opetition between giants: Collaboration with competitors for technological innovation. **Research Policy**, v. 40, n. 5, p. 650-663, 2011.
GREIS, Noel P.; DIBNER, Mark D.; BEAN, Alden S. External partnering as a response to innovation barriers and global competition in biotechnology. **Research Policy**, v. 24, n. 4, p. 609-630, 1995.
GUDERGAN, Siegfried P. et al. Strategic implications for (non-equity) alliance performance. **Long Range Planning**, v. 45, n. 5-6, p. 451-476, 2012.
GUIDE, V. Daniel R.; KETOKIVI, Mikko. Notes from the editors: Redefining some methodological criteria for the journal. **Journal of Operations Management**, n. 37, p. v-viii, 2015.
HADJIMANOLIS, Athanasios. Barriers to innovation for SMEs in a small less developed country (Cyprus). **Technovation**, v. 19, n. 9, p. 561-570, 1999.
HAGEDOORN, John; LINK, Albert N.; VONORTAS, Nicholas S. Research partnerships1. **Research policy**, v. 29, n. 4-5, p. 567-586, 2000.
HAIR, Joseph F. et al. **Multivariate data analysis**. Upper Saddle River, NJ: Prentice hall, 1998.
HANDLEY, Sean M.; GRAY, John V. Inter-organizational quality management: The use of contractual incentives and monitoring mechanisms with outsourced manufacturing. **Production and Operations Management**, v. 22, n. 6, p. 1540-1556, 2013.
HASHI, Iraj; STOJCIC, Nebojsa. Knowledge spillovers, innovation activities, and competitiveness of industries in EU member and candidate countries. **Economic annals**, v. 58, n. 198, p. 7-34, 2013.
Heckman, J. J., 1979. Sample selection bias as a specification error. Econometrica 47 (1), 153–161.
HÖLZL, Werner; JANGER, Jürgen. Distance to the frontier and the perception of innovation barriers across European countries. **Research Policy**, v. 43, n. 4, p. 707-725, 2014.
HORVITZ, Daniel G.; THOMPSON, Donovan J. A generalization of sampling without replacement from a finite universe. **Journal of the American statistical Association**, v. 47, n. 260, p. 663-685, 1952.
IBGE. **Pintec, Estatísticas do registro civil 2014**, 2014
IAMMARINO, Simona; SANNA-RANDACCIO, Francesca; SAVONA, Maria. The perception of obstacles to innovation. Foreign multinationals and domestic firms in Italy. **Revue d'économie industrielle**, n. 1, p. 75-104, 2009.
KALE, Prashant; SINGH, Harbir. Building firm capabilities through learning: the role of the alliance learning process in alliance capability and firm-level alliance success. **Strategic management journal**, v. 28, n. 10, p. 981-1000, 2007.
KAMIEN, Morton I.; SCHWARTZ, Nancy L. **Market structure and innovation**. Cambridge University Press, 1982.
LEONCINI, Riccardo. Learning-by-failing. An empirical exercise on CIS data. **Research Policy**, v. 45, n. 2, p. 376-386, 2016.
LEWANDOWSKA, Małgorzata Stefania; SZYMURA-TYC, Maja; GOŁĘBIOWSKI, Tomasz. Innovation complementarity, cooperation partners, and new product export: Evidence from Poland. **Journal of Business Research**, v. 69, n. 9, p. 3673-3681, 2016.
LUZZINI, Davide et al. From sustainability commitment to performance: The role of intra-and inter-firm collaborative capabilities in the upstream supply chain. **International Journal of Production Economics**, v. 165, p. 51-63, 2015.
MADRID-GUIJARRO, Antonia; GARCIA, Domingo; VAN AUKEN, Howard. Barriers to innovation among Spanish manufacturing SMEs. **Journal of Small Business Management**, v. 47, n. 4, p. 465-488, 2009. BRASIL. MINISTÉRIO DA FAZENDA. . **Fazenda comenta resultado do PIB no 3º trimestre de 2016:** Nota à imprensa. 2016. Disponível em: <http://www.fazenda.gov.br/noticias/2016/novembro/nota-sobre-a-variacao-do-pib-no-3o-trimestre-de-2016>. Acesso em: 31 nov. 2016.
MENTION, Anne-Laure. Co-operation and co-opetition as open innovation practices in the service sector: Which influence on innovation novelty?. **Technovation**, v. 31, n. 1, p. 44-53, 2011.
NAGANO, Marcelo Seido; STEFANOVITZ, Juliano Pavanelli; VICK, Thais Elaine. Innovation management processes, their internal organizational elements and contextual factors: An investigation in Brazil. **Journal of Engineering and Technology Management**, v. 33, p. 63-92, 2014.
OECD, Eurostat. Oslo Manual. **Guidelines for Collecting and Interpreting Innovation Data,**, 2005.
OLAVARRIETA, Sergio; VILLENA, Mauricio G. Innovation and business research in Latin America: An overview. **Journal of Business Research**, v. 67, n. 4, p. 489-497, 2014.
PAVITT, Keith. Sectoral patterns of technical change: towards a taxonomy and a theory. **Research policy**, v. 13, n. 6, p. 343-373, 1984.

PETTER, Rodolfo Reinaldo Hermes et al. Systematic review: an analysis model for measuring the coopetitive performance in horizontal cooperation networks mapping the critical success factors and their variables. **The Annals of Regional Science**, v. 53, n. 1, p. 157-178, 2014.
PIATIER, Andre. **Barriers to innovation**. London; Dover, NH: F. Pinter, 1984.
PORTER, Michael E. The competitive advantage of nations. **Competitive Intelligence Review**, v. 1, n. 1, p. 14-14, 1990.
RENCHER, Alvin C. **Methods of multivariate analysis**. John Wiley & Sons, 2003.
RESENDE, Marcelo; STRUBE, Eduardo; ZEIDAN, Rodrigo. Complementarity of innovation policies in Brazilian industry: An econometric study. **International Journal of Production Economics**, v. 158, p. 9-17, 2014.
ROBIN, Stéphane; SCHUBERT, Torben. Cooperation with public research institutions and success in innovation: Evidence from France and Germany. **Research Policy**, v. 42, n. 1, p. 149-166, 2013.
ROMA, Paolo; PERRONE, Giovanni. Cooperation among competitors: A comparison of cost-sharing mechanisms. **International Journal of Production Economics**, v. 180, p. 172-182, 2016.
RUIZ, Mauro Silva et al. Proposal of a theoretical model for the implementation and scalability of science parks: a case study. **RAI Revista de Administração e Inovação**, v. 14, n. 1, p. 2-15, 2017.
RUTTAN, Vernon W. Induced innovation, evolutionary theory and path dependence: sources of technical change. **The Economic Journal**, v. 107, n. 444, p. 1520-1529, 1997.
RUTTAN, V. W. Technology, Growth and Development: An Induced Innovation Perspective. New York and Oxford: Oxford University Press. 2001.
SANDBERG, Birgitta; AARIKKA-STENROOS, Leena. What makes it so difficult? A systematic review on barriers to radical innovation. **Industrial Marketing Management**, v. 43, n. 8, p. 1293-1305, 2014.
SANTOS, David Ferreira Lopes et al. Innovation efforts and performances of Brazilian firms. **Journal of Business Research**, v. 67, n. 4, p. 527-535, 2014.
SAVIGNAC, Frédérique. The impact of financial constraints on innovation: evidence from French manufacturing firms. 2006.
SCHMIELE, Anja. Intellectual property infringements due to R&D abroad? A comparative analysis between firms with international and domestic innovation activities. **Research Policy**, v. 42, n. 8, p. 1482-1495, 2013.
SCHWARTZ, Michael et al. What drives innovation output from subsidized R&D cooperation?—Project-level evidence from Germany. **Technovation**, v. 32, n. 6, p. 358-369, 2012.
SHAVER, J. Myles. Accounting for endogeneity when assessing strategy performance: Does entry mode choice affect FDI survival?. **Management Science**, v. 44, n. 4, p. 571-585, 1998.
SHETH, Jagdish N.; PARVATIYAR, Atul. Towards a theory of business alliance formation. **Scandinavian International Business Review**, v. 1, n. 3, p. 2, 1992.
STIEBALE, Joel; REIZE, Frank. The impact of FDI through mergers and acquisitions on innovation in target firms. **International Journal of Industrial Organization**, v. 29, n. 2, p. 155-167, 2011.
STOCK, Gregory N.; GREIS, Noel P.; FISCHER, William A. Firm size and dynamic technological innovation. **Technovation**, v. 22, n. 9, p. 537-549, 2002.
TAVASSOLI, Sam; CARBONARA, Nunzia. The role of knowledge variety and intensity for regional innovation. **Small Business Economics**, v. 43, n. 2, p. 493-509, 2014.
TIWARI, Amaresh K. et al. Financial constraint and R&D investment: Evidence from CIS. In: **Determinants of Innovative Behaviour**. Palgrave Macmillan, London, 2008. p. 217-242.
Tomlinson, P.R., Fai, F.M., 2013. The nature of SME co-operation and innovation: A multi-scalar and multi-dimensional analysis. Int. J. Prod. Econ. 141, 316–326.
TOURIGNY, Dominique; LE, Can D. Impediments to innovation faced by Canadian manufacturing firms. **Economics of Innovation and New Technology**, v. 13, n. 3, p. 217-250, 2004.
TREIBLMAIER, Horst; FILZMOSER, Peter. Exploratory factor analysis revisited: How robust methods support the detection of hidden multivariate data structures in IS research. **Information & management**, v. 47, n. 4, p. 197-207, 2010.
TRIGO, Alexandre; VENCE, Xavier. Scope and patterns of innovation cooperation in Spanish service enterprises. **Research Policy**, v. 41, n. 3, p. 602-613, 2012.
TSOU, Hung-Tai; CHENG, Colin CJ; HSU, Hsuan-Yu. Selecting business partner for service delivery co-innovation and competitive advantage. **Management Decision**, v. 53, n. 9, p. 2107-2134, 2015.
UYARRA, Elvira et al. Barriers to innovation through public procurement: A supplier perspective. **Technovation**, v. 34, n. 10, p. 631-645, 2014.
VÁSQUEZ-URRIAGO, Ángela Rocío; BARGE-GIL, Andrés; RICO, Aurelia Modrego. Science and technology parks and cooperation for innovation: Empirical evidence from Spain. **Research Policy**, v. 45, n. 1, p. 137-147, 2016.

