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**PhD DISSERTATION**

# THE PROCESS OF BUILDING INNOVATION CAPABILITIES

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**PhD DISSERTATION**

# THE PROCESS OF BUILDING INNOVATION CAPABILITIES

PhD dissertation presented to the Graduate Program in Business Administration at the Universidade Federal do Rio Grande do Sul as a final requirement to obtain the title of PhD in Business Administration.

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## ABSTRACT

The main objective of this PhD dissertation is to discuss the process of building innovation capabilities over time. To understand how to couple stability and change into an organized firm over time, it is necessary to understand how the firm is organized based on its internal innovation capabilities arrangement, what are the possible paths to build innovation capabilities and which paths are related to firm's success and failure. Therefore, this PhD dissertation addresses these issues through three sequential papers written from 2017 to 2021 and based on the innovation capability model, proposed by Zawislak *et al*. (2012), encompassing four dimensions (development, operations, management, and transaction capability). The three papers analyze the innovation capabilities of the same sample of manufacturing firms in two different moments in time, 2014 and 2020, and enlighten the discussion on the process of building innovation capabilities. The first paper presents the different types of organization of the firm, the second paper suggests paths to be followed by these firms towards innovation, and finally the third paper presents the process of building innovation and discusses successful and failed paths based on panel data. This PhD dissertation concludes that the process of building innovation capabilities should be toward transaction and development capabilities to ensure competitive performance over time.



**Keywords:** building innovation capabilities, process, change, stability.

## RESUMO

O principal objetivo desta tese de doutorado é discutir o processo de construção de capacidades de inovação ao longo do tempo. Para entender como associar estabilidade e mudança em uma firma organizada ao longo do tempo, é necessário entender como a firma está organizada com base em seu arranjo interno de capacidades de inovação, quais são os caminhos possíveis para construir capacidades de inovação e quais caminhos estão relacionados com o sucesso e fracasso da firma. Esta tese aborda essas questões por meio de três artigos sequenciais escritos de 2017 a 2021 e embasados no modelo de capacidades de inovação proposto por Zawislak *et al*. (2012) que envolve quatro dimensões (desenvolvimento, operação, gestão e transação). Os três artigos analisam as capacidades de inovação da mesma amostra de firmas industriais em dois momentos diferentes, 2014 e 2020, e baseiam a discussão sobre o processo de construção de capacidades de inovação. O primeiro artigo apresenta os diferentes tipos de organização da firma, o segundo artigo sugere caminhos a serem seguidos por diferentes firmas rumo à inovação e, por fim, o terceiro artigo apresenta o processo de construção da inovação e discute caminhos de sucesso e fracasso com base em dados em painel. Esta tese conclui que o processo de construção de capacidades de inovação deve ser voltado para as capacidades de transação e desenvolvimento a fim de garantir um desempenho competitivo ao longo do tempo.



**Palavras-chave:** construção de capacidades de inovação, processo, mudança, estabilidade.

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# INTRODUCTION

Any firm is expected to operate under a stable organizational structure that changes over time (Baecker, 2006; De Clercq *et al*., 2013). This dichotomous behavior is the very essence of successful trajectories. To succeed in the long term, a firm must find a way to undertake the matching of its technology and business – through change and innovation – with the coordination of the organization – through stability and management. Therefore, to prosper and survive, firms must excel at both stability and change (O'Reilly and Tushman, 2013; Pérez *et al*., 2019). In other words, adapting Albert Einstein's simile to riding a bicycle, firms keep their balance only as long as they keep moving (Isaacson, 2007).

To couple stability and change, any firm should be the sum of both a Coasean coordination ability and a Schumpeterian entrepreneurial capability (Zawislak *et al*., 2012; Lai and Lorne, 2014). If, for Coase (1937), the firm can be considered as a coordination structure capable of minimizing the sum of production costs and marketing costs for selling a product, for Schumpeter (1942), the firm, even before being an agent of market, should be an agent of change. It is the entrepreneurial effort that would drive new source, product, process, organization or marketing innovations to further transactions by the firm. Any existing firm should seek to be, though, an organized firm that constantly deals with the Coasean internal coordination (and stability) and the Schumpeterian entrepreneurship (and change). But how to coordinate movement in a structure that seeks for balance over time?

The challenge of coupling stability with change, coordination with entrepreneurship, management with innovation, as natural movements of the progress of any firm, ought to be related to a capabilities-based approach.

## *Innovation capabilities*

Following an evolutionary approach, scholars have been discussing such dichotomy through different lenses, especially those related to the capabilities of firms: technological capabilities (Lall, 1992; Bell and Pavitt, 1995; Pavitt, 1998; Kim, 1999; Madanmohan, Kumar and Kumar, 2004), dynamic capabilities (Teece, Pisano and Shuen, 1997; Winter, 2003; Teece, 2016, 2017), organizational capabilities (Nelson and Winter, 1982; Chandler, 1992; Rosenbloom and Christensen, 1994; Dosi, Nelson and Winter, 2000), routines (Nelson and

Winter, 1982; Helfat, 2018; Nelson, 2018), and organizational learning (Cohen and Levinthal, 1990; Malerba, 1992; Kogut and Zander, 1996; Lichtenthaler, 2009; Yoon *et al*., 2018).

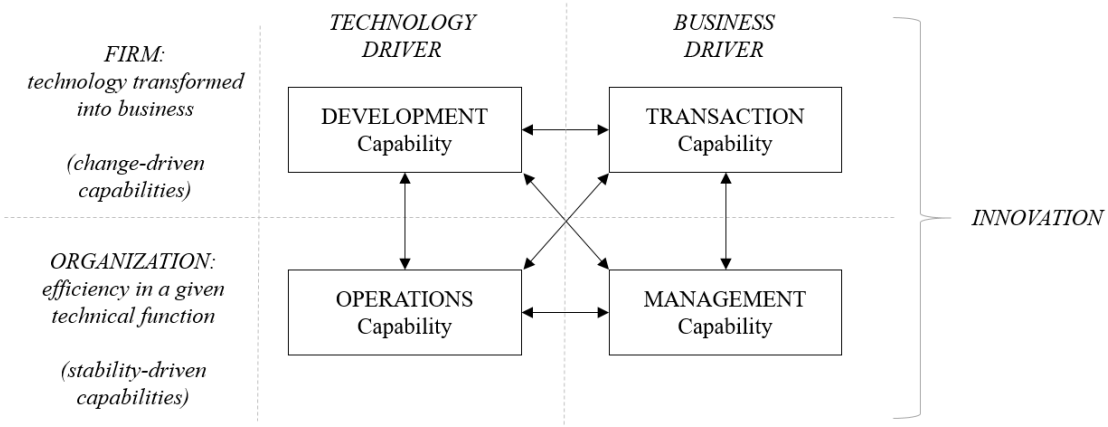
The technological capabilities approach explores the capabilities needed to deal with technological change and innovation. Lall (1992), for example, highlights the power of technological capability as the way firms absorb, process, create, change and generate feasible technical applications (new technology, new processes, new products, new routines) within the knowledge frontier. Dynamic capabilities are defined as the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments (Teece, Pisano, and Shuen, 1997). Dynamic capabilities reflect thus a firm's ability to achieve new and innovative forms of competitive advantage given path dependencies and market positions. Nelson and Winter (1982) argue that organizational capabilities consist largely of the ability to perform and sustain a set of routines. The organization's routine, considered as the way of doing things, is an order that can persist only if it is imposed on a continually changing set of specific resources (Nelson and Winter, 1982). The routines submitted to change will be defined based on organizational learning, which dictates the path to be followed by the firm over time. In fact, organizational learning illustrates how firms can develop their corporate foresight to acquire new capabilities and use such capabilities to create a competitive advantage (Yoon *et al*., 2018). Firms learn in a variety of ways. Particularly in environments where technological advance is very rapid, advance seems to follow advance in a way that appears almost unavoidable to firms. Either way, these various learning processes produce enhancements in the stock of knowledge and technological capabilities of firms, which generate a whole range of trajectories of technological advance and not just cost reduction (Malerba, 1992).

Based on such approaches and on the idea that the organization of the firm is the outcome of the innovative behavior of the firm (Nelson, 2018), coupling stability and change is a matter of balancing innovation capabilities. Innovation capabilities refer to the balanced set of knowledge, technologies, resources, skills, routines and other assets necessary for a firm to function and change its product development, processes operation, resource allocation management and commercial transactions over time (Lawson and Samson, 2001; Guan and Ma, 2003; Yam *et al*., 2011; Bell and Figueiredo, 2012; Zawislak *et al*., 2012; Börjesson *et al*., 2014; Alves *et al*., 2017; Wang and Dass, 2017; Dutrénit *et al*., 2019; Ferreira *et al*., 2020; Figueiredo *et al*., 2020). In short, innovation capabilities reflect the basic dimensions of every firm: product (development capability), process (operations capability), efficient internal

resource coordination (management capability), and coordination of external commercial relations (transaction capability) (Zawislak *et al*., 2012).

Innovation capabilities involve the matching of technology (development and operations capabilities) and business (management and transaction capabilities) within firms. Moreover, through the lens of capabilities, one is able to better capture how the coordination of such capabilities shapes the types of organization of the firm that differently balance stability (operations and management capabilities) and change (development and transaction capabilities) toward innovation. Figure 1 shows a conceptual framework encompassing those capabilities.

**Figure 1. Conceptual framework of innovation capabilities**




Source: Adapted from Zawislak *et al*. (2012)

Each firm must be able to ensure the best arrangement of its different innovation capabilities to increase its innovation performance (Zawislak *et al*., 2012). Therefore, the heterogeneity of firms is based on different arrangements of those capabilities (Bessant *et al*., 2000). Firms may arrange and rearrange their innovation capabilities, moving along different types of organizations in order to deal with the dilemma of stability and change. Therefore, different arrangements of innovation capabilities, balancing stability and change, enable different paths to be followed toward innovation over time.

Firms have different histories and accumulated competences (Dosi, 1991). Their current position is often shaped by the path they have traveled. Where a firm goes is a function of its current position and the paths ahead (Teece *et al*., 1997). Within this context, Sirmon *et al*. (2007) highlight the necessary process by which capabilities are formed, considering past, present and future variables. It is not a matter of having static routines, skills and resources; it

is much more related to developing these routines, skills and resources, i.e., building innovation capabilities (Bell and Figueiredo, 2012; Börjesson *et al*., 2014; Lee, 2019). Thus, to follow the paths toward innovation over time, firms must constantly engage in a process of building innovation capabilities (Lee and Malerba, 2017, 2018).

### *Building innovation capabilities*

Building capabilities for innovation is strongly related to managing change constantly coping existing and new knowledge (Eisenhardt and Martin, 2000; Zollo and Winter, 2002). To build innovation capabilities, firms may choose which types of knowledge to change or augment in light of market opportunities (Helfat, 2018). Firms must be prepared to react to influential changes in the market and to exploit unforeseen opportunities when they occur (Sirmon *et al*., 2007). Firms do so by defining integrative initiatives focused on organization for innovation (Börjesson *et al*., 2014) and by doing so they can move from one type of organization of the firm to another, seeking for more innovation performance.

Building capabilities is then related to the firm' ability to integrate, build, and reconfigure internal and external competences to address changes, given path dependencies and market positions (Leonard-Barton, 1992; Teece, 2007). Even though there is a homogeneity in the way firms share and respond to the system they are embedded in, their internal heterogeneity may lead to different performance over time (Lee and Malerba, 2017). In that sense, considering firms' heterogeneity, processes of successfully and unsuccessfully building innovation capabilities are expected. It is then important to know which are the possible paths to build innovation capabilities and which paths are related to firm's success – and failure.

Thus, considering the conceptual framework proposed in Figure 1, which relates, on the one hand, technology and business, and on the other hand, stability and change, it is possible to propose that the process of building capabilities is prone to succeed whenever firms focus on change-driven capabilities, involving both technological and business (non-technological) drivers. In other words, since innovation will always rely on change, the firm that bets on development and transaction is more likely to succeed on the process of building capabilities than a firm that bets on operations and management, mainly priming for stability.

Thus, **the main objective of this PhD dissertation is to discuss the process of building innovation capabilities over time.** To understand how to couple stability and change into an organized firm over time, it is necessary to understand how the firm is organized based

on its internal innovation capabilities arrangement, what are the possible paths to build innovation capabilities and which paths are related to firm's success and failure.

***The study***

This PhD dissertation addresses these issues through three sequential papers written from 2017 to 2021 and based on a model proposed by Zawislak *et al*. (2012) encompassing four innovation capabilities (development, operations, management, and transaction capability). This model proposes a bunch of variables that represent the different capabilities and the innovation performance of the firm. The same 20 variables of innovation capabilities are analyzed in the three papers (Table 1).

**Table 1. Variables about innovation capabilities and performance**

| Capability | Variables |
|---|---|
| Development | ✓ Designs its own products<br>✓ Monitors the latest technological trends in the sector<br>✓ Adapts the technology in use to its own needs<br>✓ Prototypes its own products<br>✓ Uses formal project management methods (Stage-Gate, PMBOK, innovational funnel, etc.)<br>✓ Launches its own products |
| Operations | ✓ Carries out the productive process as programmed<br>✓ Establishes a productive routine that does not generate rework<br>✓ Delivers the products promptly<br>✓ Manages to expand the installed capacity whenever necessary<br>✓ Manages to ensure that the process does not lead to products being returned |
| Management | ✓ Formally defines its strategic goals annually<br>✓ Updates its management tools and techniques<br>✓ Maintains the personnel adequately trained<br>✓ Uses modern financial management practices |
| Transaction | ✓ Conducts formal research to monitor the market<br>✓ Imposes its negotiating terms on its suppliers<br>✓ Imposes its prices on the market<br>✓ Imposes its negotiating terms on its customers<br>✓ Uses formal criteria to select its suppliers |
| Performance | ✓ Profit growth<br>✓ Market share growth<br>✓ Revenue growth |

In this PhD dissertation, data from two rounds of an innovation survey conducted by the NITEC Innovation Research Center were analyzed. The two rounds were carried out respectively in 2014 and in 2020 and focused on understanding the innovation dynamics in Brazilian manufacturing firms through a questionnaire based on the model proposed by

Zawislak *et al*. (2012). The survey received 1,331 valid responses from senior managers or owners of firms in 2014. In 2020, while 366 out of those firms have remained operating (from which 300 represented valid responses regarding the innovation capabilities), 230 were found to have closed their doors – 735 could not be reached or did not want to answer the survey. The three papers analyze the innovation capabilities of the same sample of manufacturing firms in different moments in time: the first and second papers analyze data of the 2014 round and the third paper analyzes data of both rounds, 2014 and 2020. The three papers together enlighten the final discuss on the process of building innovation capabilities. The first paper presents the different types of organization of the firm, the second paper suggests paths to be followed by these firms toward innovation, and finally the third paper presents the process of building innovation and discusses successful and failed paths based on panel data. Table 2 presents the highlights of each paper.

**Table 2. Highlights of the papers of the PhD dissertation**

| Paper ID | Title | |
|---|---|---|
| **1** | **Innovation capabilities and the organization of the firm: evidence from Brazil** | |
| **Main objective** | **Publication** | **Authors** |
| The purpose of the paper is to examine different types of organization of the firm considering the innovation capabilities of manufacturing firms. | Journal of Manufacturing Technology Management, Vol. ahead-of-print No. ahead-of-print, 2021. https://doi.org/10.1108/JMTM-02-2021-0054 | Nathália Pufal and Paulo Antônio Zawislak |
| **2** | **Innovation capabilities and catch-up: evidence from manufacturing firms in Brazil** | |
| **Main objective** | **Publication** | **Authors** |
| The aim of this study is to identify paths to build firm innovation capabilities for a competitive reconversion to catch-up. | First Conference on Micro-dynamics, Catching-Up and Global Value Chains, Bocconi University, Italy, 2019.<br><br>The paper has received the Marie Skłodowska Curie Award: Best Young Scholar Paper. | Nathália Pufal, Paulo Antônio Zawislak, and Fernanda Maciel Reichert |
| **3** | **The process of building innovation capabilities: success and failure of Brazilian manufacturing firms** | |
| **Main objective** | **Publication** | **Authors** |
| The aim of this study is to identify the process of building innovation capabilities by analyzing the different arrangements of capabilities that are responsible for firms' success and failure over time. | Early versions of the paper have been presented at the R&D Management Conference 2021, Glasgow - online, and 18th International Schumpeter Society Conference 2021, Rome - online. | Nathália Pufal, Paulo Antônio Zawislak, and Nicholas Vonortas |

Note: The permission letters of co-authors are presented in the Appendix.

In the first paper, from an innovation capabilities approach, it was possible to identify different types of organization of the firm. From the original 1,331 firms in 2014, the cluster analysis presented 1,156 valid responses, which is the total sample considered in the paper. The variables of development and transaction capabilities were grouped, forming the change-driven capabilities construct. The variables of operations and management capabilities were also grouped, forming the stability-driven capabilities construct. The change and stability capabilities of each different type of organization of the firm were analyzed through multivariate data analysis techniques.

Results show four different types of organization of the firm: advanced, intermediate and basic stability-oriented, and change-oriented. Each type presents a different innovation capabilities arrangement. The successful strategies toward innovation are related to change-oriented organization of the firm and advanced stability-oriented organization of the firm. The advanced stability-oriented firms not only present the highest operations and management capabilities means, but also the highest levels of development and transaction capabilities within the sample, that is, they are the more overall balanced firms. Firms with change-oriented organization focus more on development capability than on any other capability.

In the second paper, the aim is to identify paths to build firm innovation capabilities for a competitive reconversion to catch-up. Such paths are based on the identification of different combinations of existing capabilities within incumbent firms, considering their different innovation performances. From the original database of 1,331 firms in 2014, a total of 1,327 firms informed their manufacturing industry, which is the total sample considered in the paper. The 1,327 firms were divided and analyzed according to the classification of manufacturing industries by the Organization for Economic Cooperation and Development (OECD, 2011): low-, medium low-, medium high-, and high-technology industries on the basis of research and development (R&D) intensities. Firms are analyzed using fuzzy-set QCA so that the paths to build firm innovation capabilities can be identified.

Results show that incumbent manufacturing firms in Brazil may either prepare capabilities to catch-up or be already in the process of catching up. To catch-up, firms acting in low-tech and medium low-tech industries should adopt a focus on differentiation, either in terms of development or transaction, having operations and management as support. They should become what one may refer to as ‘the high-tech of low-tech’, i.e., invest in product development and create a special solution to be sold in the market. Thus, to catch-up, firms with lower technology intensity need to build change-related capabilities over time, i.e., development and

transaction capabilities. It is expected that these firms promote internal changes, triggered by in-house research development, external alliances, product differentiation and so on (Lee, 2013). Firms acting in medium high-tech and high-tech industries can be seen as already in the process of catching up. They have management as a necessary condition for innovation performance with the support of operations, when seeking for productive efficiency, or of transaction, when dealing with negotiation power. In other words, these firms already have development capability to the necessary extent. Thus, development should already be settled in catching-up firms with higher technology intensity. They should, in fact, focus on building transaction capability to change business patterns, while considering stability-driven capabilities, such as management and operations, to support growth.

