FEDERAL UNIVERSITY OF SÃO CARLOS - UFSCar
GRADUATE PROGRAM IN PRODUCTION ENGINEERING - PPGEP
DOCTORATE IN PRODUCTION ENGINEERING

NAIJELA JANAINA COSTA SILVEIRA

Building Blocks of country-level Absorptive Capacity

São Carlos,
2020

FEDERAL UNIVERSITY OF SÃO CARLOS - UFSCar
GRADUATE PROGRAM IN PRODUCTION ENGINEERING - PPGEP
DOCTORATE IN PRODUCTION ENGINEERING

NAIJELA JANAINA COSTA SILVEIRA

Building Blocks of country-level Absorptive Capacity

Thesis defense presented to the Graduate Program in Production Engineering at the Federal University of São Carlos.
Research Line: Technology Management and Innovation
Advisor: PhD Herick Fernando Moralles

São Carlos,

2020

UNIVERSIDADE FEDERAL DE SÃO CARLOS

Centro de Ciências Exatas e de Tecnologia
Programa de Pós-Graduação em Engenharia de Produção

Folha de Aprovação

Assinaturas dos membros da comissão examinadora que avaliou e aprovou a Defesa de Tese de Doutorado da candidata Naijela Janaina Costa Silveira, realizada em 12/12/2019:

Prof. Dr. Herick Fernando Moralles
UFSCar

Profa. Dra. Ana Lucia Vitale Torkomian
UFSCar

Prof. Dr. Mário Sacomano Neto
UFSCar

Profa. Dra. Daisy Aparecida do Nascimento Rebelatto
USP

Prof. Dr. Enzo Barberio Mariano
UNESP

Certifico que a defesa realizou-se com a participação à distância do(s) membro(s) Enzo Barberio Mariano e, depois das arguições e deliberações realizadas, o(s) participante(s) à distância está(ao) de acordo com o conteúdo do parecer da banca examinadora redigido neste relatório de defesa.

Prof. Dr. Herick Fernando Moralles

DEDICATION

I dedicate to Christ Jesus, my best friend

ACKNOWLEDGMENTS

Wow, this is the worst part of the thesis to write, perhaps because life does not come under regression analysis and it is not through p-value that we discover the significance of people in our path.

First of all thank you for God's kind providence, He is my refuge and strength, a very present help in trouble. We all have troubled moments and God was my pillar in both the Master and the Doctorate. To him the honor, always!

To my parents for their understanding and support. My father in particular, who though he lives 8,000 kilometers away, has always been very present in all my decisions. I admire your character father, your fear of God and your dedication and concern for my life. Extremely grateful!

To my husband, Thiago, who has always been a companion, friend and my love. Without you, nothing would be possible. You are a fundamental piece, always!

To my advisor Herick for the attention and support during the orientation process, and who at the end of my PhD became a great father, literally! You have always been very present and friend! May you continue to be that person of character and admiration for all. Our partnership continues!

I thank the other teachers of UFSCar for their attention during the research, in the articles! UFSCar, especially the DEP, only has “top people”!

To my friends, research partners, people I met in the Master and Doctorate who will always be part of my life! To you, my sincere thanks for the partnership in these five years. We are not saying goodbye, just starting another cycle! To Diogo Ferraz in particular, I support him more than me, you were fundamental in my research and helped me a lot! I grew up with you a lot! My friend Izabel, who was my conversation and article partner, was a successful friend! At Diego Mello, we're just getting started, haha!

To my old friends, who, although not research partners, are life partners, there is no way not to mention you. They always encouraged me! My big hug to my best friends Weslem, Carla, Vivian, Wanessa, Gislaine, Jack, Katia (Sogrita), Rita ... Thank you friends!

To all who directly or indirectly helped me in this paper, thank you very much!

We are in the situation of a little child who enters a huge library full of books in many languages. The child knows that someone must have written those books, but does not know how. Does not understand the languages in which they were written. He has a pale suspicion that the arrangement of books obeys a mysterious order, but he does not know what it is.
Albert Einstein

ABSTRACT

In organizations, knowledge is already assumed as a strategic asset, as well as an explanatory variable for their performance and growth. Thus, it is considered that the diffusion and acquisition of knowledge determine the innovative potential of companies. In this context, this paper aimed to select the Absorptive Capacity (BB) Buildings Blocks (BBs) through the Systematic Review Literature (SRL) and validate them through econometric models for developing and developed economies. The research also identifies possible thresholds of these BBs using the fixed effects threshold model in panel data (2007-2015). The results show that BBs and their respective most significant thresholds for developed countries are not, in fact, the most important for emerging and developing countries, as groups have different socioeconomic conditions and therefore assume that each group has BBs that are more expressive.

Keywords: Total Factor Productivity. Threshold Model. Emerging countries. Developed countries. R&D activities.

RESUMO

Nas organizações o conhecimento já é assumido como um ativo estratégico, bem como uma variável explicativa para o seu desempenho e crescimento. Assim, considera-se que a difusão e a aquisição de conhecimento determinam o potencial inovador das empresas. Neste contexto, este trabalho teve como objetivo selecionar os *Buildings Blocks* (BBs) da Capacidade de Absorção (CA) por meio da Revisão Sistemática da Literatura (SRL) e valida-los através de modelos econométricos para economias em desenvolvimento e desenvolvidas. A pesquisa também realiza a identificação de possíveis limiares desses BBs usando o modelo de limiar de efeitos fixos em dados em painel (2007-2015). Os resultados demonstram que os BBs e seus respectivos limiares mais expressivos para os países desenvolvidos não são, de fato, os mais importantes para países emergentes e em desenvolvimento, pois os grupos têm diferentes condições socioeconômicas e, portanto, assumem que cada grupo tem BBs mais expressivos.

Palavras-chave: Produtividade Total dos Fatores. Modelo por Limiar (*Threshold*). Países emergentes. Países desenvolvidos. Atividades de P&D.

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS AND ABBREVIATIONS

AC - ABSORPTIVE CAPACITY

ANBERD - BUSINESS ENTERPRISE ANALYSIS AND DEVELOPMENT

FDI - FOREIGN DIRECT INVESTMENT

GCC - GULF COOPERATION COUNCIL

HDI - HUMAN DEVELOPMENT INDEX

LABMCDA - LABMCDA MULTI-CRITERION DECISION-MAKING METHODOLOGY

LAB (LABMCDA)

OECD - ORGANIZATION FOR ECONOMIC COOPERATION AND DEVELOPMENT

OLS - ORDINARY LEAST SQUARES

PB – PORTFOLIO BIBLIOGRAPHIC

PROKNOW-C - KNOWLEDGE DEVELOPMENT PROCESS - CONTRUTIVIST

RSL – REVIEW SYSTEMATIC LITERATURE

TFP - TOTAL FACTOR PRODUCTIVITY

SUMMARY

I INTRODUCTION

One of the effective channels for technology transfer is Foreign Direct Investment (FDI), which not only brings foreign capital but also advanced technology that can strengthen technological capacity, accelerate economic growth and improve the productivity of native companies (Ying) (Hun et al., 2009).

It is noteworthy that the Absorptive Capacity (AC) literature suggests that a certain level of knowledge is required for a focal firm to use another company's knowledge stock, because a company's ability to use new knowledge elements depends to a large extent existing knowledge of the company (Zhang et al., 2010).

The concept of AC was introduced by Cohen and Levinthal (1989) and then developed by Zahra and George (2002) in the context of learning and innovation of a company, and is currently a keyword for a variety of learning strategies, routines, and processes that influence a company's ability to tap into the external knowledge needed to build other organizational capabilities (Todorova; Durisin, 2007; Zahra; George, 2002).

The diffusion and acquisition of knowledge determine the innovative potential of companies (Griliches, 1998). