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DEPARTAMENTO DE ENGENHARIA DE PRODUÇÃO

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REGIONAL RELATED VARIETY AND COMPANIES' PRODUCTIVITY IN BRAZIL

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Projeto de Mestrado apresentado ao Programa de Pós-Graduação em Engenharia de Produção da Universidade Federal de São Carlos para Exame de Qualificação.

Orientador: Dr. Herick Fernando Moralles

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Assinaturas dos membros da comissão examinadora que avaliou e aprovou a Defesa de Dissertação de Mestrado da candidata Anaisa Comparini, realizada em 09/10/2019:

Prof. Dr. Herick Fernando Moralles
UFSCar

Profa. Dra. Ana Lucia Vitale Torkomian
UFSCar

Profa. Dra. Ana Elisa Périco
UNESP

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Prof. Dr. Herick Fernando Moralles

“...porque aos seus anjos
ele mandou que te guardem
em todos os teus caminhos.”
Salmos 91:11

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ABSTRACT

There is a discussion in the literature about the benefits that the regional diversity can result in the companies' productivity due to knowledge recombination, that allows greater opportunities to imitate, share and recombine ideas. However, few studies have been conducted in developing economies. This study aims to analyze the effects of the regional related variety (an indicator that captures the complementarity between sectors) on the companies' productivity. Also, we intend to verify whether the absorptive capacity is a significant moderator in this process and its thresholds. For the empirical study, a database containing data on 80 Brazilian municipalities and 194 companies was used, with data between 2010 and 2014. By calculating the related variety indicator to measure regional diversity and threshold regressions to measure absorptive capacity, this research contributes to the literature, given that empirical studies on this subject in Brazil are still limited. Besides, as the country has a diversified economy, we believe in recombination as an option for economic growth. The results indicate that the related variety has no significant effect on productivity when analyzed alone, but when moderated by the absorptive capacity it has a positive effect.

Keywords: related variety, recombination, absorptive capacity.

RESUMO

Há uma discussão na literatura sobre os benefícios que a diversidade regional pode resultar na produtividade das empresas devido à recombinação do conhecimento, que permite maiores oportunidades de imitar, compartilhar e recombinar ideias. No entanto, poucos estudos foram realizados em economias em desenvolvimento. Este estudo tem como objetivo analisar os efeitos da variedade relacionada da região (indicador que capta a complementaridade entre setores) na produtividade das empresas. Além disso, pretendemos verificar se a capacidade de absorção é um moderador significativo neste processo e quais são seus limiares. Para o estudo empírico, uma base de dados contendo dados sobre 80 municípios brasileiros foi utilizada, com dados entre 2010 e 2014. Ao calcular o indicador de variedade relacionada para calcular a diversidade regional e regressões por limiar para medir a capacidade de absorção, esta pesquisa contribui com a literatura, dado que estudos empíricos sobre esse assunto no Brasil ainda são limitados. Além disso, como o país possui uma economia diversificada, acreditamos na recombinação como opção de crescimento econômico. Os resultados indicam que a variedade relacionada não tem efeito significativo na produtividade quando analisada isoladamente, mas quando moderada pela capacidade de absorção possui efeito positivo.

Palavras-chave: variedade relacionada, recombinação, capacidade de absorção.

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LIST OF ABBREVIATIONS

ABC – Absorptive Capacity

ADS – Abstract-driven search

CNAE – Classificação Nacional de Atividades Econômicas

FDI – Foreign Direct Investment

FGLS – Feasible Generalized Least Squares

HS - Harmonized System

ISIC - International Standard Industrial Classification

NACE - European Classification of Economic Activities (for the French term "Nomenclature statistique des activités économiques dans la Communauté européenne")

SIC -Standard Industrial Classification

SNI - Swedish Standard Industrial Classification

TFP – Total Factor Productivity

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CHAPTER 1: INTRODUCTION

1.1 RESEARCH TOPIC

Knowledge is one of the main drivers of economic growth, as it makes the national workforce more qualified and able to absorb knowledge and produce ideas (FOSTER-MCGREGOR, PÖSCHL AND STEHRER, 2017; GLAS, HÜBLER AND NUNNENKAMP, 2016; KHORDAGUI AND SALEH, 2016; OLIVEIRA, 2004).

Knowledge Spillovers tend to occur through informal ways (such as meetings of different companies, employees migration between companies). The regional industrial structure is related to the absorption of spillovers by a company, and the literature distinguishes two types of spillovers produced from economic agglomerations, classified as Marshall-Arrow-Romer (MAR) spillovers, known to happen in the agglomeration of companies specialized in a given sector (GLAESER et al., 1992) and more pronounced in small or R&D intensive sectors (PANNE, VAN DER, 2004), and the Jacobs spillovers, that occur from the agglomeration of different industrial sectors which, due to a diversified environment, encourage the production of new ideas and generate innovation (JACOBS, 1969). The benefits of diversity can result from the recombination of knowledge because there are greater opportunities to imitate, share and recombine ideas and practices in all sectors that are part of a more diverse regional economy (BEAUDRY AND SCHIFFAUEROVA, 2009; VAN DEN BERGH, 2008; CARNABUCI AND OPERTI, 2013; GUAN AND YAN, 2016).

However, to take advantage of spillovers, it is also required to have the absorptive capacity to have the benefits arising from this overflowing knowledge (ALCÁCER AND CHUNG, 2007; CARAGLIU AND NIJKAMP, 2012; LIN AND CHANG, 2015; VOLBERDA, FOSS AND LYLES, 2010; WANG et al., 2016). Absorptive capacity (ABC) increases the capacity of a region to identify, assimilate and exploit knowledge, and is related to the capacity that the company has to find and use new knowledge to grow (COHEN AND LEVINTHAL, 1989, 1990; GIRMA, 2005; KIM, 2015; MIGUÉLEZ AND MORENO, 2015; ZAHRA AND GEORGE, 2002; ZHANG ET AL., 2010). This growth occurs from potential sources of innovation that every organization will find and use, but the reality, however, is that companies differ in their ability to use these sources (BESSANT AND TRIFILOVA, 2017).

Wang et al. (2016), when studying diversity in China, found a positive relationship between regional diversity and innovation, and an inverse relationship between diversity and specialization. Thus, the authors' results encouraged the governments to work on policies to enhance diversify regional production to maximize productivity gains. Zhang et al. (2010) take into account the absorptive capacity to examine the effects of diversity spillovers. Using panel data on Chinese manufacturing companies during the period from 1998 to 2003, they find that regional diversity has a positive relation to company productivity. This provides an important scenario for understanding the role of diversity as an external source of knowledge and the effect on regional innovation in developing economies, as well as in Brazil.

To measure regional diversity, the related variety has been widely used in recent literature, for measuring the degree of proximity between different industries of a region, but which have some similarity in their activities, thus allowing spillovers of knowledge (AUTANT-BERNARD AND LESAGE, 2011; BOSCHMA AND IAMMARINO, 2007; FRENKEN et al., 2007). According to the authors, it is necessary a degree of proximity, i.e., related variety, to ensure effective communication and learning. Frenken et al. (2007) associates related variety with Jacob's spillovers.

Related variety is important for economic development as it enhances the learning and growth opportunities of industries (BOSCHMA, 2014; BOSCHMA, COOKE AND ASHEIM, 2011) . Thus, this investigation aims to verify if regional related variety has a positive impact on the companies' productivity. Besides, it intends to analyses the importance of absorptive capacity as a moderator, while measuring possible thresholds.

1.2 RESEARCH PROBLEMS AND GOALS

This study aims to analyze the effects of the region's related variety on companies' productivity. More specifically, the intention is to empirically evaluate the impacts of the related variety from a region on the productive aspects of companies in this region. In addition, absorptive capacity is considered to be a determining factor in obtaining the benefits of a diverse environment and is therefore also being evaluated. Related variety is a measure that captures the complementarity between sectors, and its calculation has been studied by Frenken (2009). To measure companies' productivity, Total Factor Productivity (TFP) is used.

Thus, the research question of this study is: Is there a positive relationship between the regional related variety and the companies' productivity? Based on the research question presented and the main objective, it is possible to define specific goals of this study:

i) Propose an econometric model to measure the relationship between companies' productivity and the region's related variety;

ii) Verify if the absorptive capacity is a significant moderator in this process;

iii) Verify the effects of the related variety on the firm's productivity according to the levels of absorptive capacity (thresholds).