In the third paper, the discussion narrows down to the process of building innovation capabilities considering the firms that have remained operating after six years vis-à-vis firms that have closed their doors. In order to identify the process of building innovation capabilities and discuss success and failure paths, it is needed to know which are the capabilities, how they are actually arranged within firms and how they impact performance over time. This has been done by analyzing data of the two rounds of the same survey, in 2014 and 2020. Therefore, the paper analyzes panel data of 300 firms (from the original database of 1,331 firms in 2014) that remained operating in 2020 and data of the 230 firms that closed their doors in this interval. Econometric panel data analysis, descriptive statistics, mean and regression analyses are used to identify capabilities responsible for firm survival and failure over time.

To thrive over time, successful firms have incorporated more development capability into their set, in a way that transaction and development capabilities became responsible for more innovative performance over time. Firms that have remained focusing on operations and management and have not built the capabilities that mostly impact performance over time have closed their doors. Only firms that balanced non-technological (business) capabilities and technological capabilities (transaction and development, or change-driven capabilities) to offer distinguished products in the market remained active.

The paths to success, i.e., the path that will lead the firm toward growth and innovation involves building more transaction and development capabilities over time. The path to failure, i.e., the path that will lead the firm to deviate its focus and most likely close the doors in the future, is one majorly related to focusing on operations and management capabilities, priming for efficiency instead of selling different products.

All three papers are based on the idea that every firm is both a technology and a business, constituted upon some competitive advantage. Once established, to keep operating and maintain the competitive advantage, firms have to build capabilities that support its original idea. Therefore, the three papers analyze the innovation capabilities of firms to enlighten the discussion on the process of building innovation capabilities. The three papers are presented in sequence in the next sections and then concluding remarks are made to wrap the discussion up.

# PAPER 1

## Innovation capabilities and the organization of the firm: evidence from Brazil[1][2]

[1] Paper published in the Journal of Manufacturing Technology Management, Vol. ahead-of-print No. ahead-of-print, 2021, https://doi.org/10.1108/JMTM-02-2021-0054.
[2] Authors: Nathália Pufal and Paulo Antônio Zawislak

# INNOVATION CAPABILITIES AND THE ORGANIZATION OF THE FIRM: EVIDENCE FROM BRAZIL


## Purpose

The purpose of this paper is to examine different types of organization of the firm considering the innovation capabilities of manufacturing firms.

## Design/methodology/approach

The authors carried out an innovation survey with Brazilian manufacturing firms. A sample of 1,156 firms was analyzed in this paper. Collected data were analyzed using multivariate data analysis techniques. From an innovation capabilities approach, it was possible to identify different types of organization of the firm.

## Findings

Results show four different types of organization of the firm: advanced, intermediate and basic stability-oriented, and change-oriented. Each type presents a different innovation capabilities arrangement. The successful strategies towards innovation are related to change-oriented organization of the firm and advanced stability-oriented organization of the firm.

## Originality

The study is based on a unique dataset that traces a large set of companies, being able to check different types of firm organization and associate it with innovation capabilities. The study relates to an emerging economy which have not received adequate attention until now, largely because of the lack of micro-level data. The study is based on a robust theoretical model of innovation capabilities which is being tested through such data. Finally, results elucidate ways to improve innovation performance of firms.


**Keywords**: innovation, organizational change, capabilities, competitive strategy.

## 1. INTRODUCTION

This article aims to examine different types of organization of the firm based on innovation capabilities. Considering that the arrangement of innovation capabilities will give shape to the different forms that any firm must organize itself, it is essential to understand its intricacies. Based on that, firm theorists and practitioners will be able to better deal with its structure and, mainly, to make more assertive strategic decisions on how to manage change and stability concomitantly.

Richardson (1972) presented the idea that capabilities are determinants of the boundaries of the firm, since they determine the relative costs of different firms in organizing particular activities (Langlois and Foss, 1999). Resources, information, skills, routines, transaction costs, among others, allow considering the organization of the firm as the result of intertwined capabilities (Foss, 1996). Therefore, the heterogeneity of firms is based on different combination of those capabilities, and, mainly, accordingly to how they are connected to the need to innovate (Bessant *et al.*, 2000). Considering that the process of configuring and arranging the different capabilities of a firm relates to the process of designing, developing and organizing its knowledge, structures, resources, routines and skills towards new solutions, hereinafter we refer to the capabilities of the firm as 'innovation capabilities'. The coordination of such capabilities shapes the types of organization of the firm that differently balance change and stability within this process of generating new solutions.

Any firm operates under a stable organizational structure and changes over time, by internal or external forces (Baecker, 2006; De Clercq *et al*., 2013). From stability organizational goals to change challenges, the company must rely on its innovation capabilities to thrive. It is our major assumption that firms may arrange and rearrange their innovation capabilities, moving along different types of organizations in order to deal with the dilemma of change and stability.

The organization of the firm has been discussed with different lenses over time. The theory of the firm (mostly with Coase, 1937; Penrose, 1959; and Williamson, 1985) deals with fundamental issues such as the nature and growth of the firm, considering the costs of organization, governance and transaction. The field on strategic management (Mintzberg, 1989; Lazonick, 1992; Teece *et al.*, 1997; Langlois, 2003) proposed concepts and toolboxes for planning and coordinating the growth of the firm. Recently, managerial economics discipline has been focusing on operational challenges, such as optimal input procurement, resource orchestration, principal-agent problem, innovation success factors and specialized investments

(Brandon and Guimaraes, 2016; Cingano and Pinotti, 2016; Zoo *et al.*, 2017; Cruz et *al.*, 2018; Guimaraes *et al*., 2019; Stucki and Wochner, 2019; Khan *et al.*, 2020).

However, there still lacks further discussion on how the innovation capabilities help on shaping the organization of the firm and thus the strategic realm of the company. Considering that the organization of the firm is a function of the coordination of the innovation capabilities, this paper aims at narrowing the existing gap by analyzing different types of organization of the firm based on innovation capabilities. By doing so, this paper provides guidelines so that managers can conduct changes within their companies towards more innovation and superior performance.

In order to identify different types of organization of the firm, we have investigated and analyzed the innovation capabilities of 1,156 Brazilian manufacturing firms. Results show four different types of organization of the firm: *advanced*, *intermediate* and *basic stability-oriented*, and *change-oriented*. For each type there is a different arrangement of innovation capabilities. The successful strategies towards innovation are related to *change-oriented organization of the firm* and *advanced stability-oriented organization of the firm*.

The paper proceeds as follows. The next section presents a literature review, elucidating the concepts of firm, organization and innovation capabilities. After that, the method is presented. In the fourth section, results are presented and, in the fifth section, results are discussed. Finally, the paper consolidates the findings and ends with the concluding remarks.

## 2. LITERATURE REVIEW

To deepen the understanding of the organization of the firm we shall depict the words firm and organization. If, in everyday life, they are taken as synonyms, here we propose to consider them as different however intertwined concepts. In Penrose's words (1959, p. 28), 'the business firm, as we have defined it, is both an administrative organization and a collection of productive resources'. Somehow, it is as if the company has two sides: the firm-side and the organization-side.

On the one hand, the firm-side of the business company refers to the economic agent that masters knowledge and applies technology in order to develop and sell valuable products over time. From an industrial organization point of view, the company exists as a firm in the market through transactions, change and innovation (Grether, 1970; Graham *et al*., 2018). However, to do so, the firm has to internally transform specific knowledge into an efficient,

well-arranged set of procedures, decision rules, specific skills, and technology (Coase, 1937). Thus, on the other hand, this internal operations and management structure is its organization-side, constantly dealing with formalization, coordination and stability (Pufal *et al*., 2014; Brunswicker and Schecter, 2019).

### *2.1 The Organization of the Firm*

To succeed in the long term, a firm must find a way to undertake the matching of its technology and marketing, through change and innovation, with the organization, through stability and management – constantly coupling existing and new knowledge. In fact, to prosper and survive, firms must excel at both change and stability, even though tensions emanate from their different knowledge management processes (Tushman and O'Reilly, 1996; O'Reilly and Tushman, 2013; Pérez et *al.*, 2019). However, identifying the right way to do so is not a simple task, and has consumed researchers for quite some time (Zang and Li, 2016; Walrave *et al*., 2017; Kuo *et al.*, 2018; Cui *et al*., 2019; Ferreira *et al*., 2021).

Those processes are related to strategic behaviors; either focus on costs – as for management and the internal organization, or focus on value – as for innovation and the firm performance in the market (Keren and Levhari, 1983; Baecker, 2006; Teece, 2017). However, it is our assumption that change and stability should be taken together rather than separately (Colombo and Delmastro, 2002; Pufal *et al*., 2014).

To couple these dichotomous relations (i.e. value and cost, change and stability, innovation and management), any firm should be the sum of both a *Schumpeterian entrepreneurial capability* and a *Coasean coordination ability* (Zawislak *et al*., 2012; Lai and Lorne, 2014). If, for Coase (1937), the firm can be considered as a coordination structure capable of minimizing the sum of production costs and marketing costs for selling a product, for Schumpeter (1942), the firm, even before being an agent of market, should be an agent of change; it is the entrepreneur's effort that would drive new product, new process, new organization or new marketing innovations to further transactions of the firm.

If the boundedness of different firms configures the complementary external technological interfaces that build transactions in the market (Alves and Zawislak, 2015), the combination of both technological and non-technological internal capabilities gives rise to the organization of the firm.

Any existing firm should seek to be, though, an *organized firm* that constantly deals with Schumpeterian entrepreneurship (and change) and Coasean internal coordination (and stability) – of its products, processes, management and transactions. The way to handle this 'Schumpeterian-Coasean tradeoff' is through the innovation capabilities of the firm.

### *2.2 Coordination of Innovation Capabilities*

Following an evolutionary approach, the organization of the firm is the outcome of the innovative behavior of the firm (Nelson, 2018). Coupling change with stability, entrepreneurship with management, innovation with management, as a natural movement of technical progress, is a capabilities-related issue. In other words, by organization of the firm we are considering the way knowledge, skills, resources, and routines are combined and crystalized into technological and business capabilities, developed and stabilized in order to give the firm enough innovativeness for its products and cost efficiency to its operations and transactions in any given market.

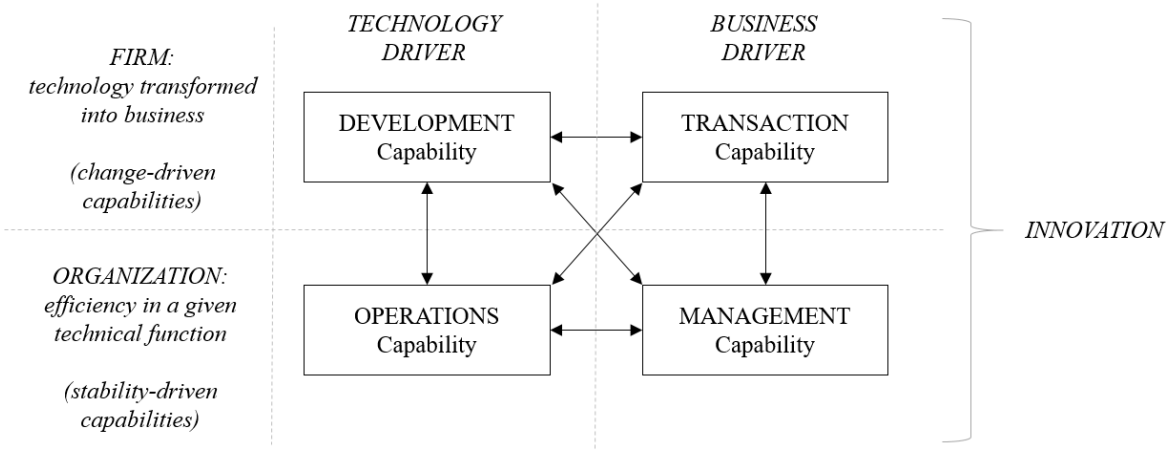
Scholars have been dealing with capabilities for more than 50 years. Since the early work by Richardson (1972), going through seminal research made by Lall (1992), Bell and Pavitt (1995), Teece *et al*., (1997), Dosi *et al*., (2000), Loasby (2010) and others, literature has been focusing on encompassing the definition of innovation capabilities (Figueiredo and Brito, 2012; Lim *et al*., 2013; Börjesson *et al*., 2014; Su *et al*., 2018; Dutrénit *et al*., 2019; Ferreira *et al*., 2020). Aiming at bridging theory to practice, applicable frameworks have been developed to seize the different and integrated innovation and organizational features of a firm (Fujimoto, 2000; Sirmon *et al*., 2007; Figueiredo and Brito, 2012). Innovation researchers have addressed special characteristics of the innovation process as an important factor for implementation success, but many researchers of innovation management have ignored this construct altogether (Guimaraes, 2011). Therefore, there is still an open research question: *how does the firm internally coordinate its different capabilities into a coherent innovative behavior?*

Following the neo-Schumpeterian tradition, where innovation at firm-level is based on different types (i.e. product, process, organization and marketing), Zawislak *et al*. (2012) proposed a four-fold Innovation Capability Model encompassing technological and business capabilities. Their model offers a straightforward framework in which any firm has different combinations of *development, operations, management, and transaction capabilities*. In short,

innovation capabilities deal with technology (development and operations) and business (management and transaction) for the organization of the firm.

By offering a practical analysis, this model helps to analyze innovation capabilities in different firms, as shown in several recent studies (Hartono and Sheng, 2016; El-Awad *et al*., 2017; Guichardaz *et al*., 2019; Oliveira *et al*., 2019; Raghuvanshi *et al.*, 2019, Schiavi *et al*., 2020). Thus, we use this model to identify and detail the different types of organization of the firm. Figure 1 shows the research framework for the coordination of innovation capabilities. It highlights both the capabilities related to the firm essence and those related to the organizational structure of the company.

**Figure 1. The Coordination of Innovation Capabilities Model**




Source: Adapted from Zawislak *et al*. (2012).

*Development capability* and *transaction capability* give body to the very essence of the *firm*. i.e. to transform technology into business by taking a product to the market. The firm must track and master the technical progress in order to formally translate it into ever-changing products, priming for value adding and innovation. Thus, we consider these capabilities as **change-driven capabilities** (Lall, 1992; Bell and Pavitt, 1995; Wang and von Tunzelmann, 2000). Change-driven capabilities relate to the concept of exploration, associated to ground-breaking improvisation, autonomy, chaos, and emerging markets and technologies (March, 1991; Yalcinkaya *et al*., 2007; Ferreira *et al*., 2020).

Conversely, the combination of *operations capability* with *management capability* constitutes the pillars of the *internal organization*, i.e. the standards of quality, the seek for cost reduction, productivity and efficiency for running any given process, its technical functioning

and the optimal allocation of resources (Pufal *et al*., 2014; Wu *et al*., 2010). Thus, we consider these capabilities as **stability-driven capabilities**. Such capabilities relate to the concept of exploitation, which refers to refining existing knowledge, skills and resources (March, 1991; Benner and Tushman, 2003; Ferreira *et al*., 2020).

In order to settle quality, productivity and efficiency standards, however, it is necessary to have, previously, the boundaries of a technology defined and the resulting product developed. In this sense, we will consider hereinafter that the stability-driven capabilities, especially in the startup of every company, are dependent on the change-driven capabilities as well as change-driven capabilities must count on stability-driven capability, especially on incumbent companies. Whenever innovation emerges, coordination must find a standing point that must further enable new innovation, and so on.

From this perspective, different levels of and tradeoffs on innovation capabilities brings into light different types of organization of the firm. Thus, *the coordination of the different arrangement of both change- and stability-driven capabilities shapes the types of organization of the firm.*

## 3. METHODS

With the intention to examine different types of organization of the firm through innovation capabilities, we analyzed quantitative data from manufacturing firms in Brazil. Brazil is a prominent case to base our discussion on the organization of the firm at the level of manufacturing sectors.

On the one hand, Brazilian industrial landscape is well diversified, presenting a vast array of manufacturing firms from both low- and high-tech industries (Reichert *et al*., 2015). On the other hand, Brazil as an emerging economy is constrained to deal with opportunities, deficiencies, crisis and growth (Amann and Baer, 2012; Figueiredo and Cohen, 2019). In that sense, Brazil constantly deals with stability and change. In this study, we conducted an unprecedented analysis with Brazilian manufacturing firms, considering the approach of capabilities to verify how different types of organization of the firm are structured.

### *3.1 Data*

We conducted an innovation survey by the NITEC Innovation Research Center (NITEC, 2015) to understand the innovation dynamics in the Brazilian manufacturing industry. The analyzed firms were listed in an existing database provided by the South Brazilian Manufacturing Association (FIERGS, 2010). The survey was conducted with the application of a questionnaire to firms with ten or more employees and received 1,331 responses from the senior manager or owner of firms, composing a response rate of 21.7%. The cluster analysis presented 1,156 valid responses, which is the total sample considered in this paper.

Considering all valid respondents, it was verified that more than 85% of the firms are small, reflecting Brazilian firms' characteristics as a whole. Moreover, 75% of the firms are from low or medium-low tech industries.

### *3.2 Measures*

The measures are based on the Innovation Capability Model proposed by Zawislak *et al.* (2012). They relate the four capabilities (development, operations, management, and transaction capabilities), through 29 variables, with three innovation performance indicators (profit growth, market share growth and revenue growth).

The questionnaire used in the survey had Likert scale questions to measure all four innovation capabilities and performance [see, for example, Reichert *et al*., (2016) and Alves *et al*., (2017) for detailed information on the survey procedures and preliminary statistical analyses]. Table 1 presents the analyzed questions.

**Table 1. Questions on innovation capabilities and performance**

| Company | Capability | Questions: |
|---|---|---|
| **Firm** | Development | The company…<br>✓ Designs its own products<br>✓ Monitors the latest technological trends in the sector<br>✓ Adapts the technology in use to its own needs<br>✓ Develops products in partnerships with Science and Technology Institutions<br>✓ Prototypes its own products<br>✓ Uses formal project management methods (Stage-Gate, PMBOK, innovational funnel, etc.)<br>✓ Launches its own products |
| | Transaction | The company…<br>✓ Conducts research to measure its customers' satisfaction<br>✓ Conducts formal research to monitor the market |

| | | |
|---|---|---|
| | | ✓ Imposes its negotiating terms on its suppliers<br>✓ Imposes its prices on the market<br>✓ Imposes its negotiating terms on its customers<br>✓ Uses formal criteria to select its suppliers |
| **Organization** | Operations | The company…<br>✓ Formalizes the PPC procedures<br>✓ Keeps statistical control of the process<br>✓ Uses leading edge technology in the sector<br>✓ Maintains adequate stock levels of materials for the process<br>✓ Carries out the productive process as programmed<br>✓ Establishes a productive routine that does not generate rework<br>✓ Delivers the product promptly<br>✓ Manages to expand the installed capacity whenever necessary<br>✓ Manages to ensure the process does not lead to products being returned |
| | Management | The company…<br>✓ Formally defines its strategic objectives annually<br>✓ Includes social and environmental responsibilities on its strategic agenda<br>✓ Uses technology to integrate all its sectors<br>✓ Standardizes and documents the work procedures<br>✓ Updates its management tools and techniques<br>✓ Maintains the personnel adequately trained for the company functions<br>✓ Uses modern financial management practices |
| **Performance** | | ✓ The net profit has grown continuously over the last 3 years<br>✓ The company's market share has continuously grown over the last 3 years<br>✓ The company's revenue has continuously grown over the last 3 years |

Respondents rated their level of agreement to each item using a five-point Likert scale ranging from strongly disagree to strongly agree. As a result of our Principal Component Analysis, we remained with 20 from those 29 survey items for further analyses.