VEUGELERS, Reinhilde; CASSIMAN, Bruno. R&D cooperation between firms and universities. Some empirical evidence from Belgian manufacturing. **International Journal of Industrial Organization**, v. 23, n. 5-6, p. 355-379, 2005.

WATKINS, Andrew et al. National innovation systems and the intermediary role of industry associations in building institutional capacities for innovation in developing countries: A critical review of the literature. **Research Policy**, v. 44, n. 8, p. 1407-1418, 2015.

WOOLDRIDGE, Jeffrey M. **Econometric analysis of cross section and panel data**. MIT press, 2010.

WORLD BANK GROUP. Global Economic Prospects, June 2017: A Fragile Recovery. **World Bank**, 2017.

ZANDER, Ivo. Technological diversification in the multinational corporation—historical evolution and future prospects. **Research Policy**, v. 26, n. 2, p. 209-227, 1997.

ZENG, S. Xie; XIE, Xue M.; TAM, Chi Ming. Relationship between cooperation networks and innovation performance of SMEs. **Technovation**, v. 30, n. 3, p. 181-194, 2010.

4 ARTICLE 3 – The role of innovation barriers in shaping innovation strategies: the antecedents of market-orientation and technology-acquisition strategic options

Mateus José do Rêgo Ferreira Lima[1]
Daniel de Abreu Pereira Uhr[2]
Alejandro Germán Frank[1]**

Abstract

One of the main features of industrial innovation is the strategy in which it is based. Moreover, recent literature has recommended investigations around the adoption of innovation strategies and its motivations. In this paper we investigate the role of innovation barriers as triggers for the adoption of innovation strategies, considering two juxtaposed innovation strategies: *Market-Orientation* and *Technology-Acquisition*. Our empirical evidences were based on the latest edition of the Brazilian innovation survey (PINTEC-2014), which represents more than 40,000 innovative businesses of this country analyzed throughout the years 2012-2014. We used an econometric approach based on the Continuous Updated Estimator (CUE) method with instrumental variables. We found that *Market-Orientation* strategy adoption is associated to an industrial context where cost and regulation barriers are present and also when the industrial sectors have internal knowledge to support their innovation activities. On the other hand, the *Technology-Acquisition* option is associated to industrial sectors that face difficulties in promote obtaining information for the development of knowledge capabilities and when they have a favorable financial regulatory environment. These findings illustrate a great challenge for the Brazilian industry: the difficulty in combining innovation strategies.

Keywords*:* industrial innovation; innovation barriers; innovations strategies; large-scale innovation survey; emerging countries.

4.1 INTRODUCTION

A well-established range of studies have been dedicated to map the structural techno-economic features of industrial innovation activities and to offer an understanding about the exploitation of such economic and technological potential around the so-called *innovation trajectories* (Nelson and Winter, 1977; Dosi, 1982; Pavitt, 1984; Castellacci, 2008). Inspired by these original insights, a host of empirical studies have focused on a more strategic comprehension about innovation. Among their many contributions, an interesting one regards the emergence of a juxtaposition of innovation strategies: *Market-orientation*, also known as "make" strategy (Veugelers and Cassiman, 1999; Cassiman and Veugelers, 2006; Zuniga and Crespi, 2013; Frank et al., 2016) and *Technology-acquisition* (Jones et al., 2001; Ahuja and Katila, 2001; Tsai et al., 2008; Tsai et al., 2011; Franco et al., 2011 Frank et al., 2016) or "buy" strategy (Veugelers and Cassiman, 1999; Cassiman and Veugelers, 2006; Zuniga and Crespi, 2013). Most of these works are centered either on the understanding about these strategies or on the impact they promote to the innovation system and to the firm´s performance.

Nevertheless, the antecedents regarding the choice of adopting these strategies have not been yet approached from the perspective of the innovation barriers, which characterizes a fruitful research avenue.

This strategic choice of firms is closely related to their innovation path, which, as highlighted by the literature, is rarely clear and characterized by a set of drawbacks (Galia and Legros, 2004; Blanchard et al., 2013; Hölzl and Janger, 2014). In a nutshell, these drawbacks are considered barriers to the extent that they hinder the innovation activities of firms, jeopardizing, therefore, the full potential of their innovation capabilities (Greis et al., 1995, D'este et al., 2012). These barriers, which have different origins and characteristics, impact firms in different ways and exert an influence on the choice of innovation strategies (Ferriani et al., 2008; Madrid-Guijarro et al., 2009; D'este et al., 2012; Blanchard et al., 2013; Leoncini, 2016).

As the studies about the influence of innovation barriers to innovation activities are still maturing among scholars, we followed an exploratory approach (Hadjimanolis, 1999; Baldwin and Lin, 2002; Galia and Legros, 2004; Blanchard et al., 2013; Hölzl and Janger, 2014). In this study, therefore, we extend prior work on the role of innovation barriers in shaping strategies associated to innovation by exploring whether innovation barriers influence the adoption of innovation strategies. Moreover, we also aim to take a step forward by identifying which barriers define the choice of firms to adopt either *Market-orientation* or *Technology-acquisition* options. We based our analysis on a broad conceptualization of innovation barriers, which were specifically drawn in accordance to the classification of CIS (OECD, 2005) into cost, market, knowledge and regulation barriers. We bring a comprehensive analysis of the most recent report of the Brazilian Innovation Survey (PINTEC), comprehending the period 2012-2014. Hence, the main contribution of this study is *to explore the role of innovation barriers on the choice of industrial sectors to adopt predominately either 'Market-orientation' or 'Technology-acquisition' as innovation strategies*.

4.2 MARKET-ORIENTATION VS. TECHNOLOGY-ACQUISITION STRATEGIES

Technological innovation is the result of the innovation strategies undertaken by firms (Zuniga and Crespi, 2013). A vast literature has found the existence of two distinct and opposing strategies (Cohen and Levinthal, 1989; Veugelers and Cassiman, 1999;

Cassiman and Veugelers, 2006). The *Market-orientation* strategy regards the firm's own capacity to innovate, by focusing on internal R&D and the association with external partners as a mean for firms to enhance it, and product launching activities (Tsai et al., 2008; Frank et al., 2016). On the other hand, the *Technology-acquisition* option is a strategy based on the acquisition of machinery and equipment related to innovation. In short, the obtaining of any technological capabilities by external means (Katila, 2001; Jones et al., 2001; Tsai et al., 2008; Tsai et al., 2011; Zuniga and Crespi, 2013; Frank et al., 2016). In a practical world, firms exclusively adopt one of these two strategies and, rarely, a combination of both (Zuniga and Crespi. 2013).

One of the main points that literature has attacked so far is the mapping of the benefits associated to the use of both strategies. For instance, Cohen and Levinthal (1989) argue that the investment on internal capabilities not only allows the development of new internal knowledge and value creation, but also enhances the ability of firms to generate and exploit the existing information. In line with that, Li and Kozhikode (2009) and Sok and O'Cass (2011) stresses that market-oriented innovations enable firms to develop truly effective innovation-oriented learning and absorptive capacities. Moreover, the *Market-orientation* option also exerts a positive impact on the innovation capabilities of the overall industrial innovation activity (Castellacci and Natera, 2013) and leads to higher firm employment (Zuniga and Crespi, 2013), evincing that such a strategy may also contribute to the national innovation landscape. Likewise, previous works also highlight positive implications about the adoption of the *Technology-acquisition* option. Ahuja and Katila (2001), for example, found empirical evidence regarding the positive impact of technology acquisitions to innovation outcomes and its importance to the enhancement of the firm's knowledge base. Through acquisitions, the assets housed within one organization may be merged with the assets of another organization. Once combined, these assets may lead to improvements in productivity (Haspeslagh and Jemison, 1991; Anand and Singh, 1997; Ahuja and Katila, 2001). These two currents of research shed light to the benefits associated with the adoption of both strategic options. This primary thought, therefore, allows us to infer that no option can be simply coined as 'the best' and that the answer for why firms choose one or another strategy may be associated with other aspects outside the relation *'innovation strategies-innovation performance'*.

To enhance this debate, it is worth contemplating thoughts of scholars who pioneered research regarding this juxtaposition of strategies, analogously named by them as the

demand-pull and *technology-push* alternatives (eg. Schmookler, 1966; Meyers and Marquis, 1969; von Hippel, 1976; Mowery and Rosenberg, 1979; Rosenberg, 1982) and bring in an important insight about the downsides of conciliating both strategies. As innovation requires a multilateral competition, firms will be inclined to pursue the development of different (and sometimes opposite capabilities). However, as argued by Dosi (1989) and Porter (2008), this orientation has its some shortcomings. Since firms will seek to a mixed strategic approach, they may not fully accomplish its integration. This choice may yield a lost of focus, consequently occasioning in a lack customer perception and weakening in its competitive force.

4.3 THE ROLE OF INNOVATION BARRIERS

To be successful in innovation, several capabilities should be taken into account. For instance, the access to financing resources, the capacity to understand market needs, the availability of knowledgeable staff and the establishment of effective and fruitful interactions with external actors are some of the factors that firms may eventually be forced to cope with (Greis et al., 1995; Baldwin and Lin, 2002; D'este et al., 2012; Hölzl and Janger, 2014). Some of these factors may be challenging and impact firms from different perspectives. For instance, some firms are deterred from engagement in innovation because of the difficulties involved, which keeps them locked into established routines. The acme of this phenomenon, called "failure without learning", is the point at which the environment is so infeasible for firms that they end up withdrawing from the attempt to innovate. Other firms, in turn, do try to innovate and invest in formal or informal research and development, but they fail to bring new products or processes to the market because they are unable to overcome these barriers (Baldwin and Lin, 2002; D'este et al., 2012; Pellegrino and Savona, 2017).