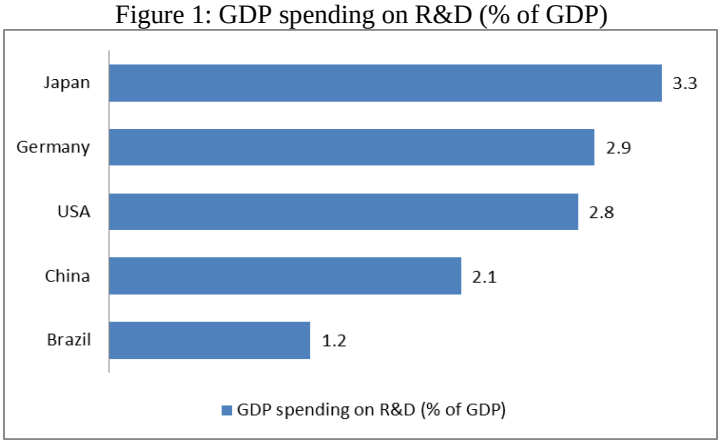
1.3 MOTIVATION

There are several empirical studies on recombination. Antonelli, Krafft, and Quatraro (2010) studied patent applications in Europe between 1981 and 2003, and they identified that the recombination process has been more effective in countries characterized by higher levels of specialization and higher rates of productivity growth. König et al. (2011) argue that economic growth is a result of the recombination of knowledge between companies in an R&D intensive industry.

However, many studies have been conducted in developed countries, and this scenario in developing countries is probably different. Bessant, Rush and Trifilova (2012) studied recombination as an alternative where the main sources of innovation are blocked and where alternative solutions are needed, such as in conditions of a financial crisis. Zaccaria et al. (2016) investigate that recombination helps countries about excessive dependence on their own resources, such as primary sector exports. Guan and Yan (2016) argue that recombination is an alternative when the culture or financial structure of organizations does not allow taking risks in their R&D projects. Harrison, Kelley and Gant (1996) argue that developing countries can benefit from a more diversified economy, as is the case in Brazil.

The national industrial structure has grown and consolidated as one of the widest and most diversified of the group of late industrialization countries (ROSSI, SANTOS AND SANTOS, 2017). Besides, from Figure 1 is possible to verify that investment in R&D in Brazil is still scarce. China, for example, a developing country like Brazil, presents a much better result. Therefore, for Brazil, diversification can be an appropriate strategy.

Figure 1: GDP spending on R&D (% of GDP)

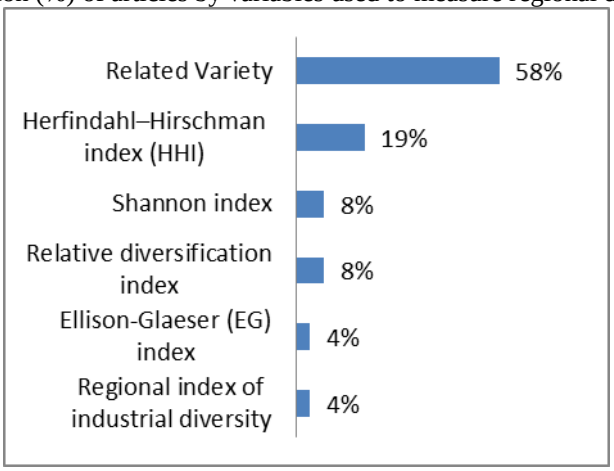


Source: adapted by the author of World Economic Forum (2018)

Thus, given the current configuration of the Brazilian industry, where R&D intensive sectors are scarce, and due to the country's diversified economy, recombination may be an appropriate strategy for economic growth.

As discussed earlier, for many authors, a diverse environment enables recombination, which can be a way to economic growth. In addition, we know that Jacobs' spillovers occur in diverse environments. For this reason, a research was performed on the Scopus database to verify what is the most used variable to measure Jacobs' spillovers, and after selecting 26 articles from 2007 to 2018, we identified that 58% of the studies use the related variety to make this measurement, as shown in Figure 2.

Figure 2: Distribution (%) of articles by variables used to measure regional diversity



Source: developed by the author

From the 26 selected articles, only one had Brazil as the focus of study, however, it used the Herfindahl-Hirschman Index (HHI) to measure diversity. Then a new search for "related variety" was performed at Scielo database, since it is a digital library of Brazilian journal, and the result of publications was null. Thus, the relevance and justification for this study can be summarized in the following topics:

i) In Brazil, empirical studies measuring the relationship between diversity and companies' productivity are still scarce;

ii) Brazil has low investment in R&D and has a diversified economy, which can justify recombination as an option for economic growth.

This dissertation is in article format. Chapter 1 presents, in addition to the introduction, a preliminary theoretical framework on diversity, recombination and related variety. Chapter 2 presents the complete article and will be described in more detail below.

1.4 PRELIMINARY THEORETICAL FRAMEWORK

1.4.1 DIVERSITY, RECOMBINATION AND RELATED VARIETY

Many authors argue that, for developing countries, diversification of the production structure is important to economic growth (HARTMANN, 2014; HARTMANN et al., 2017). The idea of the importance of diversity was developed before Jacobs (1969) by Chinitz (1961), arguing that diversity was one of the reasons why New York performed better than Pittsburgh after World War II, referring to the idea that large areas are more diverse than smaller. Jacobs (1969), on the other hand, takes into account job diversity rather than simply the size of the city. Their studies capture the idea that a city's diversity of activities can lead to the cross-fertilization of technology and thus lead to innovation and growth (ROSENTHAL; STRANG, 2004).

The economic diversification of a country is important because it is related to the occupational choices of people and technological and institutional changes of companies. A city that offers a variety of work options has an influence on people's learning processes, values and desires, occupational choices and quality of life when compared to a rural region, for example (HARTMANN, 2014). The literature defends that a more diversified industrial environment stimulates economic growth through recombination (BEAUDRY AND SCHIFFAUEROVA, 2009; VAN DEN BERGH, 2008; CARNABUCI AND OPERTI, 2013; FRENKEN et al., 2007; GUAN AND YAN, 2016).

Beaudry and Schiffauerova (2009) wrote about a systematic review of the literature on the types of knowledge spillovers, defend that a more diversified industry promotes opportunities to imitate, share and recombine ideas and practices in all sectors, and the exchange of complementary knowledge facilitates the innovation. Frenken et al. (2007) argue that Jacobs' spillovers stimulate innovation through the recombination and cross-fertilization

of existing knowledge. Van den Bergh (2008) argues that diversity should be seen as an investment and not as a cost, as it brings long-term results.

Carnabuci and Operti (2013) used theoretical data forecasts from 126 semiconductor companies between 1984 and 2003 and wrote about two types of recombination: recombinant creation (creation occurs from new combinations) and recombinant reuse (a combination that has already been performed is reconfigured). The authors argue that the difference between them is in the fact that the processes of building these capacities represent different challenges, while in the recombinant creation companies experiment combinations of as yet unexplored technologies, the recombinant reuse requires companies to improve the technological combinations already known, to discover new contexts where they can be applied. They identified in their results that factors that favor the recombinant creation often prevent recombinant reuse and vice versa.

Another famous example of recombinant creation is the development of the assembly line by Henry Ford when he has adapted his automotive assembly line technologies from the assembly lines of meat processing units. An example of recombinant reuse is smartphone factories, which invest in innovation from existing known technological combinations (recombinant reuse).

In more recent studies, it is possible to verify that the recombination factor through diversity continues to attract the attention of the authors, as is the case of Guan and Yan (2016) and Subramanian and Soh (2017) who studied patents in the USA. Guan and Yan (2016) identify that the technological proximity of the regions has a U-shaped relationship with the capacity of recombination, because if there is a lot of proximity between the regions, there may then be a homogenization of knowledge, which harms the innovative power, while Subramanian and Soh (2017) found that the technological diversity of a company has a positive impact on recombination.

However, besides to recombination, it is also important to evaluate the related variety of the region. An environment with a high degree of related variety has a high degree of proximity between sectors, which in turn enhances recombination, generating significant effect on regional employment growth and economic development (AUTANT-BERNARD AND LESAGE, 2011; BOSCHMA AND IAMMARINO, 2007; FRENKEN et al., 2007).

Therefore, we believe that a diversified environment that has complementarity between sectors (related variety) is favorable for recombination. However, we argue that

recombination is only possible with absorptive capacity, and therefore, we will review this theme in the next section.

1.4.2 ABSORPTIVE CAPACITY (ABC)

First introduced by Cohen and Levinthal (1989), absorptive capacity is defined as "the company's ability to identify, assimilate and exploit knowledge of the environment" (p. 569). Roberts et al. (2012) make a comparison of the absorptive capacity with a sponge, writing that the ability of a sponge to absorb water depends on the number of holes, the nature of the material and its resistance to absorb water, as well as the amount of water it contains. Similarly, an organization can absorb knowledge from the outside, but only if its repositories of knowledge and the brains of its members are seeking and being receptive to that knowledge based on what they already know.

Cohen and Levinthal (1989) and Silveira et al. (2018) associate the absorptive capacity with a company's R&D investment, that in addition to being a generator of new knowledge, also develops the company's capacity to assimilate and exploit existing information. For the authors, if the company has a considerable investment in R&D, it will naturally have already invested in its absorptive capacity, and will thus be able to absorb external knowledge.