### *3.3 Data Analysis*

The analyses used Principal Component Analysis extraction method to reduce the original set of variables into a smaller group and extract latent factors (innovation capabilities). Factors with loading of 0.5 or above and communalities of 0.4 or above were considered as significant (Hair *et al*., 2010). Kaiser-Meyer-Olkin (KMO) measure indicated a value of 0.905 and Bartlett's test of sphericity was significant ($p = 0.000$), which showed adequacy to the conduction of factor analysis (Kaiser, 1974; Field, 2009). The Correlation Matrix did not present any value greater than 0.9 and its determinant was 0.001, greater than the necessary value of 0.0001 (Field, 2009). All the final variables presented meritorious Measure of Sampling Adequacy (>0.84) (Cerny and Kaiser, 1997). The total variance explained for the four factors representing the four innovation capabilities was 57.37%. The results allowed us to categorize four capabilities: development capability (Cronbach's $\alpha = 0.842$), operations capability (Cronbach's $\alpha = 0.789$), management capability (Cronbach's $\alpha = 0.758$) and

transaction capability (Cronbach's α = 0.772). Table 2 presents the list of items and the respective factor loadings.

**Table 2. Factor analysis for innovation capabilities**

| Variables | DC | OC | TC | MC |
|---|---|---|---|---|
| Product Prototyping | .769 | | | |
| Product Launching | .755 | | | |
| Product Design | .750 | | | |
| Technology Monitoring | .678 | | | |
| Technology Adaptation | .649 | | | |
| Formal Project Management | .626 | | | |
| On-time Delivery | | .748 | | |
| Rework | | .739 | | |
| Product Return | | .735 | | |
| Production Planning | | .668 | | |
| Installed Capacity Flexibility | | .607 | | |
| Prices Definition | | | .772 | |
| Customer Negotiations | | | .763 | |
| Supplier Negotiations | | | .742 | |
| Suppliers Selection | | | .647 | |
| Market Monitoring | | | .512 | |
| Financial Management | | | | .745 |
| Updated Management Tools and Techniques | | | | .739 |
| Formal Strategy | | | | .699 |
| HR Training | | | | .661 |

Rotation Method: Varimax with Kaiser Normalization.[a.]

a. Rotation converged in 5 iterations.

Missing values excluded listwise.

Note: DC = Development Capability, OC = Operations Capability, TC = Transaction Capability, MC = Management Capability.

With all factors identified, the variables of development and transaction capabilities factors were grouped, forming thus, the *change-driven capabilities* construct, and the variables of operations and management capabilities factors were also grouped, forming the *stability-driven capabilities* construct.

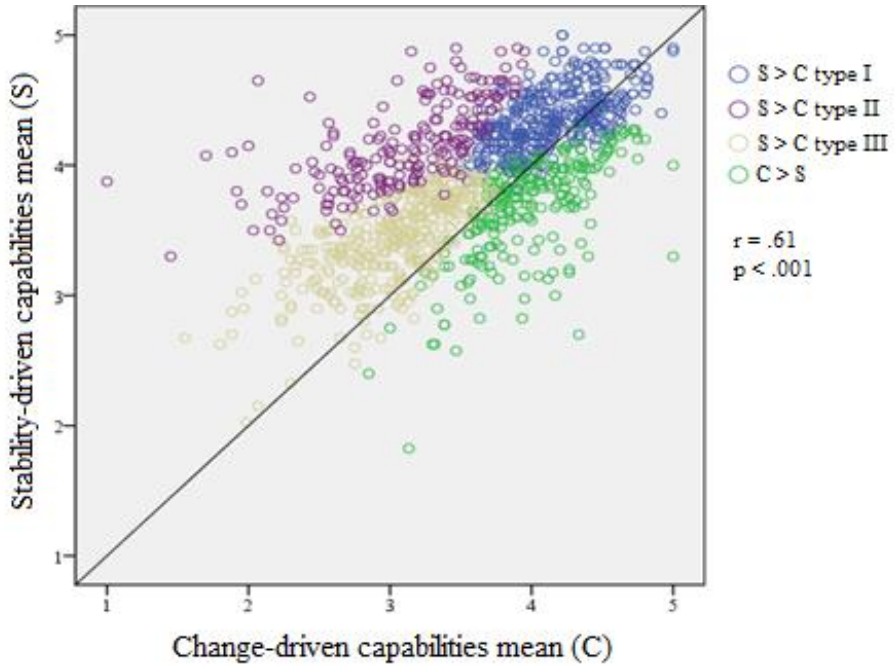
After the factor analysis, a two-step cluster analysis procedure was conducted to reveal natural groupings within the dataset that would otherwise not be apparent (Garson, 2012). Four statistically significant ($p<.001$) different groups were identified. Using regular mean of variables, Pearson Correlation analysis was conducted to investigate the relationship between firm and organization variables of clusters.

Descriptive variables regarding all four capabilities of each cluster were analyzed, as well as each cluster performance indicators. ANOVA and post hoc tests were performed to determine if there was statistically significant difference among the groups and to examine where their differences laid (Hair *et al*., 2010). Frequency of firm size was then analyzed to further explore each cluster and chi-square test evaluated if their distributions differ from one another (Hair *et al*., 2010). The software Statistical Package for Social Science – SPSS version 21 was used.

## 4. RESULTS

By correlating the aforementioned change-driven and stability-driven capabilities (see section 2.2), four different types of organization of the firm were identified within the sample, according to the cluster analysis. The four clusters are shown within the scatter plot in Figure 2.

**Figure 2. Bivariate Scatter Plot with Change and Stability Capabilities Means, Highlighting Four Different Clusters**




These types corroborate with the assumption that change-driven and stability-driven capabilities are correlated ($r = .61$, $p < .001$), showing that when change-driven capabilities (development and transaction capabilities) vary, stability-driven capabilities (operations and management capabilities) also vary. To illustrate that, a scatter plot was created, having change-driven capabilities (noted as C) as the independent variable and stability-driven capabilities (noted as S) as the dependent variable.

The four different types of organization of the firm present distinct patterns. Considering that the equilibrium between C and S is given by the 45-degree line, three types are ‘stability-oriented’ (S > C, where stability-driven capabilities take the lead on the organization of those firms) and one is ‘change-oriented’ (C > S, with change-driven capabilities drawing the organizational boundaries of the firm).

Especially concerning the three ‘stability-oriented’ types of organization of the firm, Table 3 shows that the difference among these three types lies precisely on the decreasing level of their change-driven capabilities means, reinforcing the idea of trade-off among innovation capabilities. One may consider that the lower the change-driven capabilities are, the less innovative the firm is expected to be.

**Table 3. Clusters Mean Analysis of Change and Stability Capabilities**

| Cluster | Change-driven Capabilities (C) | | Stability-driven Capabilities (S) | |
|---|---|---|---|---|
| | **Mean** | Std. Deviation | **Mean** | Std. Deviation |
| **S > C type I** (n=358) | **4.13** | .32 | **4.35** | .24 |
| **C > S** (n=233) | **3.98** | .37 | **3.68** | .39 |
| **S > C type II** (n=200) | **3.10** | .51 | **4.15** | .34 |
| **S > C type III** (n=365) | **3.03** | .40 | **3.44** | .34 |
| **All clusters** (n=1156) | **3.58** | .64 | **3.89** | .50 |

Note: p<.001 for all cases.

Table 4 shows that the *stability-oriented* (S > C) types present, as expected, their highest means both in operations and management capabilities. While, the *change-oriented* (C > S) type presents its highest mean in development capability. These findings corroborate the conceptual framework that we have previously presented (see Figure 1).

**Table 4. Clusters mean analysis of change and stability capabilities divided into the four innovation capabilities**

| | Change-driven Capabilities (C) | | | | Stability-driven Capabilities (S) | | | |
|---|---|---|---|---|---|---|---|---|
| | **DC** | | **TC** | | **OC** | | **MC** | |
| **Cluster** | **Mean** | SD | **Mean** | SD | **Mean** | SD | **Mean** | SD |
| **S > C type I** (n=358) | **4.27** | .43 | **3.99** | .46 | **4.40** | .35 | **4.29** | .40 |
| **C > S** (n=233) | **4.14** | .49 | **3.82** | .52 | **3.83** | .47 | **3.53** | .58 |
| **S > C type II** (n=200) | **3.21** | .84 | **2.98** | .65 | **4.25** | .46 | **4.05** | .49 |
| **S > C type III** (n=365) | **3.08** | .71 | **2.99** | .57 | **3.57** | .49 | **3.32** | .57 |
| **All clusters** (n=1156) | **3.69** | .83 | **3.47** | .72 | **4.00** | .57 | **3.79** | .66 |

Note: SD = Standard Deviation, DC = Development Capability, TC = Transaction Capability, OC = Operations Capability, MC = Management Capability.

Even though all capabilities are different among the clusters (p = .000), Scheffé test shows that some differences within the clusters are not statistically significant (see Appendix 1 for details). *Stability-oriented (S > C) type I* and *change-oriented (C > S* ) firms behave

similarly in terms of high level of development capability (p = .107). *Stability-oriented (S > C) type II* and *type III* firms behave similarly both in development capability (p = .114) and transaction capability (p = .999).

Given that innovation strategy positively influences firms' business performance (Bayraktar *et al*., 2016; Kafetzopoulos *et al*., 2019), Table 5 shows the mean and standard deviation of the clusters' performances. All four clusters are significantly different (p ≤ .005) in terms of performance (see Appendix 2 for details). *stability-oriented (S > C) type I* firms present the highest economic returns, underlining that stability-driven capabilities, relating to organization, do impact on performance, as indicated by Chang *et al*. (2012).

**Table 5. Clusters Mean Analysis of Performance**

| Cluster | Performance | |
|---|---|---|
| | **Mean** | **Std. Deviation** |
| **S > C type I** (n=358) | **3.92** | .58 |
| **C > S** (n=233) | **3.63** | .73 |
| **S > C type II** (n=200) | **3.36** | .85 |
| **S > C type III** (n=365) | **3.13** | .74 |
| **All clusters** (n=1156) | **3.52** | .78 |

Note: p<.001 for all cases.

Regarding firm size, all clusters present mostly small firms (Table 6). That is strictly related to the predominance of small firms within the analyzed sample, which reflects the predominance of small firms in the universe of manufacturing firms in Brazil (Reichert *et al*., 2015). The difference in firm size among clusters, though, is significant (p = .000).

**Table 6. Clusters by size**

| Cluster | Size | | |
|---|---|---|---|
| | **Small** | **Medium** | **Large** |
| **S > C type I** (n=350) | 83% | 15% | 2% |
| **C > S** (n=228) | 82% | 17% | 1% |

| | | | |
|---|---|---|---|
| **S > C type II** (n=196) | 94% | 6% | 0% |
| **S > C type III** (n=362) | 95% | 5% | 0% |
| *Missing (n=20)* | | | |

Chi-square (12df) = 46.706

Likelihood Ratio (12df) = 53.054*

Note: *p = .000

Noteworthy is that the clusters with *stability-oriented (S > C) type I* and *change-oriented (C > S)* firms contain relatively more medium and large firms than the other two clusters. Based on that, it is possible to verify that firms that present higher levels of both change and stability-driven capabilities are more prone to be large. That corroborates to the explanation of Audretsch and Acs (1991) that large companies have greater propensity to innovate than small companies. On the other hand, the clusters with *stability-oriented (S > C) type II* and *stability-oriented (S > C) type III* do not present any large firm.

Results show that the four clusters present idiosyncrasies considering firm change-driven and organization stability-driven capabilities and thus face different strategies towards innovation. Such results are discussed in the next section.

## 5. DISCUSSION

If the firm develops and transacts a certain product, it ultimately requires an organization to ensure the most efficient (optimal) operation to take that product into the market. In other words, firms' different types of organization relate to different ways on handling the transformation of technology into market value and, thus, in terms of internal innovation capabilities arrangement.

Consequently, firms with predominance of stability-driven capabilities focus on operations, while those with predominant change-driven capabilities focus on development. Therefore, we entitle the four identified types as follows:

(1) *advanced stability-oriented organization of the firm (S > C type I);*

(2) *intermediate stability-oriented organization of the firm (S > C type II);*

(3) *basic stability-oriented organization of the firm (S > C type III); and*

(4) *change-oriented organization of the firm (C >S).*

To further explore the different types of organization of the firm, we analyzed their descriptive variables regarding all four capabilities (found in Appendix 3).

## *5.1 Exploring the Types of Organization of the Firm*

Henceforth, we discuss the characteristics of each type of organization of the firm, based on their innovation capabilities and performance indicators.

### *5.1.1 Advanced stability-oriented organization of the firm (S > C type I)*

The *advanced stability-oriented firms* not only present the highest operations and management capabilities means, but also the highest levels of development and transaction capabilities within the sample, i.e. they are the more overall balanced firms. These companies reflect the idea proposed by Nelson (1991) that, in a well-tuned firm, its organization must have built the capabilities to support and complement the new product and process technologies emanating from R&D.

Moreover, these firms have the highest performance indicators. Although being more stability-oriented, they present higher levels of change-driven capabilities as well – even higher than the change-driven firms. This balance reflects companies' ability to convert its ambidextrous posture into enhanced performance, combining internal and external components (De Clercq *et al*., 2013).

Formalization permeates all processes, from development to transaction, ensuring that each activity occurs as planned. The formalization in project management seems to echo in operations, since these firms carry the productive process as programmed, with routines that do not generate rework, and delivering the products promptly. That corroborates to Pufal *et al.* (2014), who state that formal norms and procedures are essential in establishing a standard range of decision rules throughout the organization.

These firms also present high flexibility to expand the installed capacity if necessary and high index of product conformity. Monitoring of technological and market trends allows these firms to keep up to date to the ever-changing demands, profiting from that (Alves *et al*., 2017; Teece, 2017). In addition, personnel are constantly trained and machines and equipment face also systematic improvement.

### *5.1.2 Intermediate Stability-oriented organization of the firm (S > C type II)*

Stability-driven capabilities overcome change-driven capabilities in a more unbalanced way in those firms with *intermediate stability-oriented organization.* Firms in this type present higher means in operations and management capabilities than in development and transactions capabilities and are, therefore, more stability-oriented (Pufal *et al*., 2014). They are referred to as intermediate, because their stability-driven capabilities mean ranks in-between the mean values of the other two stability-oriented types, so-called advanced and basic (as Table 3 shows).

By presenting their highest mean in operations capability, these firms are focused on producing, rather than on developing (Wu *et al*., 2010; Alves *et al*., 2017). They can be perceived as highly effective in ensuring that production is conducted as programmed, promptly delivering products to their customers and assessing high levels of product conformity. In consonance, the higher level of management capability elucidates that there is an adequate established structure that allows the firm to act effectively in terms of operations. On the other hand, they lack development and transaction capabilities. Their management capability ensures not a basic organization structure, but the necessary structure to attend several customers, with flexibility.

### *5.1.3 Basic Stability-oriented organization of the firm (S > C type III)*

Firms with *basic stability-oriented organization* present stability-driven capabilities in a greater extent than change-driven capabilities, but at the lowest level of the whole sample. They not only have the lowest capabilities means in general, but also the lowest performance mean within all firms. In other words, their efforts do not bring the necessary innovative return. They represent the typical structure of reactive supplier firms.

Although presenting management capability as the second most developed capability, these firms present solely the ideal management structure to make basic operations feasible and ensure its coherent course. It is just sufficient to establish the necessary set of tools, techniques, training and financial management to the firm act. Fixed management structures may present bureaucratic decisions and absence of a powerful change culture and high-powered incentives. Such companies are likely to be internally focused and, consequently, external changes in the market and in the science and technology establishment are unlikely to get recognized in a timely fashion (Teece, 1996).

Such companies have lower levels of product prototyping, development and launching in the market. Both technological and market trends monitoring are low, as well as project management formalization. In that sense, they present a transaction capability that allows them to simply deal with customers and deliver what has been previously defined. These firms are the least innovative of all analyzed firms.

### *5.1.4 Change-oriented organization of the firm (C > S)*

Being the only group in which change-driven capabilities are higher than stability-driven capabilities, firms with *change-oriented organization* focus more on development capability than on any other capability. Companies that guide their activities based on the perception of opportunities to be explored, due to the asymmetry of information derived from differentiated knowledge, are those in which firm is more developed than organization (Casson, 2005).

In that sense, firms with *change-oriented organization* invest in other capabilities to the extent that is needed to support their development activities. By doing so, they focus on value adding and maintain firm complexity adequate to ensure positive economic outcomes. Related to that is their highest potential to establish prices in the market.

Behaving similar to firms with *advanced stability-oriented organization* in terms of development capability, firms with *change-oriented organization* have a high level of own product development and prototyping, built on technological trends monitoring and the ability to adapt technologies to their own needs. That shows the agile responsiveness these firms present to market changes whenever necessary, which is essential to maintain their high level of own product launching. Exploring opportunities is the result of an entrepreneurial action (Gartner *et al*., 2010), based on differentiated skills that are, in fact, differentiated knowledge obtained by continuous efforts in research in the fields of science and technology, economics and new markets, which enables the development of potentially innovative products (Park, 2005). The indication of formal project management methods corroborates to the high structured product development activities, ensuring that these firms achieve positive outcomes as planned. This companies are more prone to deal with factors that are proved to improve performance in the areas of organization creativity, such as openness, proactiveness, willingness to take risks, and orientation to the future (Guimaraes and Paranjape, 2017).

### *5.2 Strategies for Organization of the Firm: Coordinating Innovation Capabilities*

As stated by Coriat and Weinstein (2002), understanding how continuity and change combine into the evolution of firms' capabilities is a challenge. Yet, beyond the diversity of organizational types, it seems relevant to identify some dominant principles that ensure different and positive performance for firms.

Our results show that performance is different among the four identified types of organization of the firm, especially higher when firms have *advanced stability-oriented organization* or *change-oriented organization* – both with the highest means of development and transaction capabilities within the sample. That corroborates the idea proposed by Williamson (1991), i.e., the more specific the asset is, the higher its costs will be; but with higher returns.

Moreover, the different capabilities combinations show different organization configurations and thus enlightens different possible strategies for innovation within firms. Rather than simply reducing strategy decision-making to 'cost or value', we consider strategic issues as the result on how to coordinate innovation capabilities for 'cost *and* value'.

Cost effectiveness is relevant to business as well as value adding, so it is our assumption that both must always be taken together, in different sequences. Knight (1921) states that the primary problem or function of the company is on deciding what to do (the firm) and, then, on how to do it (the organization). Operations and management capabilities themselves are not able to sustain a firm without development and transaction capabilities. However, development and transaction will not come to term in the market without operations and management.