This scenario, therefore, is an indication that when these barriers appear, firms are compelled to pursue alternative paths to succeed on their innovative activities. These alternative paths are strategic options established by firms with the objective to circumvent barriers. Some studies have already highlighted the role of barriers to innovation as contextual determinants for shaping innovation strategies (Özçelik and Taymaz, 2003; Hashi and Stojčić, 2013; Frank et al., 2016;). Other studies, in turn, have focused on the analysis of the influence of innovation barriers to strategic decisions taken by firms. For instance, the study of Iammarino et al. (2009) evinced that

multinational expansion and network insertion can be an alternative to innovate in face of innovation barriers associated to lack of financial resources. Savignac (2005) found that for small firms with innovation projects financially constrained, the inflow of investments by external means may be a solution. Among these studies, others also point to strategies that can help firms to circumvent innovation barriers, such as adaptation to innovation policies (Galia and Legros, 2004), technology acquisition (Baldwin and Lin, 2002) and R&D investments (Galia and Legros, 2004; D'este et al., 2012).

These evidences, in turn, suggest that although literature has been dedicated to understanding the influence of innovation barriers on the choice of firms to undertake certain strategic actions, it also indicates that the subject has much to be developed, mostly due to the lack of discussion covering a broader range of innovation barriers and its role in shaping the two most common innovation strategies. The research previously mentioned do not address more than one type of barrier on the same analysis. Also, they are essentially centered on the study of financial barriers, which limit the possibility to extend any further association to different barriers. Regarding this, we drawn our categorization based on the Oslo manual (2005) and D'este et al. (2012), by classifying innovation barriers into: cost, market, regulation and knowledge. Since this categorization considers the four most prominent types of innovation barriers, it promotes a better understanding about the effects of these barriers to firms. In addition, most of the studies are focused on short-term managerial solutions to circumvent innovation barriers, not accomplishing, therefore, the formation of long-term innovation strategies *per se* – *Market-orientation* and *Technology-acquisition*. Finally, we also intend to relate our study with the research stream proposed by Hadjimanolis (1999), and Baldwin and Lin (2002) and further developed by D'este et al. (2012) and Pellegrino and Savona (2017), that classified innovation barriers into two main categories, accordingly to the moment in which they present themselves to the innovation process. The first category, called *revealed barriers* reflect the degree of difficulty encountered by firms during the innovation process, while the second one, named *deterring barriers* encompass the obstacles that inhibit industries to engage in innovation, causing withdrawal and a phenomenon called "failure without learning". In this sense, our study addresses the former – the revealing barriers – since our sample comprises firms that face different barriers during the ongoing innovation process.

4.4 METHOD

4.4.1 Data source

In this research we used secondary data from the latest report of the Brazilian Industrial Innovation Research (PINTEC – 2014). PINTEC is a national innovation research that has been conducted by the Brazilian Institute of Statistics and Geography (IBGE), which is a government institution depending from the Ministry of Science, Technology and Innovation. IBGE leads the main economic statistics of this country. PINTEC has been collecting data from Brazilian firms since 2000 and the reports are released in every three years. In this paper, we used the most recent dataset which considers the triennial period of 2012-2014. The main objective of PINTEC is to provide information about the Brazilian innovation indicators as well as the Brazilian landscape of innovation. PINTEC is conceptual and methodologically framed in accordance to the third edition of the Oslo manual (OECD 2005) and reflects the model proposed by the Statistical Office of the European Communities (EUROSTAT). PINTEC report includes many characteristics of innovation in the Brazilian industry, such as: the type of innovation adopted, the effort made for innovation (inputs), the existence of governmental support, the results of innovative activities, the existence of collaboration among stakeholders and the barriers to innovation (IBGE, 2016).

For the sample selection, PINTEC gathers information from CEMPRE (Central Register of Firms) and it only addresses firms that are more likely to be innovative using a stratified disproportional sampling. Some of the selection profile used by PINTEC to identify potential innovators are the size of the company (500 or more employees in the extractive and transformation industry and 100 or more employees in the service industry), companies that accessed R&D funds, companies that used any kind of government incentive, innovative companies that participated in previous samples, among others. All these firms are in the Brazilian territory and must have at least 10 employees. The data collection is made through telephonic interviews conducted by a research agent and addressed to key respondents who are considered capable of providing reliable information.

As result of this large-scale survey, the 2014 report contains information from a sample of 17,171 Brazilian firms, which expanded through the Horvitz Thompson estimator[5] represents 47,693 innovative firms from a universe of 132,529 industrial businesses. The total amount of firms can be categorized into 55 main industrial sectors of four industries (extracting, processing, energy and services). In this study, we choose to exclude the Energy (electricity and gas - 1 industrial sector) and Services (12 industrial sectors) industries from our analysis because they have a different innovation nature, mainly focused on the service quality provision to the customers. This decision follows the own PINTEC (2014) report criteria that group Extractive and Processing activities as a single cluster of industrial activities while Energy and Services are treated separately from each other. Thus, our final sample comprises 42 industrial sectors from the initial 55 and this final sample is analyzed at an aggregate data level (i.e. individual firms' data is not provided in this dataset). More details about the industrial sectors under analysis as well as the universe of businesses may be found in Table 7.

Table 7 – Sample characteristics of PINTEC 2014

Main industries	**Universe of firms represented by the sample**	**Surveyed companies**	**Universe of innovative firms estimated from the sample**	**Number of industrial sectors represented in the industry**
Extractive	2,708	14,387 [(a)]	1,137	1
Processing	108,057		41,851	41
Electricity and gas [(b)]	468	96	136	1
Services [(b)]	21,295	2,688	4,569	12
Total	**132,529**	**17,171**	**47,693**	**55** [(c)]

Table notes: [(a)] This data is not discriminated in PINTEC report; [(b)]Excluded for the final sample of this research; [(c)] Final sample after exclusion: n= 42 industrial sectors

4.4.2 Variables

4.4.2.1 Variable selection

We focused on two groups of variables from PINTEC 2014: (i) the innovation barriers and (ii) the innovation activities. The variables regarding innovation barriers describe twelve different obstacles that industrial sectors face during the innovation activities

[5] Horvitz and Thompson (1952) proposed a method to estimate the population of stratified samples. The method uses an inverse probability weighting approach to consider different proportions of observations in the stratified sample of a target population.

that are consider a risk for the success of the innovation activities. The innovation activities variables, in turn, comprise eight different innovation efforts made by the Brazilian industrial sectors. Both groups of variables are described in Figures 15 and 16, respectively.

Figure 15 – Innovation barriers variables described in PINTEC

Innovation barriers	Description according to PINTEC 2014
Excessive economic risks [RISKS]	This barrier includes the risks associated to a certain innovation, specifically when this innovation is seen as radical to the market. Although the company has all the information needed, the market response to that innovation cannot be forecasted.
High innovation costs [COSTS]	This barrier affects the company when the amount of money the company has access to is not sufficient to carry out the innovation effort, and even if the company has the necessary requirements, it cannot proceed to innovate.
Lack of financial sources [SOURCES]	This barrier is related to the lack of interest or possibilities of collaboration with third parties, specifically in terms of financing.
Organizational rigidity [INFLEXIBILITY]	This barrier addresses the company's ability to adapt itself to organizational changes. Sometimes, organization and structural changes are necessary to facilitate the innovation process and if the company is unwilling to adapt, this may be an obstacle to the innovation process.
Lack of qualified personnel [UNQUALI_PERSONNEL]	This barrier is associated to the impossibility of finding qualified workforce to work in a certain innovation project. It is worth mentioning that this can happen even if the company is capable of affording it.
Lack of information on technology [TECH_INFO]	This barrier represents an impossibility of finding information regarding the technology applied to a certain innovation project. As with the [UNQUALI_PERSONNEL] barrier, this obstacle can exist even if the company can afford to search for the required information.
Lack of information on markets [MARKET_INFO]	This obstacle is related to the difficulty of finding enough information to support decision making along the innovation process. Similar to the previous barriers [UNQUALI_PERSONNEL] and [TECH_INFO] this barrier can occur even if the company has capital to support the pursuit of this information.
Scarce possibilities of cooperation with other companies/institutions [LACK_OF_COOP]	This barrier is related to the difficulty of finding capable partners for the company to cooperate with. This barrier may exist due to certain reasons such as the environment and the maturity stage of innovation in which the company is. Thus, specific aspects as lack of interested parties, knowledge protection and the capability of being involved in networks may represent an obstacle for firms to move their innovation efforts further.
Difficulty adjusting to standards, norms and regulations [REGULATIONS]	This barrier represents the misunderstanding and difficulties for firms to adjust their innovation proposals to the norms and regulations of a given environment. This may be due to the lack of information or very restricted policies.
Weak consumer response to new products [MARKET_BEHAVIOR]	This barrier is associated to consumer behavior. In some cases, the targeted market is used to deal with a certain technology or product type and may be resistant to adopting alternative ones.
Scarcity of appropriate external services [LACK_OF_SERVICES]	This barrier is related to the scarcity of external sources that can enhance the potential of the innovation, such as: research, repairing and remanufacturing, for example.
Centralization of the innovation activity [CENTRALIZATION]	This barrier is related to how the company structures the decisions related to innovation, especially when this innovation is developed in an environment outside the company.