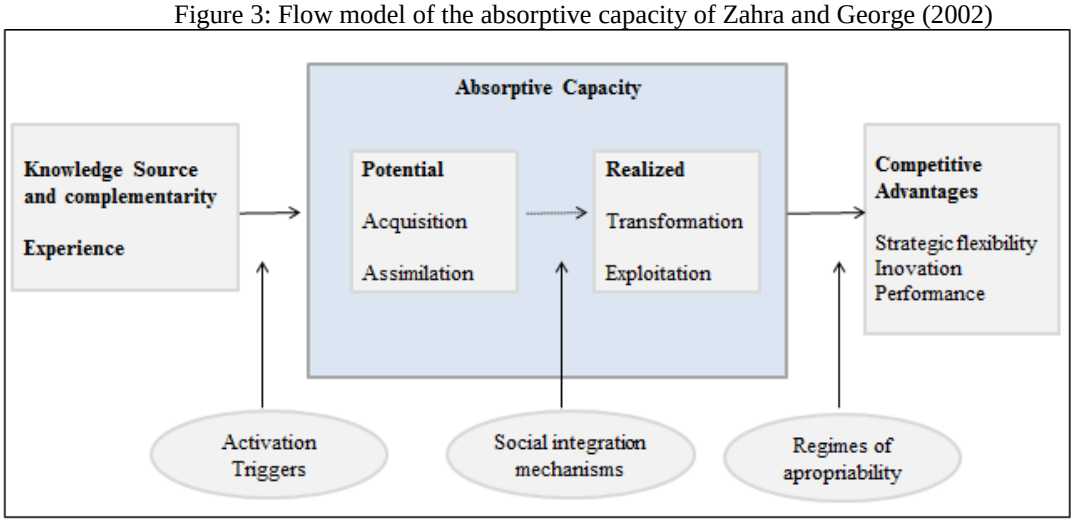
For Moreira, Torkomian and Soares (2016), ABC cannot be understood as a capacity located solely in the R&D area, but also by importing the different dimensions of the firm's ABC. Zahra and George (2002) were the first to publish a theoretical process for absorptive capacity. They define it as "a set of organizational routines and strategic processes by which companies acquire, assimilate, transform and exploit knowledge with the purpose of creating value with an emphasis on dynamic capabilities aimed at strategic change and flexibility in which companies create and exploit new knowledge by transforming acquired knowledge" (p. 193). The acquisition's dimension is the ability of a company to identify an externally generated knowledge opportunity and acquire this knowledge for the company itself; assimilation promotes understanding of knowledge generated externally, since this may be in a different context to what the company operates; transformation refers to the ability of companies to recognize information, which at first do not seem to reconcile, and from them, create a new product or process; and finally exploitation reflects a firm’s ability to incorporate knowledge, for example, in the capture of knowledge from its competitors or customers.

In addition to the four capacities that make up the absorptive capacity, the authors add two prerequisites (source of knowledge and complementarity, and experience). On the first

item, companies acquire knowledge from different sources in the environment where they are exposed, and the diversity of these sources significantly influences the ability to acquire and assimilate. The second item is related to the company's past, as experience through contacts with customers, successful or unsuccessful projects, and contact with other companies, and others.

Finally, they define some moderators, which are called: activation triggers, mechanisms of social integration and regimes of appropriability. Activation triggers are events that can influence the current operation of the company, such as radical innovations and changes in government policy. Social integration contributes to the assimilation of knowledge, both informally (conversations during off-work periods, in cafes, lunches and get-togethers) and formally (courses, during the work period, at meetings, etc.). The regimes of appropriability refer to the company's ability to protect its products and processes, with the use of patents, for example, may affect the competitive advantage of a company. Finally, according to Miguélez and Moreno (2015), absorptive capacity is essential for regions to absorb knowledge and thus obtain productivity gains and competitive advantages. Acquisition and assimilation ABC are responsible to provide strategic advantages for companies, such as greater flexibility in reconfiguring resources (VOLBERDA, FOSS AND LYLES, 2010) and transformation and exploitation ABC can influence performance and innovation process (Zahra e George, 2002) which are necessary to sustain competitive advantage. This flow is presented in Figure 3.

Figure 3: Flow model of the absorptive capacity of Zahra and George (2002)



Fonte: adaptado de Zahra e George (2002)

Zahra and George (2002) define the dimensions of acquisition and assimilation as potential capabilities, while the dimensions of transformation and exploitation are defined as

realized capabilities. The potential absorptive capacity of a company is associated with the concept addressed by Cohen and Levinthal (1990) that the company's ability to acquire external knowledge does not guarantee the exploitation of this knowledge, which is why it is called "potential". The scarce number of publications in Brazil, the complexity of the topic and the diversity of variables used in international literature, drives us to use sophisticated empirical methods to understand the phenomenon between absorptive capacity and related variety. The next chapter presents the article of this work.

CHAPTER 2: RESEARCH ARTICLE – REGIONAL RELATED VARIETY AND COMPANIES' PRODUCTIVITY IN BRAZIL

2.1 INTRODUCTION

There is a discussion in the literature about the relationship between knowledge spillovers and the location of firms, and how the impact of this knowledge depends on the ability to absorb knowledge and the local industrial structure, given that only the presence of knowledge spillovers alone is not sufficient if there is no capacity to absorb this knowledge (ALCÁCER AND CHUNG, 2007; CARAGLIU AND NIJKAMP, 2012; LIN AND CHANG, 2015; VOLBERDA, FOSS AND LYLES, 2010; WANG ET AL., 2016).

In this way, the absorptive capacity (ABC) increases the potential of a company to identify, assimilate and exploit knowledge (COHEN AND LEVINTHAL, 1989, 1990; GIRMA, 2005; KIM, 2015; MIGUÉLEZ AND MORENO, 2015; ZAHRA AND GEORGE, 2002; ZHANG ET AL., 2010). Therefore, we argue that the ABC influences the economic growth of companies since the greater the capacity to absorb knowledge and adapt productive techniques, the greater the capacity to produce technological goods, which impacts directly on productivity.

In turn, production gains reflect the efficiency of the productive sector, as well as the degree of development of society (FELEMA, RAIHER E FERREIRA, 2013). As productivity growth is not directly observed, economists use proxies for this. According to Almeida (2007), empirical literature that has tried to study the relationship between types of externalities and productivity growth has used employment growth as a proxy for productivity growth, however, this is not appropriate, since these two variables are not positively correlated if employment is heterogeneous, and a more appropriate alternative would be to use the Total Factor Productivity (TFP).

According to Caragliu and Nijkamp (2012), the TFP captures a significant share of real productivity gains since it identifies the share of product variation that can be attributed to efficiency gains and the share that can be attributed to the accumulation of inputs (capital, labor and human capital). The absorptive capacity, in turn, according to the Girma (2005) model, is defined as the level of the TFP in the previous period divided by the maximum TFP level for the entire period.

Also, we argue that a diverse environment also influences productivity. A diverse environment, with the agglomeration of different industrial sectors, encourages the production

of new ideas and innovation, generating Jacobs' spillovers (FRENKEN ET AL, 2007). In contrast, specialized environments generate spillovers that are more pronounced in small or R&D intensive industries (VAN DER PANNE, 2004), known as spillovers of Marshall-Arrow-Romer (MAR) (GLAESER, 1992).

From the 1950s to the 1970s, many developing countries replaced imports from foreign countries seeking industrialization and diversification. Brazil followed such policy with relative success, which provided the basis for some industrial sectors (Hartmann, 2014).

Hence, being Brazil in an economic context marked by a consolidated industrial structure as one of the broadest and most diversified of the group of late industrialization countries (ROSSI, SANTOS and SANTOS, 2017), and presenting a low investment in R&D (Brazil invested 1.2% of GDP in R&D in 2018, according to the World Economic Forum (2018)), the related variety can be an alternative for the increase of productivity.

The benefits of diversity can result from the recombination of knowledge because there are greater opportunities to imitate, share and recombine ideas and practices in all sectors that are part of a more diverse regional economy (BEAUDRY E SCHIFFAUEROVA, 2009; VAN DEN BERGH, 2008; CARNABUCI E OPERTI, 2013; GUAN E YAN, 2016).

In recent literature, the related variety is associated recombination due to the loan of complementary ideas, generating a significant effect on regional employment growth and economic development (AUTANT-BERNARD AND LESAGE, 2011; BOSCHMA AND IAMMARINO, 2007; FRENKEN et al., 2007). Most innovative activities come from a diverse environment with some similarity between products (e.g. new car models or the new generation of smartphones) (HARTMANN, 2014).

Apart from the fact that few studies address the impact of economic diversity on productivity, there are no Brazilian studies using related variety to measure regional diversity. Indeed, in a survey conducted in the Scopus database, 26 articles were selected, and the related variety appears in 58% of the articles. Only one had Brazil as the focus of study, however, it used the Herfindahl-Hirschman Index (HHI) to measure diversity. Thus, our study can contribute to the literature by being the first to use related variety to measure regional diversity.