The successful firm seeks to transform a specific technology into a new business rather than simply using an existing technology to an established business. While innovation leads to a temporarily disorganization, the lack of innovation can also lead to a long-lasting disorganization, since there are "decreasing returns to the entrepreneur function" (Coase, 1937, p. 394) and "diminishing returns to management" (Coase, 1937, p. 395). Thus, the essence of the firm comes prior to the organizational challenge, enabling the growth of the firm, while avoiding diminishing returns.

Based on the identification of those four different types of organization of the firm and considering that the organization itself depends on the essence of the firm, the coordination of innovation capabilities succeeds when performance is higher. Under these conditions, two different strategic pathways that companies may follow towards innovation are highlighted.

### *5.2.1. Coordinating after Innovating*

The expected growth of the firm, because of the gains from innovation, ought to be based on the consequent enhancement of its administrative unit. As originally suggested by Penrose (1959), to each knowledge unit that allows a new transaction to be internalized (innovation), it is needed one more unit of organization (coordination). Somehow, it is if as the strategy would be focused on 'value leading to cost'.

Firms that have a *change-oriented organization* (change-driven capabilities greater than stability-driven capabilities), as a result of technological or marketing advancements, after having innovated, should develop an organizational structure over time, i.e. management and operations. They have to find a new coordination set to cope with the new innovative behavior and performing level. The goal is to reach efficiency in seeking innovation and coordination, ensuring a long-lasting positive outcome, until the next innovative stage takes place. In short, they need to adapt and enhance their coordination level *after* having innovated.

Once the firm achieves a higher organizational capability structure, under the notion of a well-tuned firm (change-driven capabilities balanced with stability-driven capabilities), or close to that (such as those firms with *advanced stability-oriented organization*), it achieves stability, under the category of *advanced stability-oriented organization of the firm*. However, that does not mean it can remain unchanged. The firm needs to start seeking the next innovation, again and again.

### *5.2.2. Coordinating to Innovate*

If the firm remains with the same technology and organization over time, due to a lack of innovation, the aforementioned diminishing returns are to be unavoidable (Coase, 1937). The firm that does not innovate will tend to stagnate or even fail. In other words, firms need to constantly innovate. In other words, as a previous step to Penrose's growth of the firm, to be able to deal with a new knowledge unit and to internalize a new transaction (innovation), the firm needs first one more unit of organization (coordination). Here, the strategy becomes 'cost leading to value.

To innovate, firms with *advanced stability-oriented organization* must focus first on their change-driven capabilities and evolve their stability-driven capabilities as a sequence of

that. Whenever those firms seek innovation, they generate disequilibria, where the change-driven capabilities momentary become greater than the stability-driven ones. Therefore, firms need to have a flexible and ever-changing organization. In short, the company needs to set its coordination first in order *to* innovate.

Once the firm innovates, it will present then a *change-oriented organization of the firm* configuration and will need to reinitiate the previously discussed path of coordinating after innovating. As stated by Tushman and Nadler (1986, p. 1), "to compete in this ever-changing environment, companies must create new products, services, and processes; to dominate, they must adopt innovation as a way of corporate life".

## 6. CONCLUDING REMARKS

The purpose of this paper has been to examine different types of organization of the firm based on the innovation capabilities of manufacturing firms. We identified different types of organization of the firm and thus outlined different strategies to be pursued by firms towards innovation. Results show four different types of organization of the firm: *advanced, intermediate and basic stability-oriented,* and *change-oriented.*

Actually, innovative firms, from a strict Schumpeterian perspective, are few. The vast majority, regardless of size or industry, is focused on maintaining a given product in a given market. By doing so, focus on cost reduction and efficiency, typically coordination activities – and less related to development – top the agenda of companies. Therefore, this study contributes by elucidating ways to improve innovative performance of firms, followed by consequent organizational changes, constantly dealing with management and innovation.

As results highlight, the successful strategies towards innovation are both related to *change-oriented organization of the firm* and *advanced stability-oriented organization of the firm.* On the one hand, firms that have *change-oriented organization* will seek to organize *after* innovating, developing an organizational structure to fulfill the growing value over time. On the other, firms with *advanced stability-oriented organization* must keep organizing *for* innovation, as a constant flow of disequilibria, where change-driven capabilities may become greater than stability-driven capabilities, and further balance with a new responsive organizational structure.

These straightforward findings can serve as a guideline so that managers can conduct changes within their companies towards more innovation. Managers can reconsider its

organization as a way to foment innovation, once it is identified as a key strategy for competitiveness. Change-driven capabilities, i.e., development and transaction capabilities, should be built as a way to settle the ground for innovation in a more stability-oriented company. After that, once the company has moved towards innovation, stability-driven capabilities, i.e. operations and management capabilities, should be built as a way to support companies' success and growth.

By making a link between theory and practice with empirical data, this paper has two main implications. This study contributes to the literature by presenting a different view on the organization of the firm, encompassing the capabilities approach and thus a higher level on the perception of firms' heterogeneity. This study contributes to narrow the literature gap on how firms internally coordinate its different capabilities into a coherent organization to sustain an innovative behavior. Moreover, this study may help managers understand that focusing on stability-driven capabilities is riskier if change-driven capabilities are not present in an adequate and aligned level of development. The outcome may be the growth of the cost structure greater than the potential return. Conversely, managers should also understand that once change-driven capabilities are in a glance they need do follow up with stability-driven capabilities. Here, the risk is not having an adequate structure to sustain the upcoming growth, arising from innovation. In short, not only 'cost and value' should be taken together, but they must be arranged following the specific situation of the company. Every company should manage costs either to sustain new added value or to allow the addition of new value.

Moreover, the study advances knowledge in several ways. First, it is based on a unique dataset that traces a large set of companies, being able to identify different types of firm organization and associate it with innovation capabilities. Second, it relates to an emerging economy, Brazil, which have not received adequate attention until now, largely because of the lack of micro-level data. Third, the study is based on a robust theoretical model of innovation capabilities which was tested through such data. Fourth, the results elucidate ways to improve innovation performance of firms.

This study has some limitations. First, the fact that the questionnaire is based on respondent's opinion may imply that answers are narrowed to that point of view. However, this limitation has not affected the results in the study, since significant differences were verified among scores. Second, the method used in the cluster analysis may configure another limitation to the study, given that different clustering methods can generate different grouping results, and thus different types of firms could be verified.

Future studies could be conducted through case studies, exploring each type with more details. Besides that, as the present study portrays a static view of the analyzed sample, it is possible to suggest further panel research to capture long-term evolution, highlighting the dynamics of the coordination of innovation capabilities and the organization of the firm.

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**Appendix 1. Scheffé Test between Innovation Capabilities and Clusters.**

| Dependent variable | (I) | (J) | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|---|
| | | | | | | Lower Bound | Upper Bound |
| Development | 1 | 2 | .1297 | .05251 | .107 | -.0173 | .2767 |
| | | 3 | 1.0634* | .05507 | .000 | .9092 | 1.2176 |
| | | 4 | 1.1975* | .04640 | .000 | 1.0676 | 1.3274 |
| | 2 | 1 | -.1297 | .05251 | .107 | -.2767 | .0173 |
| | | 3 | .9337* | .06013 | .000 | .7653 | 1.1020 |
| | | 4 | 1.0678* | .05231 | .000 | .9213 | 1.2142 |
| | 3 | 1 | -1.0634* | .05507 | .000 | -1.2176 | -.9092 |
| | | 2 | -.9337* | .06013 | .000 | -1.1020 | -.7653 |
| | | 4 | .1341 | .05488 | .114 | -.0195 | .2878 |
| | 4 | 1 | -1.1975* | .04640 | .000 | -1.3274 | -1.0676 |
| | | 2 | -1.0678* | .05231 | .000 | -1.2142 | -.9213 |
| | | 3 | -.1341 | .05488 | .114 | -.2878 | .0195 |
| Operations | 1 | 2 | .5767* | .03714 | .000 | .4728 | .6807 |
| | | 3 | .1514* | .03896 | .002 | .0423 | .2604 |
| | | 4 | .8351* | .03282 | .000 | .7432 | .9270 |
| | 2 | 1 | -.5767* | .03714 | .000 | -.6807 | -.4728 |
| | | 3 | -.4254* | .04254 | .000 | -.5445 | -.3063 |
| | | 4 | .2584* | .03700 | .000 | .1548 | .3620 |
| | 3 | 1 | -.1514* | .03896 | .002 | -.2604 | -.0423 |
| | | 2 | .4254* | .04254 | .000 | .3063 | .5445 |
| | | 4 | .6838* | .03882 | .000 | .5751 | .7925 |
| | 4 | 1 | -.8351* | .03282 | .000 | -.9270 | -.7432 |
| | | 2 | -.2584* | .03700 | .000 | -.3620 | -.1548 |
| | | 3 | -.6838* | .03882 | .000 | -.7925 | -.5751 |
| Management | 1 | 2 | .7675* | .04306 | .000 | .6470 | .8881 |
| | | 3 | .2433* | .04516 | .000 | .1169 | .3697 |
| | | 4 | .9734* | .03805 | .000 | .8669 | 1.0800 |
| | 2 | 1 | -.7675* | .04306 | .000 | -.8881 | -.6470 |
| | | 3 | -.5242* | .04932 | .000 | -.6623 | -.3862 |
| | | 4 | .2059* | .04290 | .000 | .0858 | .3260 |
| | 3 | 1 | -.2433* | .04516 | .000 | -.3697 | -.1169 |
| | | 2 | .5242* | .04932 | .000 | .3862 | .6623 |
| | | 4 | .7301* | .04501 | .000 | .6041 | .8561 |
| | 4 | 1 | -.9734* | .03805 | .000 | -1.0800 | -.8669 |
| | | 2 | -.2059* | .04290 | .000 | -.3260 | -.0858 |
| | | 3 | -.7301* | .04501 | .000 | -.8561 | -.6041 |
| Transaction | 1 | 2 | .1665* | .04608 | .005 | .0375 | .2955 |
| | | 3 | 1.0085* | .04833 | .000 | .8732 | 1.1438 |
| | | 4 | 1.0004* | .04072 | .000 | .8864 | 1.1144 |
| | 2 | 1 | -.1665* | .04608 | .005 | -.2955 | -.0375 |
| | | 3 | .8420* | .05277 | .000 | .6943 | .9898 |
| | | 4 | .8339* | .04591 | .000 | .7054 | .9624 |
| | 3 | 1 | -1.0085* | .04833 | .000 | -1.1438 | -.8732 |
| | | 2 | -.8420* | .05277 | .000 | -.9898 | -.6943 |
| | | 4 | -.0081 | .04816 | .999 | -.1430 | .1267 |
| | 4 | 1 | -1.0004* | .04072 | .000 | -1.1144 | -.8864 |
| | | 2 | -.8339* | .04591 | .000 | -.9624 | -.7054 |
| | | 3 | .0081 | .04816 | .999 | -.1267 | .1430 |

*. The mean difference is significant at the .05 level.

## Appendix 2. Scheffé Test Between Performance and Clusters

Dependent variable: Performance

| (I) Two-step cluster | (J) Two-step cluster | Mean Difference (I-J) | Std. Error | Sig. | Confidence Interval 95% | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| 1 | 2 | .2897* | .06020 | .000 | .1211 | .4582 |
| | 3 | .5636* | .06314 | .000 | .3868 | .7403 |
| | 4 | .7886* | .05324 | .000 | .6395 | .9376 |
| 2 | 1 | -.2897* | .06020 | .000 | -.4582 | -.1211 |
| | 3 | .2739* | .06895 | .001 | .0809 | .4669 |
| | 4 | .4989* | .06001 | .000 | .3309 | .6669 |
| 3 | 1 | -.5636* | .06314 | .000 | -.7403 | -.3868 |
| | 2 | -.2739* | .06895 | .001 | -.4669 | -.0809 |
| | 4 | .2250* | .06296 | .005 | .0488 | .4013 |
| 4 | 1 | -.7886* | .05324 | .000 | -.9376 | -.6395 |
| | 2 | -.4989* | .06001 | .000 | -.6669 | -.3309 |
| | 3 | -.2250* | .06296 | .005 | -.4013 | -.0488 |

*. The mean difference is significant at the .05 level.

## Appendix 3. Mean Analysis of Capabilities Comparing Clusters

| Capability | Questions | Advanced stability-oriented organization of the firm (n=358) | | Intermediate stability-oriented organization of the firm (n=200) | | Basic stability-oriented organization of the firm (n=365) | | Change-oriented organization of the firm (n=233) | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Mean** | SD | **Mean** | SD | **Mean** | SD | **Mean** | SD |
| **Development** | Product Design | **4.30** | .68 | **3.09** | 1.25 | **3.16** | 1.05 | **4.25** | .67 |
| | Technology Monitoring | **4.42** | .64 | **3.57** | .96 | **3.25** | .84 | **4.23** | .74 |
| | Technology Adaptation | **4.28** | .62 | **3.64** | .89 | **3.28** | .80 | **4.02** | .73 |
| | Product Prototyping | **4.25** | .78 | **3.10** | 1.42 | **3.00** | 1.40 | **4.12** | .87 |
| | Formal Project Management | **4.08** | .78 | **2.85** | 1.07 | **2.52** | .91 | **3.80** | .84 |
| | Product Launching | **4.32** | 1.07 | **3.03** | 1.48 | **3.24** | 1.25 | **4.45** | .89 |
| **Operations** | Production Planning | **4.41** | .55 | **4.34** | .59 | **3.61** | .70 | **3.79** | .72 |
| | No Rework | **4.38** | .56 | **4.29** | .60 | **3.61** | .68 | **3.75** | .75 |
| | On-time Delivery | **4.35** | .68 | **4.29** | .75 | **3.57** | .78 | **3.78** | .75 |
| | Installed Capacity Flexibility | **4.39** | .63 | **3.98** | .79 | **3.26** | .88 | **3.86** | .77 |
| | No Product Return | **4.48** | .53 | **4.37** | .56 | **3.79** | .61 | **3.95** | .61 |
| **Management** | Formal Strategy | **4.20** | .70 | **4.01** | .85 | **3.32** | .89 | **3.53** | .92 |
| | Updated Management Tools and Techniques | **4.24** | .68 | **3.99** | .70 | **3.12** | .73 | **3.35** | .82 |
| | HR Training | **4.42** | .63 | **4.26** | .67 | **3.61** | .78 | **3.67** | .84 |
| | Financial Management | **4.32** | .67 | **3.95** | .75 | **3.23** | .74 | **3.55** | .89 |
| **Transaction** | Market Monitoring | **4.05** | .92 | **2.78** | 1.08 | **2.47** | .98 | **3.49** | 1.06 |
| | Supplier Negotiations | **4.02** | .69 | **3.17** | .90 | **3.31** | .82 | **3.92** | .71 |
| | Prices Definition | **3.79** | .87 | **2.74** | 1.07 | **2.94** | .88 | **3.89** | .79 |
| | Customer Negotiations | **3.91** | .76 | **2.94** | .96 | **2.93** | .83 | **3.86** | .78 |
| | Suppliers Selection | **4.17** | .79 | **3.29** | 1.01 | **3.29** | .80 | **3.96** | .82 |

Note: SD = Standard Deviation. $p<.001$ for all cases.

# PAPER 2

## Innovation capabilities and catch-up: evidence from manufacturing firms in Brazil[3][4]

[3] Paper presented at the First Conference on Micro-dynamics, Catching-Up and Global Value Chains, Bocconi University, Italy, 2019.
The paper has received the Marie Skłodowska Curie Award: Best Young Scholar Paper
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# INNOVATION CAPABILITIES AND CATCH-UP:

# EVIDENCE FROM MANUFACTURING FIRMS IN BRAZIL


## ABSTRACT

To analyze and discuss over economic catch-up, one must consider it is an evolutionary process. That involves both the cumulative process of learning and capability accumulation by firms, which usually takes a long time and benefits from windows of opportunities that open up, as well as the surrounding system. We highlight here that innovation capability building at the firm level is a key factor for catch-up at the macro level. The aim of this study is to identify paths to build firm innovation capabilities for a competitive reconversion to catch-up. These paths are based on the identification of different combinations of existing capabilities within incumbent firms, considering their different innovative performances. Firms are divided according to their technology intensity in order to advance existing studies mostly focused on high-tech firms as a means to catch-up. Secondary data from 1,327 Brazilian manufacturing firms is analyzed using fuzzy-set QCA to identify the paths to build firm innovation capabilities. Results show that incumbent manufacturing firms in Brazil may either prepare capabilities to catch-up or be already in the process of catching-up. On the one hand, firms with lower technology intensity should build change-related capabilities to catch-up, i.e., development and transaction capabilities. On the other hand, catching-up firms with higher technology intensity already present development capability. They should, in fact, focus on building transaction capability to negotiate, ensuring that management and operations will support the growth.


## 1. INTRODUCTION

According to recently released data from The Brazilian National Confederation of Industry (CNI, 2018), Brazil will take more than half a century to reach the GDP per capita of developed countries, if the average growth rate from the last 10 years remains the same. *How to reverse this?*

Throughout the years, the concept of catch-up has been expounded in order to better understand specifically this process in which developed and developing countries would narrow

their capability gap vis-a-vis leading countries (Gerschenkron, 1962; Abramovitz, 1986; Amsden, 1989; Hobday, 1995; Kim, 1997). Much has been discussed on how to catch up at a country level, in which the knowledge-development relationship occurs through national systems of innovation or innovation policies. However, by considering catch-up under evolutionary lens, it is possible to understand it as both sectoral and firm dependent as well (Verspagen, 1991; Fagerberg and Godinho, 2005; Lee, 2005; Mazzoleni and Nelson, 2007; Figueiredo, 2014).

It is from the applied knowledge to new solutions offered in the market as goods and services by firms, that sectors and, in a bigger sphere, countries advance to higher levels of technological development. However, *this scenario still presents some difficulties in Brazil*.

Brazil is a country where the low level of knowledge circulation and the low technological base generate a product profile with limited market penetration – either because they can be easily copied or because they are technologically outdated. In both situations, the remaining strategy is to compete for price, given the homogeneity of the products, which tends to generate lower levels of profit for the companies and, therefore, a small potential of GDP growth (Reichert et al., 2015; Alves et al., 2017). This configuration, combined with the prevalence of small-scale production, puts Brazil far behind leading countries. *So, what can be done to upgrade Brazil's performance towards the patterns of leading countries?*

Developing countries have increasingly adopted technology foresight as a mechanism for identifying emerging technologies whose adoption can bring future economic growth (Feige and Vonortas, 2017). There are, then, two main challenges, which encompass the definition of those technologies that should be developed internally vs. those that should be sourced from abroad, and the identification of the internal capabilities to be developed in conjunction with those foreign technologies (Feige and Vonortas, 2017). Actually, the key factors for gradual catch-up are the learning and building of capabilities (Fan, 2006; Lee and Malerba, 2017). And Brazil still leaves much to be desired in this regard (Alves et al., 2017). *Which are the capabilities to be built?*

It is not enough to simply build capabilities that put the firm, the sector or the country at the same level as its competitors. To ensure competitive advantage, capabilities must be built in order to allow the adaptation, transformation and advancement of the *status quo.* Reminding the idea of building capability from imitation to innovation (Kim, 1997), what we see is the necessity to, in fact, build innovation capabilities. *But how to take advantage of existing capabilities to build capabilities that respond to ongoing changes?*

To answer that, it is important to know which capabilities lead to higher innovative performance. Moreover, it is important to identify, from successful combinations of existing capabilities, alternative combinations for building capabilities aiming at a competitive reconversion to catch-up. Thus, the aim of this study is to identify paths to build firm innovation capabilities for a competitive reconversion to catch-up. These paths are based on the identification of different combinations of existing capabilities within incumbent firms, considering their different innovative performances.