Figure 16 – Innovation activities variables described in PINTEC

Innovation activities	Description according to PINTEC 2014
R&D Internal Activities [INT_R&D]	Includes the creative work undertaken in a systematic way with the objective of increasing the knowledge base and the use of this knowledge to develop new applications such as new or technologically improved products or processes;
External Acquisition of R&D [EXT_R&D]	Includes the activities described in INT_R&D, but carried out by another organization (firms or technological institutions) and acquired by the company;
External Acquisition of Knowledge [EXT_KNOW]	Includes technology transfer agreements originated from the purchase of license rights for the exploitation of patents and use of trademarks, acquisition of know-how and other types of technical and scientific knowledge of third parties, for the firm to develop or implement innovations;
Software Acquisition [SOFT]	Includes the acquisition of software (from design, engineering, data processing and transmission, voice, graphics, video, automation of processes, etc.), specifically purchased for the implementation of new or technologically improved products or processes.
Machinery and equipment acquisition [EQUIP]	Includes the acquisition of machinery, equipment and hardware specifically purchased for the implementation of new or technologically improved products or processes;
Training [TRAIN]	Includes training oriented to the development of products or processes technologically new or significantly improved and related to the company's innovative activities, which may include acquisition of specialized technical external services;
Commercialization and product launch activities [COMM]	Introduction of technological innovations in the market - includes marketing activities, directly linked to the launch of a technologically new or improved product, which may include: market research, market testing and advertising for launch.
Industrial project and other technical preparations [INDPROJ]	Refers to technical procedures and preparations to implement product or process innovations. It includes changes in production and quality control procedures, work and software methods and standards required for the implementation of technologically new or improved products or processes, as well as the activities of basic industrial technology, testing for product registration and for the effective start of production.

These two categories of variables selected for this study (Innovation barriers and Innovation activities) are measured in a perception scale. For the innovation barriers variables, the evaluation of PINTEC is based on degree of perception regarding the severity in which firms face these barriers (Figure 15). Similarly, the innovation activities were measured through the perception of firms regarding the efforts made in each of the eight activities considered (Figure 16). The data used to assess both sets of variables was measured by IBGE using a three-point Likert scale (low, medium and high) to indicate the importance of a particular barrier or of a particular innovation activity. PINTEC reports these data in aggregated categorical form, in which each industrial sector has a single value representing the percentage of companies in an industrial sector that indicated each of these three importance levels for the considered variable. In order to calculate a unique score for the innovation barriers and for the

innovation activities, for each of the 42 industrial sectors, we used the following equation proposed by Frank et al. (2016) in their analysis of PINTEC 2011:

$$T_{ij\%} = \frac{1.00 \times th_j + 0.50 \times tm_j}{T_j} \quad (1)$$

The objective of Equation 1 is to provide a weighted sum for the two partial totals, the medium and high degrees of perception (Frank et al., 2016). Hence, *Tij%* is calculated for a specific industrial sector *j* in respect to a qualitative aspect *i* (the innovation barriers in Table 2 or the innovation activities in Table 3). In this way, a weight of 1.00 is attributed to firms (*thj*) of a certain industrial sector *j* that have perceived a high influence of each one of the *i* innovation barriers or that have made high efforts towards a certain type of innovation activity. Likewise, a weight of 0.5 is given to the total amount of firms (*tmj*) of a specific industrial sector *j* that have perceived a moderated influence of an innovation barrier or that have invested a moderated amount of efforts in a certain innovation activity. In this way, all firms that reported either high or medium importance to the perception of the innovation barriers were included in our analysis. Finally, the result of the Eq. 1 provides a unique score (*Tij*) that reflects the perceived importance attributed to each variable. This equation represents a relative percentage in which the weighted sum of high and medium degrees of perception is divided by the total amount of firms in each industrial sector *i*.

4.4.2.2 Construct Definition

Both independent and dependent sets of variables were grouped into main constructs based on prior research of D'Este et al. (2012) for innovation barriers and of Frank et al. (2016) for innovation activities and strategies.

First, Innovation barriers were grouped into four constructs as proposed by D'este et al (2012) based on the CIS survey (OECD, 2005): (i) Costs; (ii) Knowledge; (iii) Market behavior and (iv) Regulation (Figure 17). Since we followed this prior categorization, we excluded two variables that were only included in the PINTEC survey: lack of cooperation and centralization. The barriers constructs were represented by the average values of the individual variables composing them.

Figure 17 – Innovation Barriers categorization

Detailed barriers according to PINTEC 2014	Barrier factors			
	COST	**KNOWLEDGE**	**MARKET**	**REGULATION**
Excessive economic risks [RISKS] *	X			
High innovation costs [COSTS] *	X			
Lack of financial sources [SOURCES] *	X			
Organizational rigidity [INFLEXIBILITY]		X		
Lack of qualified personnel [UNQUALI_PERSONNEL] *		X		
Lack of information on technology [TECH_INFO] *		X		
Lack of information on market [MARKET_INFO] *		X		
Scarcity of appropriate external services [LACK_OF_SERVICES]		X		
Weak consumer response to new products [MARKET_BEHAVIOR] +			X	
Difficulty adjusting to standards, norms and regulations [REGULATIONS] +				X

Notes: * Barrier considered in D'Este et al. (2012) framework; + Similar variable to the one considered in D'Este et al. (2012) framework.

For the innovation activities, in turn, we drawn on the results of Frank et al. (2016) from PINTEC 2011, whose findings showed that there are two main innovation strategies adopted by the industrial sectors in Brazil. The first one is the *Market-Orientation* strategy, composed by R&D Internal Activities [INT_R&D], External Acquisition of R&D [EXT_R&D], Commercialization and product launch activities [COMM] (Figure 18). The innovation activities considered in this construct are concerned with R&D efforts. On the other hand, the *Technology-Acquisition* strategy is represented by a unique innovation activity, namely 'machinery and equipment acquisition activities' [EQUIP]. As demonstrated by Frank et al. (2016) these two are opposite strategies in the Brazilian industry. Moreover, we did not consider other innovation activities presented in Figure 16 for the construct definition due to several reasons. First, Frank et al. (2016) demonstrated that the Market-orientation vs. Technology acquisition strategies are dominant in terms of investment in innovation activities. Additionally, the same study shows that training activities [TRAIN] and industrial projects development [INDPROJ] did not show a significant impact on innovation outputs, while software acquisition [SOFT] seems to be more related to administrative process improvements, which is not our main concern. Therefore, we only selected variables representing these two strategies that are the aim of this present study. Based on these definitions, both

constructs were represented by the average values of the individual variables composing them, as shown in Figure 18.

Figure 18 – Innovation strategies categorization in accordance to Frank et al. (2016) *

Detailed Innovation activities according to PINTEC 2014	**Innovation Strategies**	
	MARKET-ORIENTATION	**TECHNOLOGY-ACQUISITION**
R&D Internal Activities [INT_R&D]	x	
External Acquisition of R&D [EXT_R&D]	x	
Commercialization and product launch activities [COMM]	x	
Machinery and equipment acquisition [EQUIP]		x

Notes: * Other innovation outputs that not comprise these two main strategies and that were considered in Frank et al. (2016) were excluded from our analysis.

We also considered potential control variables available in the PINTEC dataset. In this sense, we firstly considered the predominant size of the firms comprising an industrial sector as a control variable. According to previous works, industrial sectors with larger firms are more likely to invest in innovation activities (Chudnovsky et al., 2006; De Backer et al., 2008; Evangelista and Vezzani, 2010; Resende et al., 2014). Consequently, we synthesized this feature into a single control variable called firm size [Firm_Size]. This variable categorizes all firms in accordance to the number of employees in each industrial sector (0 = small/medium; 1 = large). Due to limited information about the sectorial characteristics, all small and medium firms were included into the same category. Secondly, we included a control variable called [Revenue] by means of the natural logarithm of the revenues of each industrial sector consider for analysis. This control variable considers the different amount of revenue of each industrial sector. Finally, we generated three (k-1) dummy variables in order to differ all sectors based on four most prominent industrial characteristics: labor [Dummy_Natural]; scale [Dummy_Scale]; natural resources intensive [Dummy_Natural] and R&D (when all dummies equal to 0) (Chudnovsky et al., 2016).

4.4.3 Model specification and econometric methods

4.4.3.1 Model specification

The theoretical model we propose to analyze is illustrated in Figure 1. According to the model, there are four different independent variables, which are the innovation barriers [COST], [KNOWLEDE], [MARKET] and [REGULATION] and two different

dependent variables, comprising the two juxtaposed innovation strategies [MARKET_ORIENTATION] and [TECHNOLOGY_ACQUISITION]. As Figure 19 shows, the main objective of our econometric analysis is to understand the antecedents of these two innovation options from the perspective of the innovation barriers. In other words, we hypothesize that some innovation obstacles may force firms to adopt either *Market-orientation* or *Technology-acquisition* as strategic options to innovate. Furthermore, our theoretical model considers, based on prior evidence from the literature in large-scale innovation surveys, that innovation barriers, as many other innovation variables, are endogenous, which means that they are contextually dependent. Therefore, we used a set of instrumental variables as contextual characteristics aiming to reduce the possibility of biased results. The instrumental variables included in our model is discussed in the further section 4.4.3.2.