Another point to be analyzed is the identification of possible thresholds for the companies' absorptive capacity. That is, we intend to analyze if there is a limit where the absorptive capacity has a differentiated impact on productivity. For this purpose, the econometric regression model by threshold adapted from Girma (2005) is applied. This

method allows testing the existence and significance of the ABC threshold levels in the productivity growth relationship.

There are articles in which ABC thresholds were analyzed so that the benefits of diversity are greater in productivity. The paper of Girma (2005) and Yasar (2013) identified the ABC thresholds for manufacturing companies, and the authors Wu and Hsu (2008, 2012) for several countries.

Therefore, we intend to test the following hypotheses:

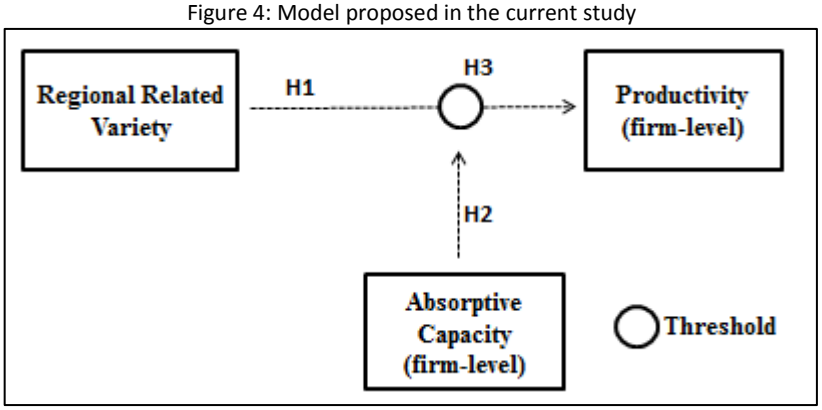
H1: The regional's related variety has a positive impact on the companies' productivity growth in this region.

H2: The absorptive capacity is a moderator in the relationship between related variety and productivity growth.

H3: There is a threshold of companies' absorptive capacity so that they can take advantage of positive spillovers of regional related variety.

Figure 4 introduces a representation of the model we want to estimate:

Figure 4: Model proposed in the current study



Source: developed by the author

As the Brazilian industry is characterized by its diversity, it has decrease its complexity during the last 15 years and lost relative labor productivity. Thus, this study intends to contribute to developing countries literature since its results may provide support for regional policies on cluster building according to the related variety concept, therefore increasing companies productivity. In addition, it intent to detect whether regional related variety has positive effects on productivity and if the absorptive capacity is a moderator in this process, besides testing different effects of related variety on firm productivity according to the absorptive capacity levels (thresholds).

This article is organized into five sections in addition to this introduction. Section 2.2 presents the theoretical review of the literature on economic agglomerations, recombination and related variety. Section 2.3 presents the method, data, econometric model and estimation

strategy. Section 2.4 presents the results obtained and section 2.5 presents the discussion of the results.

2.2 LITERATURE REVIEW

An important topic in economics is the contribution of economies agglomerations to local growth. The literature distinguishes two types of agglomeration economies for the occurrence of knowledge spillovers: economies of specialization and diversification. When the region is specialized, the spillovers of Marshall-Arrow-Romer (MAR) occur between companies of the same sector (GLAESER et al., 1992); when the region is diversified, the spillovers of Jacobs occur between companies of different sectors (GLAESER et al., 1992; FRENKEN et al., 2007)

According to Glaeser et al. (1992), the Marshall-Arrow-Romer (MAR) model focuses on knowledge spillovers within a given industry sector. This can occur, among other ways, with the migration of employees between companies (which take the knowledge acquired with them), or with the physical proximity (which facilitates the transmission of information). Jacobs (1969), on the other hand, believes these companies are benefited by a market cluster due to the decrease in transaction and communication costs, arguing that the diversity of the industry improves the opportunities to interact, copy, modify and recombine ideas., the externalities occur from the agglomeration of different industrial sectors that, due to a diversified environment, stimulate the production of new ideas and generate innovation.

Bishop e Gripaios (2007) argue that highly specialized industries may find it difficult to benefit from spillovers from other productive activities, while sectors with more diversified technologies may face fewer constraints. According Catela, Gonçalves, and Porcile (2010), innovation and growth may arise from the agglomeration of different industrial sectors, because they generate diversity and stimulate the fertilization of new ideas. In fact, Jacobs (1969) argues that the most important sources of knowledge spillovers are external to the industry in which the company operates. Unlike Marshall, Jacobs emphasizes that it is primarily the local variety of industries that promotes knowledge spillovers and, ultimately, innovation activity.

Jacobs spillovers occur because, in a diverse environment, there is the possibility of recombining existing knowledge, thus leading to the creation of new markets, economic growth, and productivity (FRENKEN ET AL., 2005). Therefore, recombination is a very

important factor in a diversified environment, and therefore we will study this concept in more detail in the next chapter.

2.2.1 RECOMBINATION

The communication between different industries, especially the complementary sectors, is considered a crucial form of knowledge recombination (GLAESER et al., 1992). The notion of innovations as a result of new combinations began with Schumpeter (1934, 1950). According to him, one of the fundamental roles of knowledge is to combine solutions that already exist to generate new combinations. Since that, the analysis of the relationship between recombination and economic growth has increasingly attracted economic scholars (ANTONELLI, KRAFFT AND QUATRARO, 2010; BESSANT, RUSH AND TRIFILOVA, 2012; BESSANT AND TRIFILOVA, 2017; CARNABUCI AND OPERTI, 2013; LAURSEN AND SALTER, 2006).

According to Bessant, Rush and Trifilova (2012), with recombination it is possible to have a reduction in learning costs, since much of the original development of an innovation has already been carried out in a different context and, although there is still a need for adaptation, there is the opportunity to adopt an innovation with less risk.

Although the literature addresses the performance of recombination capabilities in companies, its concept is used very broadly, and it is not known why some companies are better than others to build them (CARNABUCI AND OPERTI, 2013). Bessant and Trifilova (2017) developed a routine for the enable companies' recombination and associate this process to the absorptive capacity model developed by Zahra and George (2002) (which includes routines for acquisition, assimilation, transformation, and exploitation). The authors suggest three routines: abstract-driven search (ADS), brokerage and cyclic adaptation. Abstract-driven search (ADS) focuses on search efforts for solutions that are outside the common activities of the company ("going out of the box" process), brokerage is responsible for the generation and maintenance of partnerships and for attracting potential recipients for the use of recombination, and in terms of the absorptive capacity of Zahra and George (2002), this stage corresponds to "acquisition", and finally cyclic adaptation is necessary to adapt the practices that occur in one scenario in another, with the application occurring in a specific environment, and in terms of absorptive capacity, corresponds to assimilation and exploitation.

Jacobs' spillovers are expected to facilitate radical innovation and product innovation as knowledge and technologies from different sectors are recombined (FRENKEN et al., 2007). However, as the literature argues, knowledge will overflow easily from one sector to another when it is complementary in terms of knowledge bases and shared competencies (BOSCHMA, COOKE AND ASHEIM, 2011). Thus, innovation is more likely to occur where the degree of related variety is greater, and as innovations lead to the creation of new markets, an increase in productivity is also expected. Therefore, the next chapter will explain in more detail what the related variety is.

2.2.2 RELATED VARIETY

The regional's related variety attempts to capture the complementarity between sectors in a region that is necessary for knowledge spillovers to occur effectively, thus, the greater the related variety among sectors within a region, the greater the number of related sectors and more learning opportunities there are in local industries, and this will result in greater knowledge spillovers, improving regional performance (BOSCHMA, MINONDO, AND NAVARRO, 2011).

Related variety (RV) literature has also evolved into unrelated variety, which occurs when sectors are not complementary, but on the other hand, are good for reducing sector risks, that is, a region with a high degree of related variety is made up of companies that operate in different industries but share several similarities, while in a region with a high level of unrelated variety, companies operate in different industries but share few or limited similarities (FRENKEN et al., 2007).

For a better understanding, think of a company that diversifies its sales into 20 different products with related variety (for example, 20 different types of chocolate). This will not reduce your risk of bankruptcy since if there is a crisis in cocoa production, all 20 products will be hit. In contrast, a company that diversifies into fewer products, but with unrelated variety, will be able to reduce the risk.

The concept of related variety holds that related sectors generate more Jacobs' spillovers than unrelated ones (FRENKEN et al., 2007). On the other hand, in the unrelated variety, there is a greater cognitive distance between the companies, which causes this to negatively affect the knowledge spillovers, in addition to restricting the company's productivity (AARSTAD, KVITASTEIN AND JAKOBSEN, 2016).

Related / unrelated variety is a relatively new concept in literature and, so far, there is no perfect way to measure them (BOSCHMA AND GIANELLI, 2014). A review 15 of studies that analyze the related variety to productivity growth, or another indicator of economic performance was realized and the results of each study were summarized in Appendix A. The objective was to identify which literature is most used for the calculation of RV and as shown in Table 1, 60% of studies used exclusively Frenken et al. (2007) to this measure.