Therefore, the focus will be on Brazilian manufacturing firms, which have lost competitiveness in recent years against international competitors (CNI, 2018). Brazilian manufacturing sector still figures as a traditional sector, with firms acting mostly in low-technology intensity industries (low-tech firms), producing low value-added solutions based on costs and with improvements focused only on the production process – constantly doing more of the same (Reichert et al., 2016; Alves et al., 2017).

At the same time that the so-called Industry 4.0 – where science and technology are conducted in an integrated way for the digitization, automation and advancement of the sector – figures as the future for the area, Brazilian firms face difficulties in this direction.

It urges to concentrate initiatives for the restructuring of the Brazilian manufacturing sector. Considering its pre-existing capabilities base, the Brazilian manufacturing sector must seek to build capabilities in order to incorporate principles and technologies of the ongoing digital revolution. Thus, Industry 4.0 serves to reconfigure current standards and promote competitive reconversion for catch-up (Morrar et al., 2017).

Although its contribution to Brazilian GDP has declined, the manufacturing sector remains fundamental to the dynamism of innovation systems and technological development in the country (Pisano, 2015). The later its reaction, the greater its distance from more dynamic firms – and the greater will be the obstacles to be overcome in order to reposition the Brazilian manufacturing sector and, thus, to catch up (Arbix et al., 2017).

This study advances the literature by analyzing the opportunities to build innovation capabilities in all industries (from low-tech to high-tech firms) of the manufacturing sector, rather than solely focusing on high-tech industries, which are usually the focus of catching-up studies on developing countries (Morrison and Rabellotti, 2017).

This paper is organized as follows. In section 2, we provide the theoretical framework for our analyses on the paths for building innovation capabilities in incumbent manufacturing

firms. In section 3, we present the research method. In sections 4 and 5, we present and discuss our results, respectively. Section 6 then summarizes our main findings and concludes the paper.

## 2. THEORETICAL FRAMEWORK

### *2.1 Economics of innovation and catch-up*

Evolutionary economists argue that to understand how the current economic scenario works, one must understand how the remarkable capabilities that we now have, compared with those of an earlier era, got developed (Dosi and Nelson, 2018). In other words, to discuss over economic changes in contemporary economies, one must recognize the range of capabilities that today's economic actors, both incumbent and new firms, have and can work with (Nelson, 2018).

In many cases the shift of an industry from one technology to another superior is accomplished by existing firms adopting the new, while other established firms (that do not adopt it) succumb and new firms are brought to life (Nelson, 2018). In fact, over the years, both innovating firms and those not discretionary willing to innovate were compelled to adapt their policies and develop new capabilities to deal with contexts that were new to them and for which their established ways of doing things were unlikely to be viable (Helfat, 2018).

In rapidly changing environments, there is clear value in the ability to sense the need to reconfigure the firm's asset structure, and to accomplish the necessary internal and external transformation (Amit and Schoemaker, 1993). Evolutionary economists highlight then the importance of capability building efforts to catch-up.

The emergence and development of capable firms is greatly facilitated by the emergence of human capital capable of understanding the technologies being adopted, and the development of the kind of institutions needed to support efficient operation of the industries and technologies being taken aboard (Nelson, 2018). Capabilities can thus be shaped in part by the ecosystem in which an organization operates as well as by its internal resource endowment (Zeng and Mackay, 2018).

However, especially in developing countries, firms have extremely weak levels of capability. In general, firms are unable to pursue and conduct in-house R&D, which they consider as an uncertain endeavor with uncertain returns. That reflects precisely the Brazilian

scenario, in which 80% of manufacturing firms are from low-technology industries (Reichert et al., 2015).

Therefore, in dealing with catch-up, it is important to consider the issue of capability failure and the need to raise the capabilities of firms, sectors, and nations in broad areas of innovation beyond solely formal R&D. The capability failure concept essentially stresses the importance of raising the level of capabilities of the firms by providing learning opportunities (Lee and Malerba, 2018). Only countries that have invested greatly in the formation of skills and R&D, as well as organizational and managerial capabilities, seem to be capable of catching up, while those who did not have fallen farther behind (Lee and Malerba, 2018).

Thus, to analyze and discuss over economic catch-up, one must consider it is an evolutionary process. That involves both the cumulative process of learning and capability accumulation by firms, which usually takes a long time and benefits from windows of opportunities that open up, as well as the surrounding system (Lee and Malerba, 2018). We highlight here that capability building at the firm level is a key factor for catch-up at the macro level.

### *2.2 Innovation capabilities*

Capability can be summarized as a bundle of resources, knowledge, experience, skills and routines that allows the firm to perform accordingly to market expectations and achieve thus positive financial results (Richardson, 1972; Lall, 1992; Bell and Pavitt, 1995). Bessant et al. (2000) argue that firms will be different accordingly to their capabilities, and, mainly, accordingly to how they are connected to the need to innovate. In this sense, Yang (2012) argues that firm innovation capability is the single most important characteristic a firm needs in order to sustain growth and maintain a competitive advantage.

Expanding on the idea that solely the technological capabilities, those related to product and process, will lead any firm to achieve innovative performance (Dosi, 1988; Lall, 1992; Bell and Pavitt, 1993), Zawislak et al. (2012) propose an innovation capabilities model[5] that encompasses both technological and non-technological (business-driven) capabilities. For

[5] The model proposed by Zawislak et al. (2012) has been tested and validated through empirical data from manufacturing industries, which ensures its accuracy when detailing innovation capabilities of firms (Zawislak et al., 2013; 2014; Reichert et al., 2015; Reichert et al., 2016; Alves et al., 2017). We replace 'technology development capability' with 'development capability' to avoid confusion with innovations at the technological frontier and thus to provide a better alignment with the innovative activities of different industries (from low-tech to high-tech).

them, every company, once aware of technological, sectoral and institutional external features, will internally perform four different strategic functions: technology development, operations, management and transaction. For each function, there should be a specific capability of innovation. The ensemble of these four capabilities composes the innovation capabilities.

From this point of view, innovation capabilities refer to the "ability to absorb, adapt and transform a given technology into specific operational, managerial and transactional routines that can lead a firm to Schumpeterian profits, i.e., innovation" (Zawislak et al., 2012, p. 23).

According to Zawislak et al. (2012), *development capability (DC)* refers to the ability that any firm has to interpret the current state of the art, absorb and transform a given technology to create new products, processes, methods and techniques aiming at reaching higher levels of technical-economic efficiency. It involves monitoring, acquiring, adapting, designing, and developing a new set of knowledge and technical systems for internal use. *Operations capability (OC)* is the ability to perform the given productive capacity through the collection of daily routines that are embedded in knowledge, skills and technical systems. It is a result of the selection of competitive priorities in order to take advantage of low cost, quality, delivery time, responsiveness, flexibility, degree of product standardization, size of product mix carried within the firm, volumes required, and production lead-time. *Management capability (MC)* refers to the ability to transform the technology development outcome into coherent operations and transaction arrangements. It is responsible for the matching and constantly fine-tuning between internal resources and goals with the external market environment and expectations. It involves corporate strategy, resource allocation, norms and procedures, coordination, and integration. Management capability maintains a smooth flow of information and outputs to reach higher rates of efficiency. Finally, *transaction capability (TC)* is the ability to reduce marketing, outsourcing, bargaining, logistics, and delivering costs; in other words, transaction costs. Transaction capability refers then to the ability to effectively transact in the market what has been previously developed, operationalized and managed. It involves a set of specific skills and systems, which encompasses customer relationship, negotiation, contracting, and marketing.

Advancing this conceptualization, Pufal and Zawislak (2018) argue that development and transaction capabilities are change-related capabilities, while operations and management capabilities are stability-related capabilities. Once presumed that companies are embedded to a certain level of environmental homogeneity, the innovation capabilities model proposed by Zawislak et al. (2012) in fact offers a deeper explanation for firms' heterogeneity, coupling stability and change. By presuming that every company has some level of four innovation

capabilities, it is possible to suppose that there is a variety of capabilities combination within companies, which consequently ensure them different performances.

Given the external dynamics, the firm will only survive, i.e., become different, if it is also internally dynamic itself (Teece, 2016). But how to be dynamic? The firm has to look at its four capabilities, ensuring the constant adjustment between change and stability, from product development to its commercialization (Pufal et al., 2014). Considering that, the innovation capabilities should be arranged in ways to explore firm's strengths over time.

### *2.3 Building innovation capabilities in incumbent firms to catch-up*

Researchers have gone on to argue that producing new knowledge, or learning, is crucial to a firm's ability to do new things or to do existing things better (Holan and Phillips, 2004). On the other hand, while firms must learn new things, they must forget others, sometimes.

However, while forgetting may be ubiquitous throughout learning processes of firms, its effect is context dependent. If critical knowledge is forgotten, then competitiveness is lost and forgetting would have been better avoided. If the forgotten knowledge is peripheral or is actively interfering with the application of more appropriate knowledge, then forgetting is a positive occurrence (Holan and Phillips, 2004). A question arises then: *how to successfully couple learning and forgetting in the context of catch-up?*

Technological discontinuities can lead to intensified technological competition or even to a complete breakdown of competitive patterns (Abernathy and Clark, 1985; Anderson and Tushman, 1990; Utterback and Suarèz, 1993). As a consequence, a process of 'creative destruction' (Schumpeter, 1942) may unfold, which eventually leads to the demise of established firms. The 'creation' is usually accomplished by invaders – new firms or entrants from other industries – while the 'destruction' is suffered by the incumbents (Rosenbloom and Christensen, 1994). From an evolutionary point of view, creative destruction is an essential aspect of the economic growth process (Pyka et al., 2018).

Discontinuous innovation exposes leading firms or countries to situations where the existing values, norms and structures upon which they traditionally have built a competitive edge turn into rigidities that limit their ability to innovate (Leonard-Barton, 1992). However, some incumbents are capable of absorbing the new technologies and integrating them with their existing capabilities (Bergek et al., 2013).

Within this context, to build new capabilities within an emerging technological paradigm, incumbent firms frequently need to leverage their external networks to source new technology (Rothaermel and Hess, 2007). As Cohen and Levinthal (1990) have argued, a firm's ability to absorb and exploit new knowledge from their environment largely is conditioned by their prior accumulated knowledge, and this in turn influences the firm's perception of future technological advances. While path dependent technological evolution helps to incrementally reinforce or enhance the capabilities of existing firms, radical technological changes subsequently can disrupt or destroy these capabilities (Tushman and Anderson, 1986).

Relating these ideas, Pavitt (1986) gave rise to the notion of 'creative accumulation', which describes the process of generating new knowledge, which builds on existing knowledge rather than replacing it. Creative accumulation involves the inherent tension between the creativity and accumulation aspects: creativity implies responses "outside of the range of existing practice" (Schumpeter, 1947, p. 150), whereas accumulation implies knowledge creation building on these existing practices (Bergek et al., 2013).

Therefore, the paths to build innovation capabilities within incumbent firms will be extended to related areas of their primary activities. That relates to the idea stressed by Penrose (1959) that a firm's ability to compete successfully depends upon its resource base.

Thus, for incumbent firms make a competitive reconversion to catch-up, learning and forgetting are not paradoxical; they are, in fact, complementary. To build innovation capabilities is not a matter of forgetting previous existing knowledge, but accumulating and deriving from this existing knowledge. Through the process of creative accumulation, such firms will expand their knowledge to the extant they profit from it, in different ways. The gales of creative destruction are channeled and tamed by incumbent firms through the process of building innovation capabilities, developing complementary knowledge and recombining resources.

Thus, building capabilities over time lies on, first, the identification of successful existing capabilities. Consequently, a competitive reconversion lies on the difference of built capabilities to their former version, considering the positive results attained. Finally, catch-up lies on the occurrence and increment of results of different competitive reconversions over time. Therefore, to discuss over catch-up at the macro level, one may consider building capabilities to a competitive reconversion at the micro level. It urges, then, to identify which capabilities should be built.

## 3. METHODS

To identify paths to build firm innovation capabilities for a competitive reconversion to catch-up, this study focuses on identifying the successful combinations of existing innovation capabilities within incumbent manufacturing firms to infer, from this snapshot, how the process of building innovation capabilities should be conducted over time.

Firms are divided according to their technology intensity in order to advance existing studies mostly focused on high-tech firms as a means to catch-up (Morrison and Rabellotti, 2017). Therefore, in the present paper, all technology intensities (from low-tech firms to high-tech firms) are considered.

### *3.1 Data*

Secondary data from an innovation survey conducted by the NITEC Innovation Research Center were used for this study (NITEC, 2015). The survey was carried out in 2014 and focused on understanding the innovation dynamics in the Brazilian manufacturing industry.

The survey was conducted with the application of a questionnaire to 6,142 firms, with ten or more employees, from a universe of 10,930 manufacturing firms registered in the Rio Grande do Sul Industries Federation Database (FIERGS, 2010), including all manufacturing industries. The survey received 1,331 valid responses from the senior manager or owner of firms. From this database, 1,327 firms informed their manufacturing industry, which is the total sample considered in this paper.

The 1,327 firms were divided and analyzed according to the classification of manufacturing industries by the Organization for Economic Cooperation and Development (OECD, 2011). OECD classifies manufacturing into low-, medium low-, medium high-, and high-technology industries on the basis of research and development (R&D) intensities, as shown in Table 1.

**Table 1. Technology intensity of analyzed firms.**

| Technology Intensity | Industries | % of the sample |
|---|---|---|
| Low-tech | Footwear and Leather, Food, Furniture, Textile, Wood, Pulp and Paper, Printing, Textiles, Beverage, Tobacco | 47.5% |
| Medium Low-tech | Metal Products, Rubber and Plastic, Nonmetallic Mineral Products, Metallurgy, Machinery Maintenance, Petroleum Refining | 27% |
| Medium High-tech | Machinery & Equipment, Automotive, Chemicals, Electric, Transportation Equipment | 24% |
| High-tech | Electronics, Pharmaceuticals | 1.5% |
| | Total | 100% |

Of the 1,327 firms, 631 firms (47.5%) are from low-tech industries, 358 firms (27%) are from medium low-tech industries, 318 are from medium high-tech industries (24%) and 20 firms (1.5%) are from high-tech industries.

### *3.2 Measures*

The questionnaire used in the survey[6] was based on the Innovation Capability Model proposed by Zawislak et al. (2012). The measures relate to the four capabilities – development, operations, management, and transaction capabilities – through 29 items, presented as statements in the survey questionnaire. Respondents rated their level of agreement to each statement using a five-point Likert scale ranging from ‘strongly disagree’ to ‘strongly agree’.

The study also uses two indicators to measure innovative performance (IP): economic performance and the share of total sales generated by new products in the year of the survey. Economic performance is measured using three outcomes identified by Schumpeter (2008): net profit growth, market share growth and revenue growth. Respondents were asked to rate their level of agreement for each item (i.e., if each type of performance has grown continuously over the last three years) using a five-point Likert scale also ranging from “strongly disagree” to “strongly agree”. The average value of these three items is then weighted by the sales share of new products in order to capture the value of each firm’s portfolio of innovative products and thus provide a single estimate of innovative performance (Torugsa & Arundel, 2013).

[6] See Reichert et al. (2016) and Alves et al. (2017) for detailed information on the survey procedures and preliminary statistical analyses.

As a result of Principal Component Analysis, the analyses encompass 20 from those 29 survey items. Principal Component Analysis extraction method[7] was conducted to reduce the original set of variables into a smaller group and extract latent factors (innovation capabilities). The results categorize the four capabilities: development capability (Cronbach's $\alpha = 0.842$), operations capability (Cronbach's $\alpha = 0.789$), management capability (Cronbach's $\alpha = 0.758$) and transaction capability (Cronbach's $\alpha = 0.772$). Table 2 presents the list of items and the respective loadings.

**Table 2. Principal component analysis for innovation capabilities**

| Items | Development Capability (DC) | Operations Capability (OC) | Management Capability (MC) | Transaction Capability (TC) |
|---|---|---|---|---|
| Product Prototyping | .769 | | | |
| Product Launching | .755 | | | |
| Product Design | .750 | | | |
| Technology Monitoring | .678 | | | |
| Technology Adaptation | .649 | | | |
| Formal Project Management | .626 | | | |
| On-time Delivery | | .748 | | |
| Rework | | .739 | | |
| Product Return | | .735 | | |
| Production Planning | | .668 | | |
| Installed Capacity Flexibility | | .607 | | |
| Financial Management | | | .745 | |
| Updated Management Tools and Techniques | | | .739 | |
| Formal Strategy | | | .699 | |
| HR Training | | | .661 | |
| Prices Definition | | | | .772 |
| Customer Negotiations | | | | .763 |
| Supplier Negotiations | | | | .742 |
| Suppliers Selection | | | | .647 |
| Market Monitoring | | | | .512 |

[7] Kaiser-Meyer-Olkin (KMO) measure indicated a value of 0.905 and Bartlett's test of sphericity was significant ($p = 0.000$), which showed adequacy to the conduction of factor analysis (Kaiser, 1974; Field, 2009). All the final items presented meritorious Measure of Sampling Adequacy (>0.84) (Cerny and Kaiser, 1997).

### *3.3 Fuzzy-set qualitative comparative analysis*

This study employs fuzzy-set QCA (using the software program fsQCA.com) to identify paths to build firm innovation capabilities for competitive reconversion to catch-up, considering the four technology intensities of manufacturing industries. Incumbent firms in the manufacturing sector must develop their capabilities towards innovation in order to be able to compete with leading firms in the ever-changing techno-economic scenario, as a way to seize the windows of opportunity that may open up over time, especially in the context of Industry 4.0.

Different from the reliance of symmetric (correlation-based) methods on matrix algebra, fuzzy-set QCA uses Boolean algebra to specify and test combinations (Fiss, 2007; Ragin, 2008; Woodside, 2015). The process of QCA starts with defining the property space that comprises all combinations of conditions leading to an outcome. As stated by Ordanini et al. (2014, p.137), "the property space delimits potential explanations of the outcome, the [conditions] should be chosen carefully and anchored in extant theoretical knowledge".