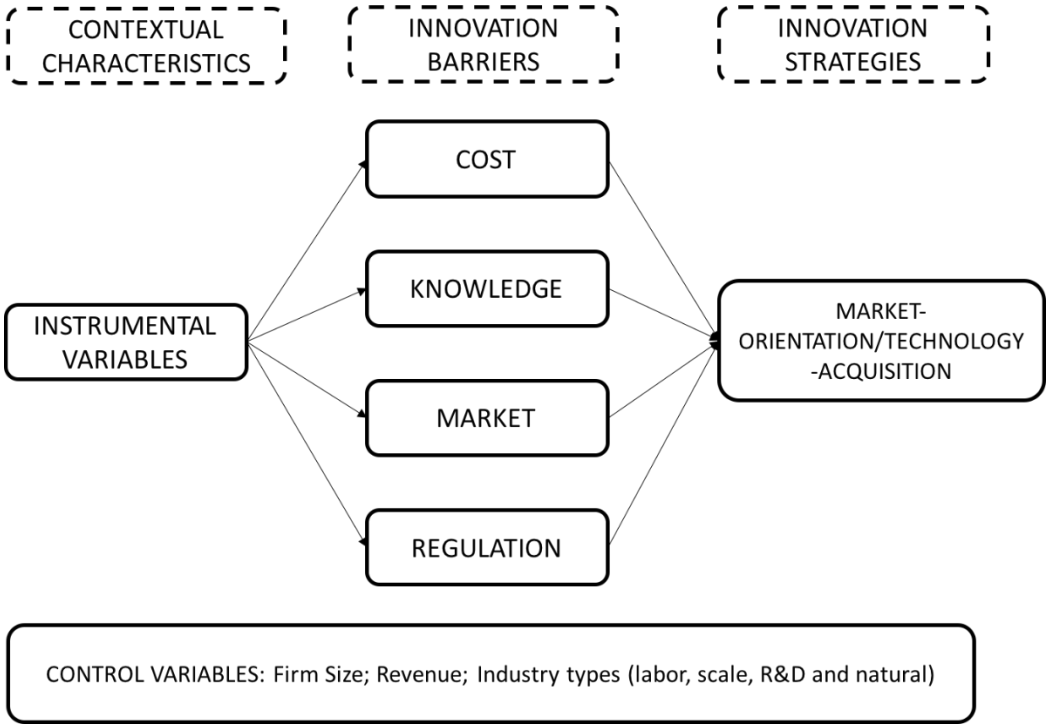

Figure 19 - Econometric model

4.4.3.2 Econometric procedures

The literature on large-scale innovation survey has largely acknowledged that data originated from this kind of survey are usually subjected to endogeneity problems (e.g. Chudnovsky et al., 2006; Tiwari et al., 2008; Crespi and Suniga, 2012 Hashi & Stojcic, 2013; Blanchard et al., 2013; Frank et al., 2016). The endogeneity problem arises when at least one of the independent variables is correlated to the error term, violating the assumption that the regressors are exogenous (Bascle, 2008). In such case, the use of

ordinary least squares (OLS) would present biased and inconsistent coefficients, being recommendable to adopt econometric procedures based on instrumental variables (IVs) regression (Bascle, 2008; Wooldridge, 2010). The IVs or simply instruments, as they are also called, are variables correlated to the endogenous variables and not correlated to the error term in the regression equations. The use of a two-stage least square (2SLS) regression method, and other upgraded procedures like Generalize Method of Moments (GMM) allows the correction of the endogenous dependent variables with the instruments (Bascle, 2008; Wooldridge, 2010).

We adopted the abovementioned IV regression procedures by selecting from PINTEC dataset eleven potential IVs. This was made following prior study of Frank et al. (2016) also using PINTEC dataset. The eleven IVs consider four groups of contextual aspects for the industrial sectors' innovation activities: a) degree of innovation project´s failure: (i) organizational innovations [IV_ORGAN_FAILURE], (ii) market innovations [IV_MARKET_FAILURE] and (iii) product/process innovations [IV_P&P_FAILURE]; b) information sources for innovation: (i) internal information sources [IV_R&D_SOURCES], (ii) market information sources [IV_MARKET_SOURCES], (iii) institutional sources [IV_INST_SOURCES] and (iv) other sources [IV_OTHER_SOURCES]; c) Public subsidies: (i) subsidies for R&D activities [IV_R&D_FUNDS], (ii) other subsidies (generic and specific programs), (iii) [IV_OTHER_FUNDS] and (iv) subsidies for technologies [TECH_FUNDS]; d) Governmental support [IV_POLICIES].

Since PINTEC provides aggregated data which can present problems related to finite sample (Baum et al., 2007) as well as potential problems of heteroskedasticity (Hahn et al., 2004), some typical econometric procedures such as 2SLS, GMM can present limited results. Therefore, we opted to use the a specific GMM approach, the Continuously Updating GMM (Hansen et al., 1996) which is pointed as a possible method to mitigate these problems, especially in the presence of weak instrumentation (Hahn et al., 2004), being considered the less biased among the GMM-type estimators (Gomes and Paz, 2013). Therefore, we employed the CUE-GMM method using the statistical software Stata 14.0®.

4.5 RESULTS

Table 8 presents the results of our econometric model for both strategies, *Market-orientation* and *Technology-acquisition*. This table shows a comparative analysis between a set of CUE models to evaluate the direct impact of the four innovation barriers constructs (COST, KNOWLEDGE, REGULATION and MARKET) on the two innovation strategies *Market-orientation* and *Technology-acquisition*. We used a sequence of CUE models where the non-significant variables were excluded to check the stability of the outputs in the next CUE model. The results indicate that the use of CUE method allow the obtaining of more robust results, as explained in Section 4.4.3.2. Moreover, as it is possible to check in the results in all models, the statistical inferences as well as the signs of the coefficients were stable.

Table 8 – Results for the impact of innovation barriers on Market-orientation and Technology-acquisition strategies

Variable names	Market-Orientation				Technology-Acquisition		
	Column 2	**Column 3**	**Column 4**	**Column 5**	**Column 7**	**Column 8**	**Column 9**
	CUE 1	**CUE 2**	**CUE3**	**CUE4**	**CUE1**	**CUE2**	**CUE3**
COST	2.84*	3.52*	2.58**	2.82**	-3.92***	-4.12***	-4.12***
KNOWLEDGE	-8.01**	-8.97**	-5.95**	-6.77**	4.14***	4.30***	4.42***
REGULATION	4.83**	6.16**	4.16***	4.59***	-1.82*	-1.94*	-2.06*
MARKET	2.16	--	--	--	-0.46	--	--
Natural	-0.68*	-0.72*	-0.44**	-0.47*	0.49**	0.48**	0.50***
Size	0.66**	0.63**	0.42**	0.46**	-0.37**	-0.37**	-0.37**
Revenue	0.069	0.07	0.030	--	-0.01	0.0016	--
Scale	-0.095	-.012	--	--	0.23*	0.245*	-0.24**
Breush-Pagan White							
Hansen test	3.84	4.822	4.559	4.409	7.219	7.332	7.10
	p-val. = 0.79	p-val. = 0.77	p-val. = 0.80	p-val. = 0.81	p-val. 0.40	p-val. = 0.50	p-val. = 0.52
Stock-Wright	Chi^2 = 26.57	Chi^2 = 26.57	Chi^2 = 28.24	Chi^2 = 28.54	Chi^2 = 30.62	Chi^2 = 30.63	Chi^2 = 30.49
	p-val. = <0.01	p-val. = <0.01	p-val. = <0.01	p-val. = <0.01	p-val. = 0.0013	p-val. = 0.003	p-val. = 0.0013
Anderson-Rubin	Chi^2 = 20.56	Chi^2 = 20.56	Chi^2 = 21.58	Chi^2 = 22.12	F = 12.23	F = 12.23	F = 12.04
	p-val. = 0.038	p-val. = 0.038	p-val. = 0.027	p-val. = 0.02	Chi^2 = 156.59	Chi^2 = 156.49	Chi^2 = 152.51
					p-val.<0.01	p-val. <0.01	p-val. <0.01

*p<0.1; **p < 0.05; ***p < 0.01; n = 42 industrial sectors.

We performed statistical tests to prove the robustness of our econometric analysis. Firstly, we tested for heteroskedasticity using the Breusch-Pagan test. This test investigates whether the variance of the errors is dependent on the values of the independent variables of a regression model. The results for the two models showed a goodness of fit for the Breusch-Pagan test. The statistical tests had a p-value bellow the appropriate threshold of 0.1 (Breusch and Pagan, 1979). Therefore, the null hypothesis of homoskedasticity is rejected and heteroskedasticity assumed. Moreover, we also performed the White test, which is an alternative to the Breusch-Pagan test. The White test investigates whether the variance of the errors in a regression model is constant (White, 1980). The result for the White test corroborates the existence of heteroskedasticity, since it had a p-value below the threshold of 0.1. Following the sequence, the Hansen test analyzes the over identification of restrictions in a statistical model. The null hypothesis of the Hansen test is accepted when instruments are not correlated with the error term (Hansen, 1982). In our case, both models indicate the acceptation of the null hypothesis for the Hansen test ($p>0.1$). Therefore, we can conclude that our instruments are valid. Lastly, we performed the Stock-Wright and Anderson-Rubin tests, which are robust to the presence of weak instruments. According to Stock et al. (2002), weak instruments may cause serious distortions in any test performed. Therefore, it is necessary to investigate in our model whether weak instruments are present. The null hypothesis for both Stock-Wright and Anderson-Rubin tests is rejected when instruments are strong. Hence, we may conclude that our instruments are adequate, since we have statistical evidence to reject the null hypothesis for the threshold of $p<0.01$ (Anderson and Rubin, 1949; Stock et al., 2002).

According to Table 8, from the four innovation barriers (COST, KOWLEDGE, REGULATION and MARKET), three of them exert a significant impact on the innovation strategy *Market-orientation*. The innovation barrier REGULATION presented the strongest impact ($B = 4.59$, $p < 0.01$) on *Market-orientation*, followed by the innovation barriers KNOWLEDGE ($B = -6.77$, $p < 0.05$) and COST ($B = 2.82$, $p < 0.05$). While the innovation barrier KNOWLEDGE showed a negative impact on this strategy, COST and REGULATION presented a positive impact. The innovation barrier MARKET, in turn, did not present a significant impact. These outcomes suggest that the three innovation barriers are opposite triggers to *Market-orientation*. Moreover, the results for the second dependent variable (*Technology-acquisition*) also evinced the significant impact of the three innovation barriers COST, KNOWLEDGE and

REGULATION. In accordance to the results, the innovation barrier REGULATION exerts the strongest impact ($B = -11.67$, $p < 0.01$), followed by KNOWLEDGE ($B = 17.04$, $p < 0.05$) and COST ($B = -7.39$, $p < 0.05$). Similarly, the innovation barrier MARKET did not present a significant effect. Also, we found opposite impacts between the innovation barriers and *Technology-acquisition* strategy. While the innovation barrier KNOWLEDGE presented a positive impact regarding the adoption of this strategic option, the other two variables COST and REGULATION showed a negative impact. Therefore, we found that the *Market-orientation* and *Technology-acquisition* strategies are juxtaposed, indicating that in the presence of specific obstacles, industrial sectors react in accordance to one or another strategy.