Table 1: Distribution (%) of literature used for related variety (RV) calculation

Referenced literature for related variety (RV) calculation	**%**
Frenken et al (2007)	60%
Frenken et al (2007) and Boschma and Iammarino (2007)	13%
Frenken et al. (2007) and Boschma et al. (2012)	7%
Frenken et al. (2007), Boschma and Iammarino (2007) and Hartog et al. (2012)	7%
Cainelli, Ganau e Iacobucci (2016)	7%
Attaran (1986)	7%

Source: developed by the author

The first study to associate variety with regional economic growth is Frenken et al. (2007). The authors analyze employment growth in the Netherlands and identify that, if on the one hand the related variety is positively related to employment growth, the unrelated variety is negatively related. They provide a proposal for calculating related variety using entropy. The entropy (or Shannon index) approach is commonly applied in the measurement of variety. The main advantage of entropy measurement is that the index cannot cause multicollinearity in linear regression model (ATTARAN, 1986; FRENKEN et al, 2007, JACQUEMIN AND BERRY, 1979). This is also the method used by Frenken et al. (2007) to measure related and unrelated variety. However, the great differentiation of the authors' work is to calculate the entropy of the industrial classification code. By using the SIC (Standard Industrial Classification), the authors measured the related variety as the mean entropy in all employment in five-digit industries within each two-digit class, while the unrelated variety is the entropy in employment in two-digit classes.

Cainelli, Ganau and Iacobucci (2016) proposed a new calculation for Related Variety. To measure variety, they built a new index that takes into account the importance of entry-exit

relationships between industries, measuring the strength of relationships and the degree of technological relationship at the local level. However, Frenken's literature is commonly used by most authors since then.

Boschma and Iammarino (2009) and Lazzeretti, Innocenti and Capone (2017), when studying data from Italy, identified that there was strong evidence that the related variety contributes to the growth of employment. In addition, the authors Caragliu et al (2016), Van Oort, Geus and Dogaru (2013) and Cortinovis and Van Oort (2015) also study employment growth in Europe. Caragliu et al (2016) found instead strong evidence that in Europe, the concentration of activities in similar industries enhances employment growth, especially in the manufacturing sector. Besides, for less dense areas, the effect of MAR spillovers on employment growth is larger. The opposite applies to Jacobs spillovers, who claimed that sectoral diversity's positive effects are especially found in high-density urban environments. Van Oort, Geus e Dogaru (2015) link related variety to employment growth positively and to specialisation negatively. Cortinovis and Oort, Van (2015) found that related variety can have a positive effect on growth but predominantly when the technological and knowledge level of the region is high. Therefore, the authors defend the importance of absorptive capacity in order to take advantage of a diverse environment. Investments in human capital, technological upgrading and R&D are preconditions for related and unrelated variety to have beneficial effects on the economy, and for this, policies should consider the context and characteristics of the region.

Boschma, Minondo, and Navarro (2011) showed that Spanish regions with higher levels of related variety are likely to have higher levels of value-added growth. The literature also identifies a positive relationship between related variety and innovation. Aarstad, Kvitastein, and Jakobsen (2016) found that related variety is a positive regional factor of business innovation for Norwegian data. Tavassoli and Carbonara (2014), using data from Swedish regions, identifies that the related variety is positively associated with regional innovation, which in turn was measured by the number of patent applications.

Other studies have analyzed the effect of related variety on productivity growth indicators. The literature argues that there is a positive relationship between related variety and productivity growth (BOSCHMA, ERIKSSON, AND LINDGREN, 2014, 2009; CAINELLI, GANAU AND IACOBUCCI, 2016; ERIKSSON, 2011; FALCIOGLU, 2011). Wixe and Andersson (2016), on the other hand, identify that the related variety in industries is considered negative for productivity growth, but positive for employment growth.

2.3 METHODS

2.3.1 DATA

We collected information from the consolidated financial statements of 194 matrixes of Brazilian companies ranging from 2010 to 2014. The sample is composed of large-sized companies from manufacturing and services sectors, listed on the São Paulo Stock Exchange (BOVESPA). Therefore, sectoral differences that affect the relationship between related variety and firm-level productivity will be treated via control variable according NACE classification.

The before mentioned firm-level database was merged to its corresponding regional data, containing all 80 municipalities where the companies' headquarter is located (Appendix B). The municipalities included in the sample are distributed across 17 Brazilian states, and thus represent the socioeconomic and institutional differences in all regions of Brazil.

Additionally, the data set includes multiple dependent variables, as well as independent and control variables. The data were acquired from multiple sources and the variables and descriptive statistics are presented in Table 2.

Table 2: Variable definition and descriptive statistics

Variable	Definition	Source	mean	min	max	dp
Gross Revenue (x1000 BRL)	Consolidated income	Economática Database	5.48E+06	7.09E+01	4.10E+08	2.76E+07
Capital (x1000 BRL)	Consolidated fixed assets property stock (plant and equipment)	Economática Database	4.69E+06	1.20E+00	7.00E+08	4.19E+07
Labour (x1000 BRL)	Consolidated expenditures on labor and other social securities	Economática Database	9.01E+04	2.73E+00	6.60E+06	4.11E+05
Investment (x1000 BRL)	Consolidated investment expenditures	Economática Database	3.57E+05	1.00E-05	2.20E+07	2.01E+06
Income per capita (pc)	Municipal per capita income	Brazilian Institute for Geography and Statistics	2.12E+03	8.75E+02	4.03E+03	5.38E+02
Age	Age of company	Bovespa website	5.59E+01	4.00E+00	1.52E+02	3.31E+01
Intangible stock (x1000 BRL)	Intangible assets stock investment	Economática Database	3.54E+06	1.00E-05	2.72E+08	1.75E+07
Networth (x1000 BRL)	Consolidated net worth	Economática Database	4.42E+06	-6.90E+06	4.70E+08	3.21E+07
Related Variety (RV)	Regional related variety, that measures proximity between sectors in a diverse	Calculated entropy using CNAE code following Frenken et al (2007)	1.69	0.00	2.04	0.18

Source: adapted from de author

2.3.2 DEPENDENT VARIABLE

Since our aim is to find evidence that regional related variety may yield firm-level productivity spillovers through recombination process, we employ the rate of change of Total Factor Productivity (TFP) as our dependent variable. According to Caragliu and Nijkamp (2012), TFP captures a significant share of real productivity gains, since it's a residue that represents the amount of production that can be explained by input variables (also known as Solow residual), containing everything that is not measured by physical factors.

Thus, TFP variation in time will capture changes in non-technical efficiency, such as creativity, manageability and all the knowledge coming from global improvements over time and regional knowledge, hence, this residue can be interpreted as the growth rate of the product in relation to the capital growth rate, or growth not explained by production factors (LESAGE, 2009)

The following proxies were applied in order to determine the TFP: gross revenue from sales as a product, total fixed assets as capital, and legal labor obligations as a proxy for labor (this variable represents a fraction of wages paid). All data were deflated by Brazil's general price index (IGP-DI) to deal with inflationary effects. Yet, the heterogeneity among the dataset companies creates the need for cautious choice of TFP calculation method, leading us to consider three methods.

The first semi-parametric approach to estimating the production function is the seminal Olley and Pakes (1996) (OP). Starting from the Cobb-Douglas function, OP method employs a proxy investment to account unobserved for productivity shocks w_{it}. The second semi-parametric technique is from Levinsohn and Petrin (2003) (LP). This technique is very similar to the OP, mainly because both estimate the labor coefficient in the first stage, but this second one corrects the endogeneity problem of the previous method, which creates inconsistent OLS estimates. Accordingly, LP estimation solves the problem of endogeneity using intermediate inputs (electricity, fuel or materials) as a proxy for unobserved productivity shocks instead of investment variable (KIM, 2015). The third approach, Ackerberg, Caves and Frazer (2015) (ACF) argue that methods of OP and LP while addressing the correlation between input levels and productivity shocks for the TFP computation, may yield estimates that suffer from functional dependence problems. The ACF method proposes an estimator that reverses the input demand functions that are conditioned to the choice of the labor input.

We can note that each method faces a different challenge in estimating the production function, and each assumes some assumptions, and the decision to use the approaches depends on the database. Thus, this investigation chose the OP method with the ACF correction given the availability of data and its capacity to solve additional potential issues not addressed by traditional OP and LP methods. Indeed, the Brazilian companies financial statements do not have material information as an intermediate input for the LP method, making it unfeasible. However, the investment data is consistent.

2.3.3 RELATED VARIETY MEASURE AND CONTROL VARIABLES

In order to analyze the impact of regional diversity on productivity at the business level considering regional diversity, our model employs the related variety as a proxy for diversity, since it is necessary a degree of proximity, i.e., related variety, to ensure effective communication and learning that will enable the recombination process, thus yielding productivity spillovers.