In the present paper, all four innovation capabilities are assumed, based on a comprehensive review of the literature, to contribute to high (instead of low) innovative performance. This study tests the following fuzzy-set QCA model:

$$High\ IP = (DC, OC, MC, TC).$$

In fuzzy-set QCA, both the causal conditions (the four innovation capabilities DC, OC, MC and TC) and the outcome (High IP) are represented using fuzzy membership scores (Ragin, 2008), which requires calibrating all variable scales to range from 0.00 for full non-membership to 1.00 for full membership. To perform fuzzy-set calibration, criteria are necessary for three breakpoints, set at 0.05 for the full non-membership threshold; 0.50 for the crossover point; and 0.95 for the full membership threshold (Ragin, 2008). As the study data are skewed (common in a large-N setting), it is not appropriate to use a conventional calibration method for a five-point scale (i.e., 1 = 0.05, 3 = 0.50, and 5 = 0.95) (Hsiao et al., 2015; Woodside, 2015). The cross-over point was based on the frequency of the averaged values (around 50%).

Fuzzy-set QCA uses a truth table function to generate combinations of conditions (DC, OC, MC and TC) that are sufficient for achieving high innovative performance (IP). The truth

table for all logically possible combinations is 2k rows (Ragin, 2008). In order to reduce the number of rows in a QCA analysis of sufficiency, a selection of a consistency level and a frequency threshold is required. Ragin (2008) suggests a consistency level of above 0.75 as a rough benchmark, while Rihoux and Ragin (2009) suggest using a frequency threshold of at least 5 cases in large-N settings.

Following Reichert et al. (2016) procedures, this study adopts higher levels of consistency. For low-tech firms, the consistency cut-off was 0.92 and the frequency threshold was of 11 cases. The analysis of medium low-tech firms adopts a consistency cut-off of 0.93 and sets a frequency threshold of 10 cases. The analysis of medium high-tech firms assumes a consistency cut-off of 0.96 and sets a frequency threshold of 13 cases. The analysis of high-tech firms adopts a consistency cut-off of 0.98 and sets a frequency threshold of 2 cases, since it is not a large-N sample, with solely 20 firms encompassed. The most possible similar consistency cut-offs and selection of cases was sought for comparison, considering the characteristics of each sub-sample of technology intensity.

Output from fuzzy-set QCA includes three sets of solutions: complex, parsimonious, and intermediate. The next section reports the findings of the intermediate solution for all four technology intensities of manufacturing industries. The intermediate solution is considered the optimal solution that "strikes a balance between complexity and parsimony, using procedures that mimic the practice of conventional case-oriented comparative research" (Ragin, 2008, p.171).

## 4. RESULTS

Results show overall four different combinations of capabilities that lead to high innovative performance within firms of different technology intensity industries.

Table 3 reports the results of the fuzzy-set QCA analysis for **low-tech firms**. The findings reveal two combinations of innovation capabilities that lead to high innovative performance (High IP) in these firms: MC (solution 1) and DC ∗ OC ∗ TC (solution 2).

The consistency values (indicating the degree to which the solutions are subsets of the outcome) for the two solutions and for the overall solution exceed 0.75, indicating that these combinations are sufficient to cause high innovative performance (Ragin, 2008). The combined results (i.e., solution coverage) account for 85% of membership in the high innovation performance outcome of low-tech firms.

**Table 3. Combinations of innovation capabilities in *low-tech* firms**

| Solution configuration | Raw coverage | Unique coverage | Consistency |
|---|---|---|---|
| **1. MC** | 0.82256 | 0.227135 | 0.851934 |
| **2. DC ∗ OC ∗ TC** | 0.633693 | 0.038267 | 0.942419 |
| Solution coverage: | 0.860827 | | |
| Solution consistency: | 0.851364 | | |

*Notes: Frequency cut-off = 11; consistency cut-off = 0.925508.*

Table 4 reports the results of the fuzzy-set QCA analysis for **medium low-tech firms**. Results show three combinations of innovation capabilities that are central to high IP in medium low-tech firms: OC ∗ MC (solution 1), MC ∗ TC (solution 2) and DC ∗ OC ∗ TC (solution 3).

The consistency values for the three solutions and for the overall solution exceed 0.75 and the solution coverage accounts for 82,5% of membership in the high innovation performance outcome of medium low-tech firms.

**Table 4. Combinations of innovation capabilities in *medium low-tech* firms**

| Solution configuration | Raw coverage | Unique coverage | Consistency |
|---|---|---|---|
| **1. OC ∗ MC** | 0.736809 | 0.0617762 | 0.908845 |
| **2. MC ∗ TC** | 0.732361 | 0.0573286 | 0.917844 |
| **3. DC ∗ OC ∗ TC** | 0.624284 | 0.0310709 | 0.950028 |
| Solution coverage: | 0.825209 | | |
| Solution consistency: | 0.88006 | | |

*Notes: Frequency cut-off = 10; consistency cut-off = 0.929645.*

Table 5 shows the results of the fuzzy-set QCA analysis for **medium high-tech firms**. Results reveal one single combination of innovation capabilities that represents more high IP in medium high-tech firms: MC ∗ TC (single solution).

The consistency value for this solution exceeds 0.75 and the solution coverage accounts for 71,7% of membership in the high innovation performance outcome of medium high-tech firms.

**Table 5. Combinations of innovation capabilities in *medium high-tech* firms**

| Solution configuration | Raw coverage | Unique coverage | Consistency |
|---|---|---|---|
| **1. MC ∗ TC** | 0.71706 | 0.71706 | 0.918738 |
| Solution coverage: | 0.71706 | | |
| Solution consistency: | 0.918738 | | |

*Notes: Frequency cut-off = 13; consistency cut-off = 0.956656.*

Table 6 reports the results of the fuzzy-set QCA analysis for **high-tech firms**. Results reveal two combinations of innovation capabilities that lead to high IP in high-tech firms: OC ∗ MC (solution 1) and MC ∗ TC (solution 2).

The consistency values for the two solutions and for the overall solution exceed 0.75 and the solution coverage accounts for 76% of membership in the high innovation performance outcome of high-tech firms.

**Table 6. Combinations of innovation capabilities in *high-tech* firms**

| Solution configuration | Raw coverage | Unique coverage | Consistency |
|---|---|---|---|
| **1. OC ∗ MC** | 0.729849 | 0.131089 | 0.940639 |
| **2. MC ∗ TC** | 0.62976 | 0.0310009 | 0.959514 |
| Solution coverage: | 0.76085 | | |
| Solution consistency: | 0.932682 | | |

*Notes: Frequency cut-off = 2; consistency cut-off = 0.98366.*

In sum, there are combinations of innovation capabilities that are common to more than one group of technology intensity industries. Therefore, there are four main combinations of innovation capabilities that lead to more innovative performance within manufacturing industries. They are:

*DC ∗ OC ∗ TC (for low-tech and medium low-tech firms);*

*OC ∗ MC (for medium low-tech and high-tech firms);*

*MC ∗ TC (for medium low-tech, medium high-tech and high-tech firms); and*

*MC (for low-tech firms).*

# 5. DISCUSSION

Even though results show four different combinations of capabilities that lead to high innovative performance within firms of different technology intensity industries, not all combinations constitute paths towards a competitive reconversion to catch-up over time. The following subsections discuss the results considering the different technology intensity industries and present the paths for building innovation capabilities for a competitive reconversion to catch-up.

## *5.1 Innovation capabilities in different technology intensity industries*

Results show that *development capability, operations capability and transaction capability* are core constructs of high innovation performance in both low-tech and medium low-tech firms. A plausible explanation is that offered by Reichert et al. (2016), which remarks that firms with lower levels of technology intensity must possess capabilities that allow them to absorb external technologies and related knowledge to apply on their own products, through the development capability. To obtain economic returns, such firms need to be able to effectively market differentiated products, based on their transaction capability. Behind that, lies the operations capability, as a means to enable a responsive and adequate production. In sum, for firms in low-tech and medium low-tech industries, offering differentiated products in the market (i.e., with design, with special functionalities, with higher quality, niche products) is what ensures more innovative performance. Thus, one may suggest that such firms should be positioned at the end of the value chain, adding value to their final products.

Results also show that the combination of *operations and management capabilities* is what ensures high innovation to medium low-tech and high-tech firms. In both cases, these two capabilities relate to the constant seek for productive efficiency and organizational stability, typical characteristics of firms positioned in the middle of a value chain. While for medium low-tech this combination may refer to maintaining the firm at the same level, for high-tech firms this seems as a necessary condition after enhancing development and transaction capabilities (Pufal and Zawislak, 2018). In other words, as operations and management capabilities are stability-related capabilities and development and transaction capabilities are more change-related capabilities, in high-tech firms the former seem to be structured as a consequence of the latter. On the other hand, in medium low-tech firms, operations and management capabilities may be more dedicated to maintaining the *status quo* – different from

the previous explained combination, in which development and transaction capabilities also appear as a necessary condition.

The third identified combination involves *management and transaction capabilities*, stressing the importance of these capabilities for innovation success in all technology intensity industries, expect for low-tech. That reflects the necessity of low-tech firms to have development capability associated to transaction capability as a means to innovate. For all other firms, this combination of management and transaction seems to be related to the negotiation power demanded to successfully act in a position in the middle of the value chain, i.e., selling to other manufacturing firms. Important here is the formalization of processes, use of management tools, ability to define prices, negotiate with customers and suppliers, and to be aware of changes in the market.

Finally, there is a solution that may not relate to a competitive reconversion over time. Management capability appears alone in a solution for low-tech firms. Even though management capability may be important to performance in existing manufacturing firms, it is so just to maintain the *status quo* for a while. In a long-term scenario, in which changes are inherent, management itself will no longer be sufficient for such firms to make a competitive reconversion. Firms focusing on management now are priming for stability and efficiency as a way to survive (Pufal et al., 2014); i.e., change is not encompassed here.

### *5.2 Paths to build innovation capabilities for a competitive reconversion to catch-up*

When dealing with catch-up, it is important to consider the issue of capability failure and the need to raise the capabilities of firms beyond solely R&D (Lee and Malerba, 2018). Results elucidate then different paths to be pursued by firms over time considering their existing capabilities. In fact, these paths relate to firms that need *to catch-up* and to firms that are already on the process of *catching-up*.

To catch-up, firms acting in low-tech and medium low-tech industries should adopt a focus on differentiation, either in terms of development or transaction, having operations and management as support. They should become what one may refer to as ‘the high-tech of low-tech’, i.e., invest in product development and create a special solution to be sold in the market. *Thus, to catch-up, firms with lower technology intensity need to build change-related capabilities over time, i.e., development and transaction capabilities.* It is expected that these

firms promote internal changes, triggered by in-house research development, external alliances, product differentiation and so on (Lee, 2013).

Firms acting in medium high-tech and high-tech industries can be seen as already in the process of catching-up. They have management as a necessary condition for innovation performance, with the support of operations, when seeking for productive efficiency, or of transaction, when dealing with negotiation power. In other words, these firms already have development capability to the necessary extent. *Thus, development should already be settled in catching-up firms with higher technology intensity. They should, in fact, focus on building transaction capability to negotiate, ensuring that management and operations will support the growth. C*atching up firms might want to form international alliances or even joint ventures to cope with the increasingly fierce global competition and to keep ahead (Lee and Malerba, 2018). These firms may well try to be export oriented as it can configure as a window of opportunity to learn from worldwide buyers and competitors.

Table 7 presents the summary of findings, highlighting which combinations of capabilities are most representative for firms in each technology intensity to pursue, as a way to make a competitive reconversion to catch-up.

**Table 7. Summary of findings**

| Combinations of capabilities | Low-tech firms | Medium low-tech firms | Medium high-tech firms | High-tech firms |
|---|---|---|---|---|
| **DC*OC*TC** | **X** | **X** | | |
| **OC*MC** | | - | | **X** |
| **MC*TC** | | **X** | **X** | **X** |
| **MC** | - | | | |
| | ***To catch-up*** | | ***Catching-up*** | |

*Notes: The 'X' sign refers to the paths to be followed by firms of each technology intensity. The '-' sign means that firms should not focus on that path, as described in the text.*

## 6. CONCLUSION

The aim of this study was to identify paths to build firm innovation capabilities for a competitive reconversion to catch-up. These paths were identified based on the different combinations of existing capabilities within incumbent firms, considering their different

innovative performances. Firms are divided according to their technology intensity in order to advance existing studies mostly focused on high-tech firms as a means to catch-up. Results show that incumbent manufacturing firms in Brazil may either prepare capabilities to catch-up or be already in the process of catching-up.

On the one hand, firms with lower technology intensity should build change-related capabilities to catch-up, i.e., development and transaction capabilities. On the other hand, catching-up firms with higher technology intensity already present development capability. They should, in fact, focus on building transaction capability to negotiate, ensuring that management and operations will support the growth.

To catch up today, and not half a century from now (CNI, 2018), Brazil must invest in technologies and relationships that allow the development and selling of products that meet the latent needs of the 21st century in an innovative way. The emerging scenario of Industry 4.0 is comprehensive and affects a whole value chain: producers, manufacturers, suppliers and workers. Incumbent manufacturing firms will have to build capabilities to positively deal with the upcoming changes.

In terms of practical implications, this study may contribute to place firm-centered innovation capabilities at the center of industrial innovation policies. As for managers, they could benefit from the proposed discussion to conduct changes within their capabilities towards innovation and competitive reconversion. Regarding theoretical perspectives, this study may contribute to the understanding of the paths for building innovation capabilities at the micro level as a means to seize catch-up opportunities at the macro level. Future case studies are encouraged, to deepen each identified path under a historical approach.

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# PAPER 3

## The process of building innovation capabilities: success and failure of Brazilian manufacturing firms[8][9]

[8] Early versions of the paper have been presented at the R&D Management Conference 2021, Glasgow - online, and 18th International Schumpeter Society Conference 2021, Rome - online.
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# THE PROCESS OF BUILDING INNOVATION CAPABILITIES: SUCCESS AND FAILURE OF BRAZILIAN MANUFACTURING FIRMS


## ABSTRACT

The aim of this study is to identify the process of building innovation capabilities by analyzing the different arrangements of capabilities that are responsible for both firms' success and failure over time. In order to identify the process of successfully building innovation capabilities and capability failures, it is necessary to identify existing capabilities, how they are actually arranged and how these arrangements affect firms' performance over time. This study is based on an innovation model that encompasses four complementary capabilities: development, operations, management and transaction. These capabilities are analyzed in the context of successful and failure paths of firms. Data was analyzed from two rounds of an innovation survey carried out in 2014 and in 2020 that focused on understanding the innovation dynamics in Brazilian manufacturing firms. This paper analyzes data of 530 firms, in which 300 of them remain operating, while 230 of them were found to have closed their doors between 2014 and 2020. Econometric analysis, descriptive statistics and regression analyses were used to assess which and how are the innovation capabilities related to those firms that are still operating in comparison to those that have closed their doors. We analyzed the actual arrangement of capabilities based on firms' perception of relevance, as well as the ideal arrangement of capabilities with the greatest impact on innovation for both successful and failed firms. Results show that firms fail to innovate mainly because they lack development capability. Conversely, to thrive over time, successful firms ought to build innovation capabilities by incorporating and integrating transaction and development for more innovation performance over time.


## 1. INTRODUCTION

The aim of this study is to identify the process of building firm innovation capabilities, by analyzing the different innovation capabilities arrangements responsible for firms' success and failure over time. The capabilities debate is heading for more than half a century of evolution. From seminal works (Richardson, 1972; Lall, 1992; Bell and Pavitt 1995; Teece *et al*., 1997) to more recent studies (Alves *et al*., 2017; Teece, 2017; Helfat, 2018; Kattel and Mazzucato, 2018; Dutrénit *et al*., 2019; Hullova *et al*., 2019; Figueiredo *et al.*, 2020), the term capability has evolved and can be summarized as a bundle of resources, knowledge, experience,

skills and routines that allows a firm to acquire and sustain competitive advantage and achieve thus positive results.

However, considering the ever-changing environment, competitive advantage and firm survival are as much related to developing new capabilities as to maintaining capabilities. The notion of a static perception of firm performance, such as how to minimize cost for a given output level, must be surpassed (Teece, 2016). In such context, dynamic issues come to the fore. Firms must be prepared to react to influential changes in the environment and to exploit unforeseen opportunities when they occur (Teece, 2017). It is not just a matter of having routines, skills and resources; it is rather a matter of perpetually developing these routines, skills and resources, i.e., a matter of building capabilities (Kim, 1999; Dutrénit, 2004; Lee, 2019).

Building capabilities is needed to exploit opportunities in dynamic environments (Sirmon *et al*., 2007). Nevertheless, it is not enough to simply build capabilities that put the firm at the same level as its competitors. To ensure competitive advantage, capabilities must be built in order to allow the adaptation, change and advancement of the *status quo*. It is necessary, in fact, to build innovation capabilities (Shapira *et al*., 2011; Bell and Figueiredo, 2012; Börjesson *et al*., 2014; Wang and Dass, 2017; Figueiredo *et al*., 2020). But how to effectively build innovation capabilities?

During the last few years, some authors have been arguing that this process is based on elements that provide dynamicity and potential for change in firms' capabilities (Figueiredo, 2014; Teece, 2017; Nelson, 2018, Lee, 2019). Also, it deals with two major dimensions: how to leverage existing assets into new or related business; and how to learn and combine assets to establish new businesses and address new markets (Teece, 2000).

Nevertheless, firms may face internal barriers to innovate (Moraes Silva *et al*., 2019). As literature usually focuses on successful cases, little is known about why firms fail to innovate – especially on the lack of coordination of innovation capabilities (Damanpour and Aravind, 2012). How are capabilities arranged in failed firms? How can firms overcome capability failure? Which are the fundamental capabilities for traditional sectors to avoid failure and remain competitive in a shifting environment? How is the process of building innovation capabilities? This paper helps to narrow this gap, by identifying the arrangements of capabilities in both successful and failed firms, enlightening thus the odds in the process of building innovation capabilities.

In order to identify the process of building successful innovation capabilities and capability failures, it is needed to know which are the capabilities and how they are actually arranged within firms. Other than technological-oriented capabilities, i.e., those related to product and process, any firm also depends on non-technological ones, i.e., internal efficiency and marketing. Zawislak *et al*. (2012) propose an innovation model that encompasses both dimensions, technological and non-technological, in a four-fold complementary capabilities framework: development, operations, management and transaction. These four capabilities are analyzed here in the context of successful and failed firms. We analyzed the actual arrangement of capabilities based on firms' perception of relevance, as well as the ideal arrangement of capabilities with the greatest impact on innovation for both successful and failed firms.

The empirical analysis is based on data from two rounds of an extensive innovation survey conducted by the NITEC Innovation Research Center in South Brazil. The innovation survey of manufacturing firms was carried out in 2014 and in 2020. Econometric panel data analysis, descriptive statistics, mean and regression analyses were used to identify capabilities responsible for firm survival and failure over time. Based on robust findings, we discuss the paths to success, as well as the paths to failure and how to overtake it, through a process of building innovation capabilities. We conclude that the process of building innovation capabilities should be towards focusing on transaction and development capabilities to ensure competitive performance over time.

## 2. BACKGROUND

As stated by Dosi (1991), firms have different histories and accumulated competences. They constantly seek for learning and new solutions, breaking with the idea of general equilibrium and, consequently, establishing decentralized processes of success and failure, reinforcing firms' heterogeneity. Even though there is a homogeneity in the way firms share and respond to the system they are embedded in, their internal heterogeneity may lead to different performance over time (Lee and Malerba, 2017). In that sense, considering firms' heterogeneity, processes of successfully and unsuccessfully building innovation capabilities are expected. Aiming at discussing success and failure in process of building innovation capabilities, this section addresses the different capabilities of the firm and how they relate to innovation.