The positive impact of the innovation barrier COST on *Market-orientation* indicates that the industrial sectors that face barriers associated to financial aspects, such as innovation risks, innovation costs or lack of financial sources tend to adopt this strategy to innovate. Oppositely, industrial sectors negatively impacted by the innovation barrier COST tend to adopt the *Technology-acquisition* option. In a nutshell, the more cost barriers impact firms, the less resources to acquire new technologies or to upgrade the existing one the firms have. Therefore, firms in these industrial sectors tend to motivate the internal development of their activities. Moreover, our results also indicated that as industrial sectors face less KNOWLEDGE barriers such as organizational rigidity; lack of qualified personnel; lack of information on technology; lack of information on market and scarcity of appropriate external services, they tend to establish a strategy to innovation based on the *Market-orientation* choice. However, the more this type of barrier industrial sectors face, the more likely to position themselves towards a *Technology-acquisition* strategy they are. In summary, this may be interpreted by the fact that firms have available internal knowledge, they tend to strengthen this aspect (especially when they are resource-constrained and cannot afford to buy new technologies). On the other hand, industrial sectors that find difficulties to develop internal knowledge are more motivated to make investments in technology and, therefore, follow the *Technology-acquisition* stream. Finally, the innovation barrier REGULATION also exerts an opposed effect on the adoption of innovation strategies. Hence, when industrial sectors face the positive impact of regulation polices, they tend to pursue alternatives to overcome this obstacle in order to adjust the innovation activities so as the requirements for the implementation of the innovation can be met. Contrarily, the less impact of REGULATION industrial sectors encounter, the more

generic the innovation activities can be and, therefore, the more motivated to follow benchmarks and to buy technologies from external sources they are.

4.6 DISCUSSIONS

Based on what the results of our empirical analysis, three of the four constructs of innovation barriers (COST, KNOWLEDGE and REGULATION) exert a significant impact regarding the adoption of innovation strategies. Interestingly, our results show that these impacts are antagonistic, suggesting that in the presence of some specific innovation barriers, Brazilian firms adopt either the *Market-orientation* or the *Technology-acquisition* strategies. Figure 20 highlights the relationship of juxtaposition between the variables of innovation barriers and innovation strategies.

Figure 20 – Juxtaposition of innovation barriers associated to innovation strategies

Innovation barriers	Market-orientation	Technology-acquisition
COST	+	-
KNOWLEDGE	-	+
REGULATION	+	-
MARKET	x	x

*Notes: (1) the signals "+" and "-" illustrate the positive and negative significant impacts of Table 6; (2) the signal "x" indicates no significant relationship among variables.

For instance, the construct COST positively impacts the *Market-orientation* option, while it exerts a negative impact on the *Technology-acquisition* one. This result may be understandable by the fact that when there is a strong perception of barriers related to cost aspects, the industry cannot afford to buy new technologies and, therefore, they tend to circumvent such type of obstacles by focusing on knowledge development (both internal and in association to partners) and activities related to market understanding for new product launching (Capon and Glazer, 1987). Contrary, when cost barriers are less perceived, which means that there is a greater availability to access financing and financial support from external sources, firms tend to buy new technologies (Capon and Glazer, 1987). For the construct KNOWLEDGE, in turn, a similar association can be deduced. When industrial sectors are less impacted by obstacles related to the availability of both internal and external knowledge and obtaining of information from market and technologies, it means that there is a favorable environment for *Market-oriented* activities and, consequently, firms tend to develop their knowledge capacity (Capon and Glazer, 1987; Cohen and Levinthal, 1989; Jones et al., 2001). On the other

hand, in the presence of difficulties related knowledge availability and urgency to keep R&D times low, firms are forced to circumvent this barrier through the acquisition of technologies by external means, adopting, therefore, the *Technology-acquisition* strategy (Granstrand et al., 1992; Jones et al., 2001; Tsai and Wang, 2007). This phenomenon might occur in a context where the innovation is new to the market and the appropriate knowledge for its development is not available in the firm nor among its partners (Jones et al., 2001). Also, we found opposite and significant relationships between the innovation barrier REGULATION and the two innovation strategies. This may happen in scenarios in which a new technology is being proposed and, consequently, there will be a need for adaptation. The results indicate that in the presence of REGULATION obstacles, the Market-Orientation strategy is adopted. According to Capon and Glazer (1987) this is the moment where firms fall into the "not invented here" syndrome, where a need to create internal expertise emerges. This feature opposes to a situation where it already exists a technology and, therefore, their simply external acquisition saves time and effort.

Ultimately, the MARKET variable was the only innovation barrier construct for which we did not find a significant impact on innovation strategies. This finding suggests that neither *Market-orientation* nor *Technology-acquisition* strategies support innovation in scenarios where consumer behavior is hard to analyze and not stable (Nelson and Winter, 1977). The high level of loyalty that certain industrial sectors have achieved with their customers makes difficult the adoption of new products. According to Nelson and Winter (1977), consumer taste matter for innovation, even when firms have a clear cut goal and and the decision to employ an innovation.

In a nutshell, when the industry is not financially constrained and the innovation is not entirely new, the industry tends to invest technology acquisition. On the other hand, when financial support is scarce and when there is knowledge available, the industry usually invests in R&D activities. Therefore, we may infer that there exists an antagonistic and unilateral choice of strategies. In addition, studies identified an excessive orientation towards the former strategy (Goedhuys and Veugelers, 2012; Frank et al., 2016). Previous evidences indicated that this is a result of the lack of absorptive or learning capacity by native firms (Guan et al., 2006). However, several articles have empirically proven the downsides of this option in emerging countries (Franco et al., 2011; Zuniga and Crespi, 2013). As literature indicates, there should be no prominence of strategies. Both options may coexist and, consequently, be mutual

complementary (Tsai and Wang, 2007; Tsai et al., 2008; Tsai et al., 2011). For example, as suggested by Cohen and Levinthal (1989), firms can first find a solution to the lack of knowledge and pace of innovation in the acquisition of new technologies. However, in the long run, aspects such as the constitution of a strong technological base may enhance firm's capabilities.

4.7 CONCLUSIONS

This paper presents the results of a research based on a large-scale innovation survey from Brazil. This study aimed to provide a comprehensive understanding regarding the influence of innovation barriers on the adoption of the *Market-orientation* and *Technology-acquisition* innovation strategies, which in accordance to Goedhuys and Veugelers (2012) and Frank et al. (2016) are the two most common strategies adopted by the Brazilian industry. Our results revealed that innovation barriers are antecedents of the Brazilian industry strategic formation. Our findings indicate that some barriers not only motivate the adoption of innovation strategies, but also this adoption is done in a juxtaposed way. More specifically, we found that industrial sectors tend to adopt the *Market-orientation* strategy when cost barriers are high, when innovation has high regulation policies and when the industry has prior knowledge and organizational conditions to innovate. Oppositely, we found that when financial aspects are favorable, when regulation does not constrain the implementation of innovations and when the industry face obstacle in obtaining knowledge (both internal an external) to develop innovations, the *Technology-acquisition* option is usually chosen.

4.7.1 Contributions for scholars and practitioners

Our findings present contributions for both practitioners and the academic community. Managers can benefit from the insights we produced since they can be able to comprehend how the Brazilian industry behaves. More specifically, our findings shed light on how the industrial sectors in Brazil strategically react when they face innovation barriers. As we showed, the juxtaposition of strategies is a result of the innovation barriers. The bulk of investments for innovation is associated to either technology acquisition or development of internal R&D. This feature supports what literature has been pointing out as a possible problem of the Brazilian strategic positioning to innovate. It can be argued that for Brazilian firms the *Market-orientation*

and *Technology-acquisition* are not complementary strategies, but rather opposing (Goedhuys and Veugelers, 2012; Frank et al., 2016).

We believe that we pointed to a potential avenue for practitioners to explore: *the creation of new strategies that accomplish both types of activities: R&D and technology acquisition*. Also, policy makers may use our findings to promote public policies that focus on undermining barriers that compromise the development of innovation in firms. For instance, the financial and the regulation side are both spheres that the government may act. Lastly, this study contributes to scholars by providing a deep understanding of innovation in a developing country. The academic community can use our findings to foment future research on innovation strategies in Brazil, by focusing on aspects more associated to the barriers.

4.7.2 Limitations and future research

Methodologically, our study presents some limitations that are worth to be mentioned. For instance, the database we used is based on aggregated sectorial data. Hence, we could not provide conclusions at the company level. Moreover, our study did not consider similarities among industrial sectors. This may be a limitation for the understanding of how innovation barriers are related to specific industrial sectors, which could, consequently, allow us to investigate the strategic formation of these industrial sectors to innovate. Ultimately, another limitation of our study is that we considered only a cross-section to conduct our analysis, which inhibits us to use lagged variables to have a better assessment of temporal effects. Since innovation is a dynamic phenomenon, a proper analysis of the process of structural change and industrial transformation over a longer period would be beneficial to enlarge the understanding of this research (Pavitt, 1984; Castellacci, 2008).

4.8 REFERENCES

AHUJA, Gautam; KATILA, Riitta. Technological acquisitions and the innovation performance of acquiring firms: A longitudinal study. **Strategic management journal**, v. 22, n. 3, p. 197-220, 2001.