For the calculation of the related variety, we will follow the literature of Frenken et al. (2007). According to the author, the related variety is measured based on the digits of the industrial classification. For better understanding, the digit of the industry is related to its activity. In our study, Brazilian National Classification of Economic Activities (CNAE) was employed as a variable for the industrial classification, whose number is composed of 5 digits. According to Frenken et al. (2007), the result is obtained by calculating the marginal increase by moving the industrial classification from 2 digits to 5 digits. The unrelated variety is indicated by the entropy of the 2-digit distribution.

Formally, let all five-digit sectors be reduced to a two-digit sector Sg, where g = 1, ..., G. It is possible to calculate two-digit sectors, P_g, summing the five-digit sectors p_i as in (3.1).

$$P_g = \sum_{i \in S_g} p_i \qquad (3.1)$$

The entropy at the two-digit level, or unrelated variety (UV), is given by (3.2).

$$UV = \sum_{g=1}^{G} P_g log_2 \left(\frac{1}{P_g}\right) \qquad (3.2)$$

Related variety (RV), as the weighted sum of entropy within each two-digit sector, is given by (3.3).

$$RV = \sum_{g=1}^{G} P_g H_g \qquad (3.3)$$

where:

$$H_g = \sum_{i \in S_g} \frac{p_i}{P_g} log_2 \left(\frac{1}{p_i / P_g} \right) \qquad (3.4)$$

As previously discussed, the hypothesis of this study believes that recombination can only occur also in the presence of firm-level absorptive capacity, which measure is accomplish by the formulation employed by Girma (2005) which uses the distance from the technological frontier (technological gap) as a proxy, as shown in (3.5), to relate the TFP of a company *i* to the Maximum TFP:

$$ABC_{it} = \frac{TFP_{it}}{\max(TFP)_{it}} \qquad (3.5)$$

In order to control for firm-level characteristics that may moderate related variety effects, the company's age and intangible assets stock investment were also applied as controls at the company level, the first reflects a firm's previous experience, which can potentially affect its productivity (LEE, JANG AND HONG, 2010), and the second being inserted to capture any variation in productivity resulting from investments in information technology, training of employees, trademarks and patents, since the long-run invest in intangibles provides sustainable competitive advantages that enhance (FERNANDES, 2014). Likewise, an annual depreciation rate of 15% was used to reflect the obsolescence of intangible investments and this variable was also deflated (IGP-DI index). Despite the fact that the entire base is composed of large-sized companies, we decided to use the net worth variable in order to better control the model in terms of company size. Due to the high number of negative values that net worth variable presented, a min-max rescaling method was employed. The goal is to independently normalize each feature component to the [0,1] range (AKSOY AND HARALICK, 2000). The formula is given by equation (3.6)

$$x' = \frac{x - \min(x)}{\min(x) - \max(x)} \qquad (3.6)$$

We also consider a set of sectoral controls dummies, given that our database is composed by manufacturing and service companies, meanwhile firm characteristics may moderate related variety effects. Based on NACE Rev. 2 at 3-digit level, for manufacturing,

four control dummies were applied: High technology (HT), medium high-technology (MHT), medium low- technology (MLT), and low-technology (LT). For services segment (representing 57% of companies), we applied a more detailed classification: Knowledge-intensive market services, excluding high-tech and financial services (KIMS), High-tech knowledge-intensive services (HTKIS), Knowledge-intensive financial services (KIFS), Other knowledge-intensive services (OKIS), Less knowledge-intensive market services (LKIMS) and Other less knowledge-intensive services (OLKIS). The distribution of the sectors of the sample can be seen in Appendix C.

This sectoral dummies were merged with a market-share proxy indicator that was constructed considering the net patrimony of a company "*i*" relative to the sum of the patrimony of all the companies in a given sector according to the BOVESPA database, aiming to capture the market concentration in which a particular company is exposed.

As for the regional level controls, in addition to the municipal per capita income, a set of regional dummies were created, encompassing the macro region of Brazil where the company is located (north, northeast, south, southeast and midwest), aiming to capture socioeconomic and factorial endowment characteristics that may influence productivity.

2.3.4 MODEL SPECIFICATION AND ESTIMATION STRATEGY

In order to test the presented hypotheses1 and 2, we expressed the relationship between changes in the TFP (rate of product growth above the rate of capital growth), related variety and absorptive capacity (ABC) in through the formulation presented in (3.7).

$$\Delta TFP_{it} = \beta_0 + \beta_1 ' X_{it} + \beta_2 ' Z_{jt} + \alpha_1 RV_{jt} + \alpha_2 ABC_{it} + \alpha_3 (RV * ABC)_{ijt} + a_i + \varepsilon_{it} \qquad (3.7)$$

Where,

X: Firm level controls (Intangible, Age, sectoral dummies were merged with a market-share proxy);

Z: Regional level control (Municipality "*j*" per capita income, Brazilian macro region where the company is located);

RV: Related variety;

ABC: Absorptive capacity;

a: Firm Time Invariant Characteristics (Fixed Effects);

ε : Stochastic disturbance;

Model specification presented in (3.7) is fitted by using feasible generalized least squares (FGLS) correcting for heteroscedasticity and residuals autocorrelation. Precisely, we allow a unique autocorrelation process for each specific entity, as presented in equation (3.8) (Cameron 2009).

$$\varepsilon_{it} = \rho_i \varepsilon_{it-1} + u_{it} \quad (3.8)$$

The threshold regression technique (Panel Threshold Regression) was also used in this work, following the work developed by Girma (2005), who argues that if the absorptive capacity affects the productivity spillovers, the relation is better addressed using threshold regression techniques (Panel Threshold Regression) instead of assuming cut-off values. This method allows a test for the existence and significance of ABC threshold moderation levels in the relationship of regional related variety impacts on productivity growth .

Finally, hypothesis 3 will evaluate possible nonlinearity associated to the related variety and absorptive capacity, through the threshold formulation of (3.9)

$$\Delta TFP_{it} = \beta_0 + \beta_1' X_{it-1} + \alpha_1' RV_{ijt-1} I(ABC_{ijt} \geq \gamma_1) + \alpha_2' RV_{ijt-1} I(ABC_{ijt} < \gamma_1) + a_i + \varepsilon_{it} \quad (3.9)$$

Where,

X: Firm level controls (Intangible, Age, sectoral dummies were merged with a market-share proxy);

Z: Regional level control (Municipality "*j*" per capita income, Brazilian macro region where the company is located);

RV: Related variety;

ABC: Absorptive capacity;

I(.): Is an indicator function;

a: Firm Time Invariant Characteristics (Fixed Effects);

γ_i : Thresholds to be estimated;

ε *:* Stochastic disturbance

Thus, to equation (3.9) the related variety is the regime-dependent variable. However, the absorptive capacity figures as the threshold variable, thus testing different effects or related variety on firm productivity according the absorptive capacity levels (below and above the threshold).

Finally, for the threshold estimation, which must be performed in combination with the slope parameters, $S_n[\beta(\alpha), \gamma(\alpha)]$ represents the sum of the squares of the residuals (SSR) of equation (3.9), and such a function can be minimized by ordinary least squares (OLS) with all possible values of α, in order to choose the one with the least SSR, according to equation (3.10):

$$\hat{\alpha} = \arg_{\alpha} \min S(\alpha) \qquad (3.10)$$

To accomplish this, Girma (2005) proposed the use of threshold variable quantiles to calculate threshold values, such as $\{1\%; 1,25\%; 1,50\%; \cdots ; 98,75\%; 99\%\}$, and then check whether there are two regimes for each regime-dependent variable. This is done by testing the null hypothesis ($H_0 : \alpha_1 = \alpha_2$) trough likelihood ratio test.

2.4 RESULTS

This section presents the linear model results presented at equation (3.8). Table 3 presents the correlation between all variables in the dataset in order to verify the degree of multicollinearity between explanatory variables. According to the literature, a correlation up to 70% is acceptable (DANCEY AND REIDY, 2005), and correlations between our variables were all less than 30%, as shown in Table 3.

Table 3: Correlation matrix of variables

	delta tfp	age	intangible stock (t -1)	networth	income pc	related variety (RV)	ABC
delta tfp	1						
age	-0.0416	1					
intangible stock (t -1)	0.0003	-0.1579	1				
networth	0.0093	0.0497	0.137	1			
income pc	0.0484	-0.0944	0.1236	0.0877	1		
related variety (RV)	-0.0301	0.0494	0.0691	-0.0708	-0.1866	1	
ABC	0.2553	-0.0823	0.2594	0.0304	0.0471	0.0138	1

Source: adapted from de author

Table 4 provides the results for productivity growth as the dependent variable. Model 1 was calculated by Ordinary Least Squares (OLS), but heteroscedasticity (p-value <0.01) was detected in the model according to the Breusch and Pagan (1979) test and autocorrelation (p-value <0.05) was also detected by the Wooldridge (2002) test. In addition, we also tested multicollinearity from the variance inflation factor (VIF) test, the result for this test was negative (VIF = 1.30), and if VIF is less than 10, then there is no cause for concern (FIELD, 2009).