### *2.1 The Innovation Capabilities of the Firm*

Rather than focusing solely on episodically developing innovations, firms should adopt a capabilities perspective on innovation (Teece, 2016). A capabilities perspective encourages a system view, which facilitates innovativeness in firms in a sustainable way over time (Börjesson *et al*., 2014; Teece, 2017). The capabilities approach considers the firm as a set of resources, knowledge, experience, skills and routines, which can lead the firm towards innovation (Helfat, 2018; Kattel and Mazzucato, 2018; Dutrénit *et al*., 2019; Hullova *et al*., 2019).

The different types of innovation (product, process, market, inputs and organization) proposed by Schumpeter (1942) represent, in fact, different types of capabilities. It is the arrangement and the quality of these capabilities that will determine how the firm can incorporate in its repertoire what the market would otherwise make. In that sense, Richardson (1972) suggests that capabilities are determinants of the boundaries of the firm.

Capabilities facilitate not only the ability of a firm to recognize a potential technological shift, but also its ability to adapt to change through innovation (Rothaermel and Hess, 2007). By developing and improving consistent processes, firms can reduce variability and create greater efficiency and, thus, stability (Benner and Tushman, 2003). Success and failure are thus intrinsically attached to both stability and change (Nelson, 1991; Freeman and Engel, 2007; Tushman, 2017; Pufal and Zawislak, 2021). By not coupling stability and change, the firm will fail to succeed.

Considering stability and change, the analytical distinction between ordinary and dynamic capabilities turns relevant. On the one hand, priming for stability, ordinary capabilities involve the performance of administrative, operational, and governance-related functions that are necessary to the execution of current plans (Teece, 2016). On the other hand, relating to change, dynamic capabilities involve activities that can enable a firm to direct its ordinary activities toward high-demand uses, to develop new capabilities, and to effectively coordinate internal and external resources to address and shape shifting business environments.

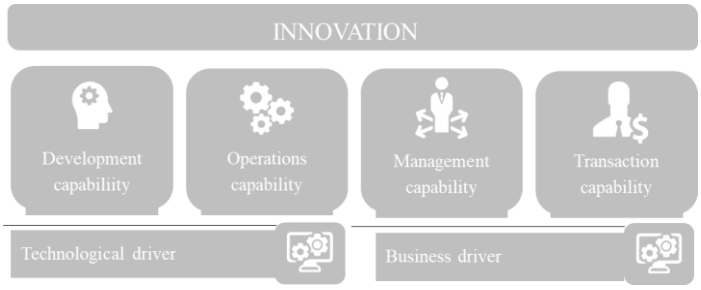
Dynamic capabilities excel at the scanning, learning, creative and interpretive activity needed to sense and seize new technological and market opportunities (Teece, 2017). Thus, considering the ever-changing environment, firms must be aware of internal and external challenges, both in terms of technological capabilities and non-technological capabilities.

Expanding on the idea that solely the technological capabilities, those related to product and process, will lead any firm towards innovation, Zawislak *et al*. (2012) propose an

innovation capabilities model that encompasses both technological and non-technological (business) capabilities (Figure 1). For them, every company, once aware of technological, sectoral and institutional external features, will internally perform four different strategic functions: development, operations, management and transaction. For each function, there should be a specific capability of innovation.

By offering a practical analysis, this model helps to analyze innovation capabilities in different firms, as shown in several recent studies (Hartono and Sheng, 2016; El-Awad *et al*., 2017; Alves *et al*., 2017; Guichardaz *et al*., 2019; Oliveira *et al*., 2019; Raghuvanshi *et al*., 2019, Schiavi *et al*., 2020; Pufal and Zawislak, 2021). For example, Reichert *et al*. (2016) used this model to analyze the arrangement of innovation capabilities of low-technology companies, indicating the ideal arrangement to improve innovation performance.

**Figure 1. Innovation Capability Model**




Source: Adapted from Zawislak *et al*. (2012)

According to Zawislak *et al*. (2012), *development capability* (DC) refers to the ability that any firm has to interpret the current state of the art, absorb and transform a given technology to create new products, processes, methods and techniques aiming at reaching higher levels of technical-economic efficiency. It involves monitoring, acquiring, adapting, designing, and developing a new set of knowledge and technical systems for internal use. *Operations capability* (OC) is the ability to perform the given productive capacity through the collection of daily routines that are embedded in knowledge, skills and technical systems. It is a result of the selection of competitive priorities in order to take advantage of low cost, quality, delivery time, responsiveness, flexibility, degree of product standardization, size of product mix carried within the firm, volumes required, and production lead-time. *Management capability* (MC) refers to the ability to transform the technology development outcome into coherent operations and transaction arrangements. It is responsible for the matching and constantly fine-tuning between internal resources and goals with the external market environment and expectations. It involves

corporate strategy, resource allocation, norms and procedures, coordination, and integration. Management capability maintains a smooth flow of information and outputs to reach higher rates of efficiency. Finally, *transaction capability* (TC) is the ability to reduce marketing, outsourcing, bargaining, logistics, and delivering costs; in other words, transaction costs. Transaction capability refers then to the ability to effectively transact in the market what has been previously developed, operationalized and managed. It involves a set of specific skills and systems, which encompasses customer relationship, negotiation, contracting, and marketing.

Given the external dynamics, the firm will only survive, i.e., become different, if it is also internally dynamic itself. But how to be dynamic? The firm has to look at its four capabilities, ensuring the constant adjustment between change and stability, from product development to its commercialization. Considering that, the innovation capabilities should be arranged in ways to explore firm's strengths over time. Therefore, different arrangements of innovation capabilities, balancing stability and change, enable different paths to be followed toward innovation over time based on a process of building innovation capabilities.

### *2.2 Building Innovation Capabilities*

Firms have different histories and accumulated competences (Dosi, 1991). Their current position is often shaped by the path they have traveled. Where a firm can go is a function of its current position and the paths ahead. (Teece *et al.*, 1997). Penrose (1959) states that the knowledge a firm possess may limit its growth, but its effective organization can broaden its boundaries over time. Within this context, Sirmon *et al*. (2007) highlight the necessary process by which capabilities are formed, considering past, present and future variables. It is not a matter of having static routines, skills and resources; it is much more related to developing these routines, skills and resources, i.e., building innovation capabilities (Bell and Figueiredo, 2012; Börjesson *et al*., 2014; Lee, 2019) to expand firms' boundaries. Thus, to follow the paths toward innovation over time, firms must constantly engage in a process of building innovation capabilities (Lee and Malerba, 2017, 2018).

Building capabilities for innovation is strongly related to managing change constantly coping new and existing knowledge (Eisenhardt and Martin, 2000; Zollo and Winter, 2002). To build innovation capabilities, firms may choose which types of knowledge to change or augment in light of market opportunities (Helfat, 2018). Firms must be prepared to react to influential changes in the market and to exploit unforeseen opportunities when they occur

(Sirmon *et al*., 2007). Firms do so by defining integrative initiatives focused on organization for innovation (Börjesson *et al*., 2014) and by doing so they can move from one type of organization of the firm to another, seeking for more innovation performance.

Building capabilities is then related to the firm' ability to integrate, build, and reconfigure internal and external competences to address changes, given path dependencies and market positions (Leonard-Barton, 1992; Teece, 2007). Considering firms' internal heterogeneity that may lead to different performance over time (Lee and Malerba, 2017), processes of successfully and unsuccessfully building innovation capabilities are expected.

The concept of capability failure highlights the need for raising the level of certain capabilities through adaptation, learning, transformation and advancement of the *status quo* (Kim, 1997; Lee and Malerba, 2018; Lee, 2019). In that sense, capability failure refers to the difficulty in coordinating innovation capabilities over time.

Thus, arranging and rearranging innovation capabilities through a process of building capabilities is crucial for firms' survival and growth. On the one hand, firms that are able to change and build innovation capabilities are more prone to follow a path to success with more innovation performance. On the other hand, firms that fail to build innovation capabilities will follow a path to failure and might even close their doors.

It is then important to know which are the possible paths to build innovation capabilities and which paths are related to firm's success and failure. Therefore, we discuss the process of building firm innovation capabilities, by analyzing the innovation capabilities arrangements responsible for firms' success and failure over time.

## 3. METHODS

Data from two rounds of an innovation survey conducted by the NITEC Innovation Research Center were analyzed. The two rounds were carried out in 2014 and in 2020 and focused on understanding the innovation dynamics in Brazilian manufacturing firms. The survey received 1,331 valid responses from senior managers or owners of firms in 2014. In 2020, we found that 300 out of those firms have remained operating (hereinafter referred to as successful firms) and that 230 have closed their doors (hereinafter referred to as failed firms). Econometric panel data analysis, descriptive statistics, mean and regression analyses were used to assess which and how are the innovation capabilities arrangement related to firms that are

still operating in comparison to firms that have closed their doors. Based on that, we discuss the process of building innovation capabilities over time.

The questionnaire was based on the Innovation Capability Model proposed by Zawislak *et al*. (2012). The measures relate to the four innovation capabilities through 20 items (Table 1).

**Table 1. Questions about innovation capabilities and performance**

| Capability | Questions |
|---|---|
| Development | ✓ Designs its own products<br>✓ Monitors the latest technological trends in the sector<br>✓ Adapts the technology in use to its own needs<br>✓ Prototypes its own products<br>✓ Uses formal project management methods (Stage-Gate, PMBOK, innovational funnel, etc.)<br>✓ Launches its own products |
| Operations | ✓ Carries out the productive process as programmed<br>✓ Establishes a productive routine that does not generate rework<br>✓ Delivers the products promptly<br>✓ Manages to expand the installed capacity whenever necessary<br>✓ Manages to ensure that the process does not lead to products being returned |
| Management | ✓ Formally defines its strategic goals annually<br>✓ Updates its management tools and techniques<br>✓ Maintains the personnel adequately trained<br>✓ Uses modern financial management practices |
| Transaction | ✓ Conducts formal research to monitor the market<br>✓ Imposes its negotiating terms on its suppliers<br>✓ Imposes its prices on the market<br>✓ Imposes its negotiating terms on its customers<br>✓ Uses formal criteria to select its suppliers |
| Performance | ✓ Profit growth<br>✓ Market share growth<br>✓ Revenue growth |

Respondents rated their level of agreement to each item of innovation capabilities using a five-point Likert scale ranging from ‘strongly disagree’ to ‘strongly agree’. The study also analyzes innovation performance based on firms’ growth of market share, net profit and revenue.

Firms’ innovation capabilities arrangements are analyzed through two different aspects as proposed by Ostermann *et al.* (2021): (1) the most prominent capabilities according to the means of the responses for each capability (i.e, actual arrangement); (2) the firms’ arrangement of capabilities with the greatest impact on innovation, according to models generated by regression (i.e., ideal arrangement).

The first analysis allowed us to verify which capabilities were evaluated with the highest score by firms, considering the capabilities that receive the most attention according to respondents' perception. The second analysis has identified, based models generated by regression, the ideal arrangement of capabilities toward innovation performance. By definition, innovation relates to changes that bring profits to the innovator (Schumpeter, 1942). Thus, we performed regression and descriptive analyses, using the means of each capability and performance to identify the capabilities arrangements of successful (n=300) and failed firms (n=230) within the sample and their effect on performance. We tested the following model:

$$PERF = \beta 0 + \beta 1DC + \beta 2OC + \beta 3MC + \beta 4TC + e$$

This model aims to explain the effects of capabilities on innovation by combining such capability measurements as processes and routines with an innovation performance outcome (PERF). Each capability (development – DC, operations – OC, management – MC and transaction – TC) has a standardized coefficient (respectively, β1, β2, β3 and β4), and the arrangement of capabilities will be determined by the combination of coefficients.

We also analyzed panel data from both 2014 and 2020 datasets, to comparatively identify the capabilities that have led firms towards success over the last six years, i.e., to identify how firms have built innovation capabilities. To do so, we ran a fixed-effect regression model:

$$PERF_{it} = \beta_0 + \beta_1 X_{it} + \ldots + \beta_k X_{kt} + c_i + e_{it}$$

Where:

$PERF_{it}$ is the dependent variable Performance, $i$ = firm identification number (id), and $t$ = year (2014, 2020);

$X_{kt}$ represents one independent variable = each capability indicators;

$\beta_k$ is the coefficient for the independent variable;

$c_i$ is the firm fixed effects;

$e_{it}$ is the error term.

The fixed effects involve firm inherent unobserved time invariant characteristics, or characteristics that wouldn't be expected to have changed over the last six years, such as culture, ownership, date of establishment, among others.

We also analyze specific firms' characteristic such as size, industry, and industry technological intensity. In order to characterize firms according to size, a revenue criterion of the Brazilian Development Bank (BNDES) was applied through an equivalence of the size ranges of each year, 2014 and 2020. The division used for industry and its technological intensity was proposed by Cavalcante (2014), who combined the Brazilian National Classification of Economic Activities (IBGE, 2017) to the industry technological intensity division created by the Organisation for Economic Cooperation and Development (OECD, 2011). By analyzing the different arrangements – actual and ideal – of innovation capabilities of successful and failed firms in a period of six years, we could identify paths to success and failure and discuss how to conduct a process of building innovation capabilities over time.

## 4. RESULTS

Results are analyzed under the lenses of successful and failed firms, in this order. Descriptive analysis regarding size, industry and technology intensity are first reported. Then the results of mean and regression analyses are shown, comparing data from 2014 to 2020 in the case of successful firms.

### *4.1 Successful Firms*

Descriptive analysis shows that successful firms have increased in size over the last six years (Table 2). If in 2014 the majority of firms were under the micro enterprise category, in 2020 the majority turned out to be small enterprises.

**Table 2. Size of "Successful firms" in 2014 and 2020**

| | 2014 | | 2020 | |
|---|---|---|---|---|
| **Size** | **Frequency** | **Percent** | **Frequency** | **Percent** |
| Micro | 162 | 54% | 53 | 17.7% |
| Small | 86 | 28.7% | 150 | 50% |
| Medium | 41 | 13.7% | 83 | 27.7% |
| Large | 3 | 1% | 11 | 3.7% |
| *Missing* | 8 | 2.7% | 3 | 1% |
| Total | 300 | 100% | 300 | 100% |

Over the last six years, firms have remained acting in the same industries. Low-technology industries are the majority, reflecting the overall characteristics of Brazilian firms (Reichert *et al*., 2016). Table 3 presents how many successful firms belong to which manufacturing industry and technological intensity.

**Table 3. Industry of "Successful firms"**

| Industry Technological Intensity | Industry | Amount of companies | % of the total surveyed |
|---|---|---|---|
| Low-technology (48%) | Food | 30 | 10% |
| | Furniture | 25 | 8.3% |
| | Clothing | 24 | 8% |
| | Footwear and Leather | 22 | 7.3% |
| | Wood | 12 | 4% |
| | Pulp and Paper | 11 | 3.7% |
| | Other Manufacturing Products | 10 | 3.3% |
| | Textile | 3 | 1% |
| | Printing | 3 | 1% |
| | Beverage | 2 | 0.7% |
| | Tobacco | 2 | 0.7% |
| Medium Low-technology (26.3%) | Metal Products | 41 | 13.7% |
| | Plastic and Rubber | 21 | 7% |
| | Nonmetallic Products | 12 | 4% |
| | Metallurgy | 4 | 1.3% |
| | Machinery Maintenance | 4 | 1.3% |
| | Petroleum Refining | 1 | 0.3% |
| Medium High-technology (23.7%) | Machinery & Equipment | 40 | 13.3% |
| | Automotive | 12 | 4% |
| | Chemicals | 8 | 2.7% |
| | Electric | 4 | 1.3% |
| | Transportation Equipment | 3 | 1% |
| High-technology (2%) | Electronics | 6 | 2% |
| **Total** | | **300** | **100%** |

In order to verify the evolution of innovation capabilities over time, we analyzed the mean of each capability and performance indicators of firms in each year. Table 4 shows the mean analysis for the whole sample of successful firms.

**Table 4. Mean Analysis for "Successful firms"**

| Capability | 2014 | | 2020 | |
|---|---|---|---|---|
| | Mean* | Std. Deviation | Mean* | Std. Deviation |
| Development (DC) | 3.75 | .77 | 3.79 | .67 |
| Operations (OC) | 4.05 | .54 | 4.16 | .47 |
| Management (MC) | 3.84 | .67 | 3.68 | .65 |
| Transaction (TC) | 3.48 | .71 | 3.45 | .64 |
| Performance (PERF) | 3.65 | .75 | 3.44 | .86 |

* $p < .05$ for all cases. n = 300.

Mean analysis reflects what the firms perceive as more relevant to achieve better performance, i.e., the actual arrangement of capabilities. Results show that the means of both management and transaction capabilities have reduced, while development and operations capabilities have increased over time. This demonstrates a greater focus on the technological driver during this time interval. Remarkable is that development capability surpassed management capability from 2014 to 2020, becoming thus the second capability most relevant based on firms' perception. Thus, the actual arrangement in 2014 was OC – MC – DC – TC, whereas the actual arrangement in 2020 was OC – DC – MC – TC.

Regression analyses aimed to identify the best capabilities arrangements for innovation performance, i.e, the ideal arrangement. The resulting ideal arrangement is rather different than the actual arrangements. In successful firms, the linear combination of capabilities measures was significantly related to performance both in 2014 and in 2020.

The estimated equation for 2014 data is ($R^2 = 0.175$, F-statistic = 15.688, $p = 0.0001$):

$$\widehat{PERF} = 1.545 + .123*DC - .005*OC + .281*MC + .168*TC \qquad \textit{[equation 1]}$$

The estimated equation for 2020 data is ($R^2 = 0.268$, F-statistic = 27.052, $p = 0.0001$):

$$\widehat{PERF} = .848 + .269*DC - .052*OC - .003*MC + .524*TC \qquad \textit{[equation 2]}$$

Note: $\widehat{PERF}$ *is the predicted value of PERF. Remarkable is that the* $R^2$ *value increased from 2014 to 2020, which means that the proportion of variance in the dependent variable that can be explained by the independent variable in the model increased from the first round to the second.*

In 2014, on the basis of the relative strength of each predictor (capability) generated in the multiple regression analysis, the only non-meaningful predictor ($p > .05$) was the strength measure for operations capability (in red). Development, management and transaction capabilities presented meaningful predictors.

In 2020, considering the relative strength of each predictor generated in the multiple regression analysis, the two non-meaningful predictors ($p > .05$) were the strength measures for operations and management capabilities (in red). The two meaningful predictors ($p < .05$) were the strength measures for development and transaction capabilities.

Panel data analysis was conducted using fixed-effect regression, in order to observe how capabilities behaved affecting performance over time. The resulting model ($R^2$ overall = 0.186, Prob > F = 0.00, t > 1.96, and $p < 0.05$ in all cases) was as follows:

$$\widehat{PERF}_{(it)} = 1.305 + .161*DC_{(it)} + .472*TC_{(it)} \qquad \textit{[equation 3]}$$

Whereas transaction and development capabilities appeared as the two capabilities responsible for firm performance over time, operations and management capabilities did not appear as significant for the model and were therefore removed. Thus, the ideal model for building innovation capabilities over time is based on transaction and development capabilities (TC & DC).