ANAND, Jaideep; SINGH, Harbir. Asset redeployment, acquisitions and corporate strategy in declining industries. **Strategic Management Journal**, p. 99-118, 1997.

ANDERSON, Theodore W.; RUBIN, Herman. Estimation of the parameters of a single equation in a complete system of stochastic equations. **The Annals of Mathematical Statistics**, p. 46-63, 1949.

BALDWIN, John; LIN, Zhengxi. Impediments to advanced technology adoption for Canadian manufacturers. **Research policy**, v. 31, n. 1, p. 1-18, 2002.

BASCLE, Guilhem. Controlling for endogeneity with instrumental variables in strategic management research. **Strategic organization**, v. 6, n. 3, p. 285-327, 2008.

BAUM, Christopher F. et al. Enhanced routines for instrumental variables/GMM estimation and testing. **Stata Journal**, v. 7, n. 4, p. 465-506, 2007.

BLANCHARD, Pierre et al. Where there is a will, there is a way? Assessing the impact of obstacles to innovation. **Industrial and Corporate Change**, v. 22, n. 3, p. 679-710, 2012.

BRASIL. MINISTÉRIO DA FAZENDA. **Fazenda comenta resultado do PIB no 3º trimestre de 2016:** Nota à imprensa. 2016. Disponível em: <http://www.fazenda.gov.br/noticias/2016/novembro/nota-sobre-a-variacao-do-pib-no-3o-trimestre-de-2016>. Acesso em: 31 nov. 2016.

BREUSCH, Trevor S.; PAGAN, Adrian R. A simple test for heteroscedasticity and random coefficient variation. **Econometrica: Journal of the Econometric Society**, p. 1287-1294, 1979.

CAPON, Noel; GLAZER, Rashi. Marketing and technology: a strategic coalignment. **The Journal of Marketing**, p. 1-14, 1987.

CASSIMAN, Bruno; VEUGELERS, Reinhilde. In search of complementarity in innovation strategy: Internal R&D and external knowledge acquisition. **Management science**, v. 52, n. 1, p. 68-82, 2006.

CASTELLACCI, Fulvio. Technological paradigms, regimes and trajectories: Manufacturing and service industries in a new taxonomy of sectoral patterns of innovation. **Research Policy**, v. 37, n. 6-7, p. 978-994, 2008.

CASTELLACCI, Fulvio; NATERA, Jose Miguel. The dynamics of national innovation systems: A panel cointegration analysis of the coevolution between innovative capability and absorptive capacity. **Research Policy**, v. 42, n. 3, p. 579-594, 2013.

CHUDNOVSKY, Daniel; LÓPEZ, Andrés; PUPATO, Germán. Innovation and productivity in developing countries: A study of Argentine manufacturing firms' behavior (1992–2001). **Research policy**, v. 35, n. 2, p. 266-288, 2006.

CIRERA, Xavier; MARIN, Anabel; MARKWALD, Ricardo. Explaining export diversification through firm innovation decisions: The case of Brazil. **Research Policy**, v. 44, n. 10, p. 1962-1973, 2015.

COHEN, Wesley M.; LEVINTHAL, Daniel A. Innovation and learning: the two faces of R & D. **The economic journal**, v. 99, n. 397, p. 569-596, 1989.

CRESPI, Gustavo; ZUNIGA, Pluvia. Innovation and productivity: evidence from six Latin American countries. **World development**, v. 40, n. 2, p. 273-290, 2012.

D'ESTE, Pablo et al. What hampers innovation? Revealed barriers versus deterring barriers. **Research policy**, v. 41, n. 2, p. 482-488, 2012.

DE BACKER, Koen; LOPEZ-BASSOLS, Vladimir; MARTINEZ, Catalina. Open Innovation in a Global Perspective. 2008.

DOSI, Giovanni. Technological paradigms and technological trajectories: a suggested interpretation of the determinants and directions of technical change. **Research policy**, v. 11, n. 3, p. 147-162, 1982.

EVANGELISTA, Rinaldo; VEZZANI, Antonio. The economic impact of technological and organizational innovations. A firm-level analysis. **Research Policy**, v. 39, n. 10, p. 1253-1263, 2010.

FERRIANI, Simone; GARNSEY, Elizabeth; PROBERT, David. **Sustaining breakthrough innovation in large established firms: learning traps and counteracting strategies**. Edward Elgar Publishing, 2008.

FRANCO, Eliane; RAY, Sangeeta; RAY, Pradeep Kanta. Patterns of innovation practices of multinational-affiliates in emerging economies: Evidences from Brazil and India. **World Development**, v. 39, n. 7, p. 1249-1260, 2011.

FRANK, Alejandro Germán et al. The effect of innovation activities on innovation outputs in the Brazilian industry: Market-orientation vs. technology-acquisition strategies. **Research Policy**, v. 45, n. 3, p. 577-592, 2016.

GALIA, Fabrice; LEGROS, Diego. Complementarities between obstacles to innovation: evidence from France. **Research policy**, v. 33, n. 8, p. 1185-1199, 2004.

GOEDHUYS, Micheline; VEUGELERS, Reinhilde. Innovation strategies, process and product innovations and growth: Firm-level evidence from Brazil. **Structural change and economic dynamics**, v. 23, n. 4, p. 516-529, 2012.

GOMES, Fábio Augusto Reis; PAZ, Lourenço S. Estimating the elasticity of intertemporal substitution: Is the aggregate financial return free from the weak instrument problem?. **Journal of Macroeconomics**, v. 36, p. 63-75, 2013.

GRANSTRAND, Ove et al. External technology acquisition in large multi-technology corporations. **R&D Management**, v. 22, n. 2, p. 111-134, 1992.

GREIS, Noel P.; DIBNER, Mark D.; BEAN, Alden S. External partnering as a response to innovation barriers and global competition in biotechnology. **Research Policy**, v. 24, n. 4, p. 609-630, 1995.

HADJIMANOLIS, Athanasios. Barriers to innovation for SMEs in a small less developed country (Cyprus). **Technovation**, v. 19, n. 9, p. 561-570, 1999.

HAHN, Jinyong; HAUSMAN, Jerry; KUERSTEINER, Guido. Estimation with weak instruments: Accuracy of higher-order bias and MSE approximations. **The Econometrics Journal**, v. 7, n. 1, p. 272-306, 2004.

HANSEN, Lars Peter. Large sample properties of generalized method of moments estimators. **Econometrica: Journal of the Econometric Society**, p. 1029-1054, 1982.

HASHI, Iraj; STOJČIĆ, Nebojša. The impact of innovation activities on firm performance using a multi-stage model: Evidence from the Community Innovation Survey 4. **Research Policy**, v. 42, n. 2, p. 353-366, 2013.

HASPESLAGH, Philippe C.; JEMISON, David B. The challenge of renewal through acquisitions. **Planning Review**, v. 19, n. 2, p. 27-30, 1991.

HÖLZL, Werner; JANGER, Jürgen. Distance to the frontier and the perception of innovation barriers across European countries. **Research Policy**, v. 43, n. 4, p. 707-725, 2014.

IAMMARINO, Simona; SANNA-RANDACCIO, Francesca; SAVONA, Maria. The perception of obstacles to innovation. Foreign multinationals and domestic firms in Italy. **Revue d'économie industrielle**, n. 1, p. 75-104, 2009.

IBGE, 2016. Pintec 2014, Estatísticas do registro civil 2014. ISSN 0101-4234.

JONES, Gary K.; LANCTOT JR, Aldor; TEEGEN, Hildy J. Determinants and performance impacts of external technology acquisition. **Journal of Business venturing**, v. 16, n. 3, p. 255-283, 2001.

LI, Jiatao; KOZHIKODE, Rajiv Krishnan. Developing new innovation models: Shifts in the innovation landscapes in emerging economies and implications for global R&D management. **Journal of International Management**, v. 15, n. 3, p. 328-339, 2009.

MADRID-GUIJARRO, Antonia; GARCIA, Domingo; VAN AUKEN, Howard. Barriers to innovation among Spanish manufacturing SMEs. **Journal of Small Business Management**, v. 47, n. 4, p. 465-488, 2009.

MOWERY, David; ROSENBERG, Nathan. The influence of market demand upon innovation: a critical review of some recent empirical studies. **Research policy**, v. 8, n. 2, p. 102-153, 1979.

MYERS, Sumner; MARQUIS, Donald George. Successful industrial innovations. A study of factors underlying innovation in selected firms. 1969.

NELSON, Richard R.; WINTER, Sidney G. In search of useful theory of innovation. **Research policy**, v. 6, n. 1, p. 36-76, 1977.

OLAVARRIETA, Sergio; VILLENA, Mauricio G. Innovation and business research in Latin America: An overview. **Journal of Business Research**, v. 67, n. 4, p. 489-497, 2014.

ÖZÇELIK, Emre; TAYMAZ, Erol. Does innovativeness matter for international competitiveness in developing countries?: The case of Turkish manufacturing industries. **Research policy**, v. 33, n. 3, p. 409-424, 2004.

PAVITT, Keith. Sectoral patterns of technical change: towards a taxonomy and a theory. **Research policy**, v. 13, n. 6, p. 343-373, 1984.

PELLEGRINO, Gabriele; SAVONA, Maria. No money, no honey? Financial versus knowledge and demand constraints on innovation. **Research Policy**, v. 46, n. 2, p. 510-521, 2017.

PORTER, Michael E. The five competitive forces that shape strategy. **Harvard business review**, v. 86, n. 1, p. 25-40, 2008.

RESENDE, Marcelo; STRUBE, Eduardo; ZEIDAN, Rodrigo. Complementarity of innovation policies in Brazilian industry: An econometric study. **International Journal of Production Economics**, v. 158, p. 9-17, 2014.

ROSENBERG, Nathan. **Inside the black box: technology and economics**. Cambridge University Press, 1982.