Table 4: Estimated models

	(1)	(2)	(3)	(4)	(5)
VARIABLES	**OLS model**	**FGLS model**	**FGLS model with ABC as moderator**	**FGLS model with one-year lag for RV**	**FGLS model with one-year lag for RV and ABC as moderator**
age	-0.0115	-0.0137*	-0.0141*	-0.0141*	-0.0141*
intangible stock (t -1)	-0.0073**	-0.0073***	-0.0071***	-0.0073***	-0.0070***
networth	0.0976	0.109	0.0448	0.131	0.0429
HT - mktshare	-0.0217	0.0483	0.0456	0.0456	0.0449
MHT -mktshare	0.0077***	0.0069***	0.0069***	0.0069***	0.0069***
MLT - mktshare	-0.0003	-0.0003***	-0.0003***	-0.0004***	-0.0003***
LT - mktshare	0.0008	0.0003	0.0003	0.0003	0.0003
KIMS - mktshare	0.0003	0.0001	-1.59e-05	0.0001	-2.02e-05
HTKIS - mktshare	-0.937	-1.081**	-1.045**	-1.071**	-1.047**
KIFS - mktshare	0.121	0.196	0.166	0.199	0.166
OKIS - mktshare	0.0237	0.0140	0.0191	0.0132	0.0184
LKIMS - mktshare	-0.001	0.0002	0.0001	0.0003	0.0001
OLKIS - mktshare	-	-	-	-	-
south	0.351	0.153***	0.153**	0.157***	0.154**
southeast	0.357	0.174***	0.172***	0.177***	0.173***
midwest	0.350	0.219**	0.197**	0.238**	0.198**
northeast	0.349	0.167***	0.166***	0.168***	0.167***
north	0.646*	0.466	0.476	0.466	0.477
income pc	0.0906	0.0791***	0.0751***	0.0784***	0.0763***
related variety	-0.0297	0.0399			
ABC	0.733***	0.623***		0.625***	
related variety * ABC			0.348***		
related variety (t - 1)				0.0500	
related variety * ABC (t - 1)					0.348***
Constant	-0.877	-0.714***	-0.613***	-0.728***	-0.622***
Observations	776	776	776	776	776
Number of companies		194	194	194	194

*** p<0.01, ** p<0.05, * p<0.1.

As previously discussed, the Feasible Generalized Least Squares (FGLS) model corrects the problem of heteroscedasticity and autocorrelation and was employed in model 2 to 5. Model 2 presents related variety and absorptive capacity variables separately and the results show that related variety statistically insignificant. Thus, at a first glance, the main

hypothesis concerning productivity growth (H1) is not confirmed since the variable is not significant.

Though, absorptive capacity is positively related to productivity growth and strongly significant. Model 3 evaluates the moderator effect of absorptive capacity on related variety by iterating both variables, whose estimated parameter was positively related to productivity growth and significant, which leads us to conclude that the related variety of the region has a positive effect on firm productivity, however, absorptive capacity plays an important moderator role in the process (H2).

Model 4 evaluates a one-year lag for the related variety effects on the productivity companies, and model 5 evaluates the one-year lag for the related variety moderate by absorptive capacity. According to Van den Bergh (2008), the benefits of diversity can be seen in the long-term and therefore the one-year lag test was also performed. The result indicates that, even with the one-year lag, related variety will only have a positive impact on productivity when moderated by absorptive capacity.

In relation to the control variables for the company level, age of the company and stock of intangibles showed significance, but have a negative impact on productivity. Some authors found a negative impact of age of companies in the financial return (Beatty, 1989; Bradley *et al.*, 2009). Another unexpected result concerns the stock of intangible assets, which appears with a negative impact on productivity. According to Fernandes (2014), this fact may be related to market expectations regarding this type of investment, i.e., in the short term, the market does not see the benefits of investing in intangible assets, since its return may take some years to occur (if it occurs). As only the one-year lag was used, and the test for more years was not possible due to sample size, we believe that the result of intangibles does not appear only in one year.

For the control dummies of the service and manufacturing sectors, we have identified that for manufacturing, medium high tech (MHT) and medium low high tech (MLHT) were significant, however, the companies medium high tech have a positive impact on productivity, while the companies medium low high tech have a negative coefficient. In the services sector, high-tech knowledge-intensive services (HTKIS) companies were significant, but had a negative impact on productivity. The other sectors did not present significance.

2.4.1 THRESHOLD MODEL AND ROBUSTNESS CHECK

Table 5 presents the Threshold model with related variety as the regime dependent variable and absorptive capacity figuring as the threshold variable, in order to verify the effects of the related variety on the firm's productivity according to the levels of absorptive capacity.

Table 5: Threshold Model

VARIABLES	(1) ABC as Threshold
age	0.0716
intangible stock (t -1)	-0.0052
networth	-0.392
HT - mktshare	-0.243
MHT -mktshare	0.0050**
MLT - mktshare	0.0002
LT - mktshare	0.0015**
KIMS - mktshare	-0.00406
HTKIS - mktshare	8.306**
KIFS - mktshare	-0.432
OKIS - mktshare	-0.351***
LKIMS - mktshare	0.0011***
income pc	0.206
related variety * (ABC < γ)	2.738
related variety * (ABC ≥ γ)	3.283*
Constant	-6.707
Threshold estimator	0.0786
Threshold effect test	0.0000
Observations	776
Number of company_num	194
R-squared	0.150

*** p<0.01, ** p<0.05, * p<0.1.

The Threshold effect test was statistically significant ($p < 0.01$), indicating that there is a difference in levels of absorptive capacity which, in turn, will affect the impact of related variety on firm productivity (H3). Thus, regional related variety has positive impacts and significant impacts for firm-level productivity only for higher levels of absorptive capacity (p-value <0.10). Accordingly, companies located in regions with high related variety will benefit from positive spillovers only with the presence of low technological gap.

The Threshold model may present different significant control variables compared to the FGLS model because the sample is broken into several parts in the estimation process.

The regional dummies were also removed because the threshold model does not allow variables that do not vary over time.

In order to check for possible endogeneity associated with related variety variable, while encompassing our limited sample size, the linear model presented in equation (3.8) was estimated through LIML (limited information maximum likelihood method) with one-year lag of related variety and related variety moderated by absorptive capacity as instrumental variable. C-statistic (infference of two Sargan-Hansen statistics) pointed that both related variety and related variety moderated by absorptive capacity were exogenous with p-values of 0.73 and 0.81, respectively.

Based on the results introduced by Frenken et al. (2007) that the related variety (measure of degree of proximity of sectors) is positively related to regional economic growth, this study identified that the benefits to be obtained by regional related variety spillovers depend on ABC threshold moderation levels, a result similar to that obtained by Cortinovis and Oort, Van (2015), which found that related variety can have a positive effect on employment growth but predominantly when the absorptive capacity is high.

Yasar (2013) and Wu and Hsu (2008), using foreign direct investment (FDI) as a proxy for diversity, also found positive effects on higher levels of absorptive capacity. Yasar (2013) analyzed the productive impact of FDI input in manufacturing firms, emphasizing its interaction with the absorptive capacity and found that the companies with greater absorptive capacity gain significantly more with the FDI. Wu and Hsu (2008) also found that the effect of FDI on economic growth depends on different absorptive capacities, indicating a positive and significant impact on growth when recipient countries have greater ABC. This study has the differential of using the related variety concept, because according to Frenken et al. (2007), some studies have ignored the important effects of related variety, which is beneficial for knowledge spillovers, thus enhancing growth.

2.5 CONCLUSIONS AND IMPLICATIONS FOR POLICY AND PRACTICE

This study contributes to the economic diversification literature with an investigation on the outcomes of related variety in Brazil and finds evidence that RV can positively affect the Brazilian companies' productivity when is moderating by a high level of absorptive capacity (firm-level).

Brazil has a vast and diversified industry, and given this characteristic, has great opportunities to obtain positive results from knowledge spillovers generated from environments with high levels of related variety.

This study used Frenken's literature to calculate the related variety applied to the CNAE code. In addition, it was analyzed the importance of absorptive capacity as a moderator between productivity and related variety. Finally, it was checked the effects of the related variety on the firm's productivity according to the levels of absorptive capacity (Thresholds), which assesses the nonlinear effects of absorptive capacity in companies, by capturing different levels in which the RV influences productivity.

The threshold model presented that the main variable of analysis, related variety, has no positive effect on productivity when tested alone, leading to the rejection of hypothesis 1. However, when testing absorptive capacity as a process moderator, the result on productivity is positive, leading us to accept hypothesis 2. Besides, the intangible stock and companies' age variables are also significant and have a negative impact on productivity, income showed a positive impact.