### *4.2 Failing Firms*

Results show that failed firms were in its majority classified as Micro enterprises, as well as the successful firms in 2014. Table 5 shows the proportion considering each size range.

**Table 5. Size of "Failed firms"**

| Size | Frequency | Percent |
|---|---|---|
| Micro | 146 | 63.5% |
| Small | 64 | 27.8% |
| Medium | 16 | 7% |
| Large | 3 | 1.3% |
| *Missing* | 1 | .4% |
| **Total** | **230** | **100%** |

Failed firms acted majorly in low-technology industries. Footwear and leather is the industry of most failed firms in general, followed by metal products and clothing. Table 6 shows how many failed firms belong to which manufacturing industry and technological intensity.

**Table 6. Industry of "Failed firms"**

| Industry Technological Intensity | Industry | Amount of companies | % of the total surveyed |
|---|---|---|---|
| Low-technology (53%) | Footwear and Leather | 36 | 15.7% |
| | Clothing | 22 | 9.6% |
| | Furniture | 20 | 8.7% |
| | Food | 17 | 7.4% |
| | Wood | 8 | 3.5% |
| | Printing | 6 | 2.6% |
| | Pulp and Paper | 5 | 2.2% |
| | Other Manufacturing Products | 4 | 1.7% |
| | Beverage | 2 | 0.9% |
| | Textile | 1 | 0.4% |
| | Tobacco | 1 | 0.4% |
| Medium Low-technology (29.6%) | Metal Products | 30 | 13% |
| | Plastic and Rubber | 21 | 9.1% |
| | Metallurgy | 10 | 4.3% |
| | Nonmetallic Products | 7 | 3% |
| | Machinery Maintenance | 2 | 0.9% |
| Medium High-technology (17%) | Machinery & Equipment | 17 | 7.4% |
| | Automotive | 8 | 3.5% |
| | Chemicals | 6 | 2.6% |
| | Electric | 6 | 2.6% |
| High-technology (0.4%) | Electronics | 1 | 0.4% |
| | **Total** | **230** | **100%** |

Table 7 shows the mean analysis for the whole sample of failed firms, i.e., those firms that have closed their doors in the period from 2014 to 2020.

**Table 7. Mean Analysis for "Failed firms"**

| Capability | Mean* | Std. Deviation |
|---|---|---|
| Development (DC) | 3.48 | .85 |
| Operations (OC) | 3.81 | .57 |
| Management (MC) | 3.66 | .62 |
| Transaction (TC) | 3.32 | .72 |
| Performance (PERF) | 3.27 | .81 |

* $p < .05$ for all cases. $n = 230$.

Mean analysis show that the actual arrangement of failed firms was focused on operations capability, followed by management, development and transaction capabilities (OC – MC –DC – TC). Regression analysis, however, show that this was not ideal.

In failed firms, the linear combination of capabilities measures was significantly related to performance, $p < .05$, $R^2 = 0.378$. Equation 4 shows the summary of regression analysis for failed firms:

$$\widehat{PERF} = -.232 + .000*DC + .183*OC + .391*MC + .412*TC \qquad [equation\ 4]$$

On the basis of the relative strength of each predictor (capability) generated in the multiple regression analysis, the non-meaningful predictors ($p > .05$) are the strength measures for development and operations capabilities (in red). The meaningful predictors ($p < .05$) are the strength measures for management and transaction capabilities. Thus, the ideal arrangement toward innovation performance for failed firms was based on transaction and management capabilities (TC & MC).

These results show that a focus on operations capability, priming for stability, can be a problem, since that is not a capability responsible for firm growth over time. The need for change is, once again, highlighted as a way to avoid a path to failure.

## 5. DISCUSSION AND CONCLUDING REMARKS

The aim of this study was to identify the process of building firm innovation capabilities, by analyzing the innovation capabilities arrangements responsible for firms' success and failure over time. Building innovation capabilities is not related to a static aspect of the firm. It deals with several evolving facets of the firm, which must be constantly orchestrated in a way to generate positive outcomes.

Results show that successful firms have increased in size over the last six years, moving mainly from the micro to small enterprises category, with a growth of medium and large enterprises as well. This is a fundamental assumption for the process of building capabilities, since that, to survive, the firm has to grow (Penrose, 1959); to keep the balance, the firm needs to constantly change (Dosi, 1991; Teece, 2017); and, as results show, to be successful, the firm

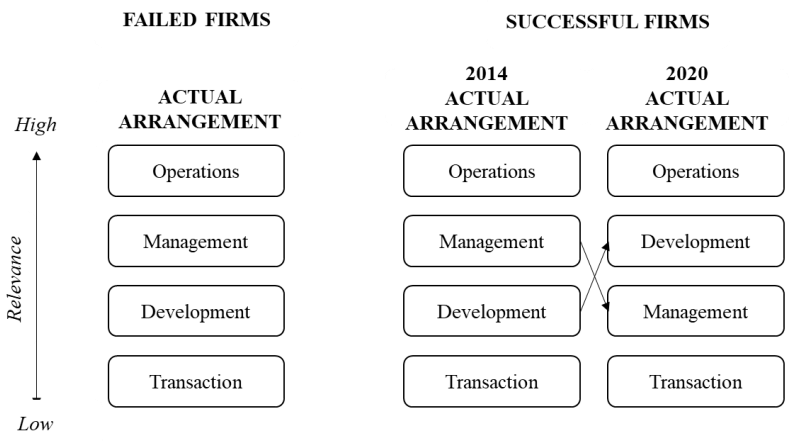
needs to develop and offer new solutions to the market. Therefore, building capabilities relates to increasing the size of the firm.

Successful firms have remained acting in the same industry, in which low-technology industries are still the majority. This is an expected outcome, given that in six years it is unlikely that the process of building innovation capabilities would take place via technological upgrading, especially when starting from a lower level. This finding reinforces the idea that, in the same technological standard and regardless of the industry, the building of capabilities takes place through the rearrangement of capabilities. The industry technology intensity does not limit firms' potential. However, the more product-oriented and more innovative a firm becomes, the more chances it has to survive in the Brazilian manufacturing environment.

As results show, in 2014, both successful and failed groups presented a similar actual arrangement of capabilities: focused primarily on operations capability, followed by management, development and transaction capabilities. However, analyzing panel data and the arrangements of capabilities over time, the importance of change is evident, as highlighted by Rothaermel and Hess (2007) and Teece (2017).

Firms that are still open have focused more on development during the last years – and management capability has received less attention. To thrive over time, successful firms have incorporated more development capability into their toolset. Management gave place to development. Thus, rather than keep focusing on traditional management, the analysis points at the need for a firm to master technology and focus on product development over time. Figure 2 shows the summary of mean analysis based on firms' perception, highlighting the actual arrangement of each group.

**Figure 2. Actual arrangement of successful and failed firms**



The analysis of the ideal arrangement of capabilities toward innovation performance highlights the importance of building capabilities and sheds light on the paths to success and failure. For successful firms, as panel data analysis showed, the ideal arrangement is the one involving transaction and development; whereas for failed firms, the ideal arrangement seemed to be the one involving transaction and management. Focusing on development was exactly the path that successful firms followed to build innovation capabilities from 2014 to 2020.

Thus, we conclude that to grow, remain active and succeed, firms have to invest in transaction and development capabilities. Firms that have remained focusing on operations and management and have not built the capabilities that mostly impact performance over time have closed their doors. Actually, operations and management capabilities were precisely the two capabilities that were not significant for innovation performance. Figure 3 illustrates then the paths to success and failure.

**Figure 3. Paths to success and failure**


The path to success, i.e., the path that will lead the firm toward growth and innovation involves building more transaction and development capabilities over time. The path to failure, i.e., the path that will lead the firm to deviate its focus and most likely close the doors in the future, is one majorly related to focusing on operations and management capabilities, priming for efficiency instead of selling different products. The ideal arrangement of capabilities in the analyzed time interval shows that only firms that have balanced non-technological (transaction) and technological (development) capabilities to offer distinguished products in the market have remained active.

By showing evidence with empirical data, this study enlarges the understanding on why firms succeed and fail to innovate. By addressing both the paths to success and failure, this paper enlightens the discussion for innovation in manufacturing firms and effective strategies for successfully building innovation capabilities, especially in an emerging country.

The study contributes to the academic literature in several ways. First, it is based on a unique dataset that traces a large set of companies six years apart, thus being able to check firm

survival and associate it with innovation capabilities. Second, it relates to an emerging economy which has not received adequate attention until now, largely because of the lack of micro-level data. Third, the study is based on a robust theoretical model of innovation capabilities which is being tested through such data. Fourth, the study contributes to the discussion over building innovation capabilities at the micro level.

In terms of practical implications, this study may contribute to the design and implementation of industrial innovation policies by elucidating that actions focused on development and transaction capabilities are those most prone to bring more positive results over time. As for managers, they could benefit from the proposed discussion to conduct changes within their arrangements of capabilities towards innovation and competitive reconversion over time.

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# CONCLUSION

Only after knowing the different arrangements of capabilities that enable an organized firm to deal with stability and change, it is possible to discuss the evolution of successful innovation paths over time. The analysis of empirical evidence regarding the innovation capabilities of the same firms in a period of six years allowed the discussion on the process of building innovation capabilities through three sequential papers. **Based on that, this PhD dissertation concludes that the process of building innovation capabilities should be toward transaction and development capabilities, i.e., change-driven capabilities, to ensure competitive performance over time.**

Through three different methods, the three papers presented support this conclusion. The first paper showed the different types of organization of the firm, the second paper suggested paths to be followed by firms toward innovation, and finally the third paper presented the process of building innovation and discussed successful and failed paths based on panel data.

In the first paper, results show four different types of organization of the firm. The successful strategies toward innovation are related to change-oriented organization of the firm and advanced stability-oriented organization of the firm. On the one hand, firms that have change-oriented organization will seek to organize after innovating, developing an organizational structure to fulfill the growing value over time. On the other, firms with advanced stability-oriented organization must keep organizing for innovation, as a constant flow of disequilibria, where change-driven capabilities may become greater than stability-driven capabilities, and further balance with a new responsive organizational structure. Change-driven capabilities, i.e., development and transaction capabilities, should be built as a way to settle the ground for innovation in a more stability-oriented company. After that, once the company has moved towards innovation, stability-driven capabilities, i.e. operations and management capabilities, should be built as a way to support companies' success and growth.

In the second paper, results show that, on the one hand, firms with lower technology intensity should build change-related capabilities to catch-up, i.e., follow paths toward innovation. These firms acting in low-tech and medium low-tech industries should adopt a focus on differentiation, either in terms of development or transaction capabilities, having operations and management capabilities as support. It is expected that these firms promote internal changes, triggered by in-house research development, external alliances, product differentiation and so on (Lee, 2013). On the other hand, catching-up firms with higher technology intensity

already present development capability. Firms acting in medium high-tech and high-tech industries have management as a necessary condition for innovation performance, with the support of operations, when seeking for productive efficiency, or of transaction, when dealing with negotiation power. Over time, such firms should focus on building transaction capability to negotiate, ensuring that management and operations will support the growth.

In the third paper, results show that firms fail to innovate mainly because they lack development capability. To thrive over time, successful firms have incorporated more development capability into their set, in a way that transaction and development capabilities became responsible for more innovative performance over time. Firms that have remained focusing on operations and management and have not built the capabilities that mostly impact performance over time have closed their doors. When taking descriptive characteristics into account, it is also possible to conclude that building capabilities is more related to size and to innovation capabilities' ideal arrangement than to industry or to technology intensity. To survive, the firm has to grow (Penrose, 1959); to keep the balance, the firm needs to constantly change (Dosi, 1991; Teece, 2017); and to be successful, the firm needs to develop and offer new solutions to the market. Building capabilities is then related to change-driven capabilities and growth.

Thus, the general conclusion that can be reached in this PhD dissertation is that, a firm, in order to be successful in building capabilities, must base this endeavor on transaction and development capabilities. Conversely, if the focus is on operations and management capabilities, the probability of success is reduced. Confirming the proposition made in the introduction section, results show that firms that thrived did so by betting on transaction and development capabilities, while those that closed, focused on operations and management capabilities – precisely the two capabilities that do not impact performance over time.

Therefore, we conclude that the path to success, i.e., the path that will lead the firm toward growth and innovation involves building more transaction and development capabilities over time. The path to failure, i.e., the path that will lead the firm to deviate its focus and most likely close the doors in the future, is one majorly related to focusing on operations and management capabilities, priming for efficiency instead of selling different products. The ideal arrangement of capabilities in the analyzed time interval shows that only firms that have balanced non-technological (transaction) and technological (development) capabilities to offer distinguished products in the market have remained active. Recalling the dichotomous behavior every firm faces when dealing with stability and change, this work concludes that firms change

by investing in transaction and development capabilities (change-driven capabilities) – having operations and management capabilities as support (stability-driven capability). Ultimately, this statement reinforces that stability and change should be coupled together for success.

To further deepen the results presented in this dissertation, future studies could reinitiate the sequential cycle of the papers presented, dividing the remaining – successful – firms of the sample into firm and organization (change-driven and stability-driven capabilities) to verify the different types of organization of the firm after building innovation capabilities. Such process is not linear and is therefore in constant evolution. Analyzing firms over time allows, as in this study, to monitor their evolutionary behavior. Addressing firms' idiosyncrasies would also generate interesting insights, especially focusing on specific sectors, technology intensity levels, and capabilities levels.

Future studies are also encouraged to analyze through case studies the evolution of the innovation capabilities of firms that performed above and below average over the last years, investigating their relationship with public policies in the period. Firms, at the micro-level, help promoting development at the macro-level. As suggested by Cirera and Maloney (2017), without capable firms to take ideas to market, innovation policy to frontier science and technology policy may yield little in terms of growth.

This study contributes to the academic literature in several ways. First, it is based on a unique dataset that traces a large set of companies six years apart, thus being able to check firm survival and associate it with innovation capabilities. Second, it relates to an emerging economy which has not received adequate attention until now, largely because of the lack of comparative micro-level data. Third, the study is based on a robust theoretical model of innovation capabilities which has been tested through such and previous data. Fourth, by discussing the paths toward innovation, the study contributes to the discussion over building innovation capabilities at the micro level as a means to seize catch-up opportunities at the macro level. In terms of practical implications, this study may contribute to fostering the fundamental firm innovation capabilities through industrial innovation policies in developing countries such as Brazil. As for managers, they could benefit from the proposed discussion to conduct changes within their arrangements of capabilities toward innovation and competitive reconversion over time.

There are some general limitations in this study that must be mentioned, even though they have been resolved through different methodological techniques over the papers. First, the fact that the questionnaire, given the way research is conducted in Social Sciences, is based on

respondent's opinion, and, therefore, answers are narrowed to that point of view. That may cause biased scores, considering that value perception may vary from one respondent to another. However, this limitation has not affected the results in the study, since significant differences were verified among scores. Second, the fact that the COVID-19 pandemic exploded in 2020 may have affected some answers in the second round of the survey, even though respondents were requested to consider their firm's performance and situation before the pandemic context. The number of respondents may have also been affected because of the pandemic, since some firms didn't have time to answer the survey due to a myriad of constraints related to their daily activities. However, the sample was sufficient to the statistical analyses conducted. Finally, the fact that this study is centered in Brazilian firms. To further explore the discussion on the process of building innovation capabilities, it would be interesting to expand the analytical perspective encompassing and comparing data from other emerging and developed countries. The literature that has guided this PhD dissertation has been majorly focused on other countries to elaborate on the concepts presented. Therefore, this study contributes to adapt the lenses to the Brazilian scenario.

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# APPENDIX

## Permission letters of co-authors

**Permission letter of co-author**

1. I hereby authorize the inclusion of the paper entitled “Innovation capabilities and the organization of the firm: evidence from Brazil” as part of the PhD dissertation of Nathália Amarante Pufal.

2. I hereby authorize the inclusion of the paper entitled “Innovation capabilities and catch-up: evidence from manufacturing firms in Brazil” as part of the PhD dissertation of Nathália Amarante Pufal.

3. I hereby authorize the inclusion of the paper entitled “The process of building innovation capabilities: success and failure of Brazilian manufacturing firms” as part of the PhD dissertation of Nathália Amarante Pufal.

   As a co-author, I have contributed substantially to all sections of the papers, in a constant exchange with Nathália.

*** * ***

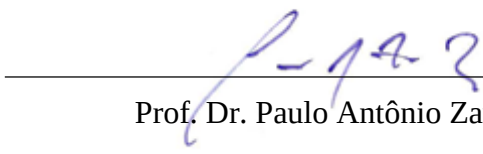
**Carta de autorização de coautor**

1. Autorizo a inclusão do artigo intitulado “Innovation capabilities and the organization of the firm: evidence from Brazil” na tese de doutorado de Nathália Amarante Pufal.

2. Autorizo a inclusão do artigo intitulado “Innovation capabilities and catch-up: evidence from manufacturing firms in Brazil” na tese de doutorado de Nathália Amarante Pufal.

3. Autorizo a inclusão do artigo intitulado “The process of building innovation capabilities: success and failure of Brazilian manufacturing firms” na tese de doutorado de Nathália Amarante Pufal.

   Como coautor, contribuí substancialmente para todas as seções dos artigos, em constante interação com a Nathália.



Prof. Dr. Paulo Antônio Zawislak

*Universidade Federal do Rio Grande do Sul, Brazil*

**Permission letter of co-author**

I hereby authorize the inclusion of the paper entitled "Innovation capabilities and catch-up: evidence from manufacturing firms in Brazil" as part of the PhD dissertation of Nathália Amarante Pufal.

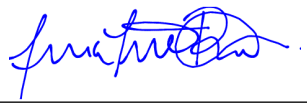
As a co-author, I have contributed substantially to the methods, results and discussion sections of the paper.

*** * ***

**Carta de autorização de coautora**

Autorizo a inclusão do artigo intitulado "Innovation capabilities and catch-up: evidence from manufacturing firms in Brazil" na tese de doutorado de Nathália Amarante Pufal.

Como coautora, contribuí substancialmente para as seções de método, resultados e discussão do artigo.



Prof. Dra. Fernanda Maciel Reichert

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OF INTERNATIONAL AFFAIRS

**Institute for International Science and Technology Policy**

November 8, 2021

**Permission letter of co-author**

I hereby authorize the inclusion of the paper entitled "The process of building innovation capabilities: success and failure of Brazilian manufacturing firms" as part of the PhD dissertation of Nathália Amarante Pufal.
As a co-author, I have contributed to the theoretical background, as well as to the results and discussion sections of the paper.

* * *

**Carta de autorização de coautor**

Autorizo a inclusão do artigo intitulado "The process of building innovation capabilities: success and failure of Brazilian manufacturing firms" na tese de doutorado de Nathália Amarante Pufal.
Como coautor, contribuí para as seções de referencial teórico, resultados e discussão do artigo.

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