SAVIGNAC, Frédérique. The impact of financial constraints on innovation: evidence from French manufacturing firms. 2006.

SCHMOOKLER, Jacob. Invention and economic growth. 1966.

SOK, Phyra; O'CASS, Aron. Achieving superior innovation-based performance outcomes in SMEs through innovation resource–capability complementarity. **Industrial Marketing Management**, v. 40, n. 8, p. 1285-1293, 2011.

STOCK, James H.; WRIGHT, Jonathan H.; YOGO, Motohiro. A survey of weak instruments and weak identification in generalized method of moments. **Journal of Business & Economic Statistics**, v. 20, n. 4, p. 518-529, 2002.

TIWARI, Amaresh K. et al. Financial constraint and R&D investment: Evidence from CIS. In: **Determinants of Innovative Behaviour**. Palgrave Macmillan, London, 2008. p. 217-242.

TSAI, Kuen-Hung; HSIEH, Ming-Hung; HULTINK, Erik Jan. External technology acquisition and product innovativeness: The moderating roles of R&D investment and configurational context. **Journal of Engineering and Technology Management**, v. 28, n. 3, p. 184-200, 2011.

TSAI, Kuen-Hung; WANG, Jiann-Chyuan. Inward technology licensing and firm performance: a longitudinal study. **R&d Management**, 37.2: 151-160, 2007.

TSAI, Kuen-Hung; WANG, Jiann-Chyuan. External technology acquisition and firm performance: A longitudinal study. **Journal of Business Venturing**, v. 23, n. 1, p. 91-112, 2008.

URRACA-RUIZ, Ana; DE AMORIM, Renata Bhawan. Diferenças de comportamento inovador entre empresas nacionais e estrangeiras no Brasil. **Revista Brasileira de Inovação**, v. 9, n. 1, p. 29-68.

VEUGELERS, Reinhilde; CASSIMAN, Bruno. Make and buy in innovation strategies: evidence from Belgian manufacturing firms. **Research policy**, v. 28, n. 1, p. 63-80, 1999.

VON HIPPEL, Eric. The dominant role of users in the scientific instrument innovation process. **Research policy**, v. 5, n. 3, p. 212-239, 1976.

WHITE, Halbert. A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity. **Econometrica: Journal of the Econometric Society**, p. 817-838, 1980.

WOOLDRIDGE, Jeffrey M. **Econometric analysis of cross section and panel data**. MIT press, 2010.

ZUNIGA, Pluvia; CRESPI, Gustavo. Innovation strategies and employment in Latin American firms. **Structural Change and Economic Dynamics**, v. 24, p. 1-17, 2013.

5 CONCLUDING REMARKS

The objective of this section is to discuss the proposal of the dissertation, synthesize the contributions in both industrial and academic fields and present avenues for future research.

5.1 FINAL DISCUSSION ON THE DISSERTATION PROPOSAL

Innovation has been calling attention of many scholars in the last decades. As seen throughout this dissertation, its role has been acknowledged to be fundamental for industry growth. However, in emerging economies, the studies around the topic are still maturing. In this dissertation we found several gaps in research are still opened, urging for contributions from both academia and industry. In this regard, we focused on one of the research avenues we identified from literature: innovation barriers.

This study presents a comprehensive insight about the different obstacles that inhibit industrial sectors from innovating in Brazil. Furthermore, this study also contributes for the analysis of these obstacles as antecedents for the adoption of innovation strategies. Therefore, we firstly focused our investigation around industrial cooperation, since this strategy has been extensively pointed out as important for innovation (Luzzini et al., 2015; Robin and Schubert, 2013; Lewandowska et al., 2016). Secondly, we analyzed the two most common Brazilian innovation activities: Market-orientation and Technology-acquisition (Goedhuys and Veugelers, 2012; Frank et al., 2016).

The first article contributed with a systematic literature review. Through this work, it was possible to identify the weaknesses of the Brazilian industrial innovation system, which served as basis for the conduction of the two following studies. The second article addressed the role of innovation barriers as triggers for the adoption of industrial cooperation in Brazil. Finally, the third article focused on the study of innovation barriers as antecedents of innovation strategies in Brazil.

5.2 ACADEMIC CONTRIBUTIONS

The three manuscripts present individual contributions which are, in turn, integrated in the general scope of this dissertation. The first article contributes with a research

agenda. This was drawn based on the weaknesses and needs of the Brazilian industrial innovation system identified on the systematic review. These results allow future academics to explore key areas of industrial innovation in the country. Moreover, it contributes to the understanding about the state of the art of industrial innovation studies in Brazil.

The second article promoted insights in line with previous research, since it identified significant relations between certain innovation barriers and cooperation. It was found that some barriers lead industrial sectors to cooperate. The results may shed light on the role of cooperation as an alternative to circumvent obstacles. These findings corroborate cooperation as substantial for innovation in industries. This may allow academics to explore the role and contribution of specific partners for the innovation process. Opositelly, it also shed light on the conservative behavior of the Brazilian industry, where certain obstacles, acutally, discourage cooperation.

Finally, based on previous findings of Goedhuys and Veugelers (2012) and Frank et al. (2016) the third article assess whether or not innovation barriers can be considered antecedents of these juxtaposed options. Again, the econometric analysis proved that innovation barriers exert a contribution for the strategic choice of the industry. These strategies, however, are not implemented in a combined way. Instead, they are chosen juxtaposedly. Therefore, these insights should encourage future research to understand and explore better alternatives to circumvent obstacles. Perhaps, by exploring these strategies in combination (Tsai and Wang, 2007; Tsai et al., 2008; Tsai et al., 2011).

5.3 PRACTICAL CONTRIBUTIONS

In light of the results found, the present dissertation brings different contributions for practitioners. The first article presents more theoretical aspects of innovation. Even though, it is useful for practitioners as a map of findings. Hence, based on the identification of their own needs, practitioners can use these findings to promote better practices. Furthermore, the 2º and 3º articles highlight strategic aspects that industries must be aware of for a better implementation of their innovation activities.

More specifically, the 2º article may encourage practitioners to investigate how cooperation can be implemented more effectively. Since this article identified that certain barriers are triggers for cooperation, industries should be encouraged to foment cooperation. The 3º article, in turn, may support practitioners in what regards the

development of innovation activities. In this sense, this study may delineate insights about ‘Why’ certain industrial innovation strategies are adopted and ‘How’ they should be.

5.4 FUTURE RESEARCH AVENUES

Based on the results here presented, it is worth to point out that different opportunities for future research. Article 1 brings several opportunities, which are synthesized on a table in the conclusions section. Also, articles 2 and 3 present important insights for future research, although more specific.

In what regards article 1 suggestions, I recommend to revisit the conclusions section for a more detailed orientation. However, it is worth to discuss here about future research that emerged from the conclusions in the 2º and 3º articles. In this sense, article 2 analyzed cooperation in its general comprehension, not differentiation, therefore, the strategy among specific partners. Hence, future research could explore in more details the contributions of each partner for industrial innovation. The 3º article approached the two most common innovation strategies in Brazil, corroborating the juxtaposition of its adoption. However, we did not considered similarities among industrial sectors. This can be done in future research using, for instance, cluster analysis.

Secondly, in what tangles the methodology we used, it is worth to highlight its limitations. Firstly, the econometric approach was conducted through cross section analysis. Further research, in turn, could use longitudinal analysis to draw more accurate conclusions. Since innovation is a dynamic phenomenon, an analysis over a longer period would benefit the understanding of these research (Pavitt, 1984; Castellacci, 2008). Secondly, our data was aggregated, which blocks a firm-level understanding. Therefore, researchers could investigate this level of analysis with the same conceptual variable set.

REFERENCES

CASTELLACCI, Fulvio. Technological paradigms, regimes and trajectories: Manufacturing and service industries in a new taxonomy of sectoral patterns of innovation. **Research Policy**, v. 37, n. 6-7, p. 978-994, 2008.

FRANK, Alejandro Germán et al. The effect of innovation activities on innovation outputs in the Brazilian industry: Market-orientation vs. technology-acquisition strategies. **Research Policy**, v. 45, n. 3, p. 577-592, 2016.

GOEDHUYS, Micheline; VEUGELERS, Reinhilde. Innovation strategies, process and product innovations and growth: Firm-level evidence from Brazil. **Structural change and economic dynamics**, v. 23, n. 4, p. 516-529, 2012.

LEWANDOWSKA, Małgorzata Stefania; SZYMURA-TYC, Maja; GOŁĘBIOWSKI, Tomasz. Innovation complementarity, cooperation partners, and new product export: Evidence from Poland. **Journal of Business Research**, 69.9: 3673-3681, 2016.

LUZZINI, Davide, et al. From sustainability commitment to performance: The role of intra-and inter-firm collaborative capabilities in the upstream supply chain. **International Journal of Production Economics**, 165: 51-63, 2015.

PAVITT, Keith. Sectoral patterns of technical change: towards a taxonomy and a theory. **Research policy**, v. 13, n. 6, p. 343-373, 1984.

ROBIN, Stéphane; SCHUBERT, Torben. Cooperation with public research institutions and success in innovation: Evidence from France and Germany. **Research Policy**, 42.1: 149-166, 2013.

TSAI, Kuen-Hung; WANG, Jiann-Chyuan. Inward technology licensing and firm performance: a longitudinal study. **R&d Management**, 37.2: 151-160, 2007.

TSAI, Kuen-Hung; WANG, Jiann-Chyuan. External technology acquisition and firm performance: A longitudinal study. **Journal of Business Venturing**, v. 23, n. 1, p. 91-112, 2008.

TSAI, Kuen-Hung; HSIEH, Ming-Hung; HULTINK, Erik Jan. External technology acquisition and product innovativeness: The moderating roles of R&D investment and configurational context. **Journal of Engineering and Technology Management**, v. 28, n. 3, p. 184-200, 2011.