Thus, we conclude that a region with a high related variety will only benefit from recombination, and consequently, increase its productivity, if it is moderated by the absorptive capacity. That is, a minimum level of knowledge is required for companies to be able to absorb the benefits from a diverse environment. As argued in the literature, it is also necessary to have the absorptive capacity to take advantage of spillovers (ALCACER AND CHUNG, 2007; CARAGLIU AND NIJKAMP, 2012; LIN AND CHANG, 2015; VOLBERDA, FOSS AND LYLES, 2010; WANG et al., 2016).

By checking thresholds for absorptive capacity, it is concluded that regions with a high related variety cause firm-level spillovers only when there is a high absorptive capacity, leading us to accept hypothesis 3.

In summary, the results point to the importance of related variety when it is moderated by absorptive capacity. These findings are relevant for Brazil, because they can contribute to regional policies on cluster building according to the related variety concept. Governments should invest in different types of diversification (especially in related variety) and in building firm-level absorptive capacities. Thus, regions, where there are clusters of specialized companies, could receive investments to attract companies from different sectors that have similarities, forming clusters that facilitate knowledge spillovers.

CHAPTER 3: GENERAL CONCLUSION

The purpose of this paper was to verify if the relationship between regional related variety and the companies' productivity is positive, besides verifying the importance of the absorptive capacity in this process and its thresholds.

This study contributes by providing information on the importance of the companies' location in Brazil, as well as the importance of absorptive capacity firm-level. Therefore, companies that have high levels of absorptive capacity and are located in regions with high related variety may have higher productivity compared to other companies.

A difficulty found in this paper is related to the size of the analyzed database. A suggestion for future research is to expand the database to have a model that takes into account neighborhood issues through a spatial model. Thus, it would be possible to evaluate, in addition to the importance of the related variety, what is the impact that the RV of a region has in the neighboring regions.

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APPENDIX A

Summary of articles on the relationship between related variety and economic growth (continues on the next page)

Authors	Country of study	Period	Referenced literature for VR calculation	Code used for VR calculation	Dependent Variable	Contribution
Boschma and Iammarino (2007)	Italy	1995-2003	Frenken et al (2007)	SIC	Employment growth	The article presents strong evidence that the related variety contributes to regional economic growth.
Frenken et al (2007)	Netherlands	1996-2002	Frenken et al (2007)	SIC	Employment growth and productivity	The authors find that the related variety has a negative influence on productivity growth, but on the other hand it has a positive influence on employment growth.
Boschma, Eriksson and Lindgren (2009)	Sweden	2001-2003	Frenken et al (2007)	SNI	Productivity	The authors identified the related variety of industrial plants significantly increases the productivity growth of companies, in contrast to the unrelated variety of industrial plants..
Boschma, Minondo and Navarro (2011)	Spain	1995-2007	Frenken et al (2007)	HS	Value-added growth	The article finds evidence that related variety is important for growth across regions.
Eriksson (2011)	Sweden	2001-2003	Frenken et al. (2007) and Boschma and Iammarino (2007)	SNI	Productivity	The author identifies that industrial plants benefit from spillovers if the region is characterized by complementary activities and not by similar or very different activities.
Falcıoglu (2011)	Turkey	1980-2000	Frenken et al (2007) and Boschma and Iammarino (2007)	ISIC and NACE	Productivity	The results suggest that the related variety, proximity to central areas, high wages and capital intensity contribute to regional productivity.
Boschma, Eriksson and Lindgren (2014)	Sweden	1998-2002	Frenken et al (2007)	SNI	Productivity	The authors show that high intensity of intra-regional labor flows between related industries has a positive impact on regional productivity growth, but less on regional employment growth.
Tavassoli and Carbonara (2014)	Sweden	2002-2007	Frenken et al. (2007) and Boschma et al. (2012).	NACE	Innovation	The empirical analysis provides robust evidence that related variety is important for innovation in regions.

(conclusion)

Authors	Country of study	Period	Referenced literature for VR calculation	Code used for VR calculation	Dependent Variable	Contribution
Cortinovis and Van Oort (2015)	Europe	2004-2012	Frenken et al (2007)	NACE	Employment growth	Diversity and especially related variety can have a positive effect on growth, but predominantly when the technological and knowledge level of the region is high.
Van Oort, Geus and Dogaru (2015)	Europe	2000-2010	Frenken et al (2007)	SIC	Employment growth	The authors found that related variety is significantly related to employment growth.
Aarstad, Kvitastein and Jakobsen (2016)	Norway	2010	Frenken et al (2007)	SIC	Productivity	The authors argue that the related variety has a positive regional factor of companies' innovation. Unrelated variety has a negative regional factor in companies' productivity.
Cainelli, Ganau and Iacobucci (2016)	Italy	1998-2007	Cainelli, Ganau and Iacobucci (2016)	NACE	Productivity (TFP)	The results suggest that the effect of geographical concentration on the TFP is stronger than that of the related variety.
Caragliu et al (2016)	Europe	1990-2007	Frenken et al (2007)	NACE	Employment growth	The results showed instead strong evidence that the concentration of activities in similar industries enhances employment growth.
Wixe and Andersson (2016)	Sweden	2002-2007	Attaran (1986)	SIC	Employment growth and productivity	The results show that related variety to work and education is positively correlated with productivity growth. In addition, the related variety across industries is considered negative for productivity growth, but positive for employment growth.
Lazzeretti, Innocenti and Capone (2017)	Italy	1991-2011	Frenken et al. (2007), Boschma and Iammarino (2009) and Hartog et al. (2012)	NACE	Employment growth	The authors found a strong relationship between the diversification of firms with a high degree of cognitive proximity (related variety) and employment growth

Source: developed by the author

APPENDIX B

List of 80 municipalities in the database

Municipality	Municipality
ARARAS(SP)	MONTES CLAROS(MG)
BARRETOS(SP)	NATAL(RN)
BARUERI(SP)	NITEROI(RJ)
BELO HORIZONTE(MG)	NOVA FRIBURGO(RJ)
BLUMENAU(SC)	NOVA ODESSA(SP)
BRASILIA(DF)	OSASCO(SP)
BRUSQUE(SC)	PASSO FUNDO(RS)
CAMACARI(BA)	POJUCA(BA)
CAMPINAS(SP)	PONTA GROSSA(PR)
CANOAS(RS)	PORTO ALEGRE(RS)
CATAGUASES(MG)	QUATRO BARRAS(PR)
CAXIAS DO SUL(RS)	RECIFE(PE)
CONTAGEM(MG)	REGISTRO(SP)
CRUZEIRO(SP)	RIBEIRAO PRETO(SP)
CURITIBA(PR)	RIO DE JANEIRO(RJ)
ELDORADO DO SUL(RS)	RIO DO SUL(SC)
EUSEBIO(CE)	RIO NEGRO(PR)
FLORIANOPOLIS(SC)	RONDONOPOLIS(MT)
FORTALEZA(CE)	SALTO(SP)
FRAIBURGO(SC)	SALVADOR(BA)
FRANCA(SP)	SANTA BARBARA D'OESTE(SP)
GOIANIA(GO)	SANTA ISABEL(SP)
GRAVATAI(RS)	SANTO ANDRE(SP)
GUARULHOS(SP)	SAO BERNARDO DO CAMPO(SP)
INDAIATUBA(SP)	SAO CAETANO DO SUL(SP)
ITAJAI(SC)	SAO JOSE DO RIO PRETO(SP)
ITAQUAQUECETUBA(SP)	SAO JOSE DOS PINHAIS(PR)
ITATIBA(SP)	SAO LEOPOLDO(RS)
ITIRAPINA(SP)	SAO LUIS(MA)
JARAGUA DO SUL(SC)	SAO SEBASTIAO DO CAI(RS)
JOINVILLE(SC)	SAPUCAIA DO SUL(RS)
JUNDIAI(SP)	SERTAOZINHO(SP)
LAJEADO(RS)	SOBRAL(CE)
LINS(SP)	TIJUCAS(SC)
MAGE(RJ)	TIMBO(SC)
MANAUS(AM)	UBERLANDIA(MG)
MOGI DAS CRUZES(SP)	VARZEA PAULISTA(SP)
MOGI MIRIM(SP)	VIANA(ES)
MOGI-GUACU(SP)	VINHEDO(SP)
MONTE CARMELO(MG)	VITORIA(ES)

Source: developed by the author

APPENDIX C

Distribuition (%) of companies' sectors in the database

Sector	Classification	Distribution(%)
Manufacturing	High Tech (HT)	1.0%
	Medium High Tech (MHT)	13.4%
	Medium Low High Tech (MLT)	9.3%
	Low Tecnology (LT)	18.6%
Services	Knowledge-intensive market services, excluding high-tech and financial services (KIMS)	17.0%
	High-tech knowledge-intensive services (HTKIS)	2.1%
	Knowledge-intensive financial services (KIFS)	1.5%
	Other knowledge-intensive services (OKIS)	7.2%
	Less knowledge-intensive market services (LKIMS)	29.9%
	Other less knowledge-intensive services (OLKIS)	0.0%

Source: developed by the author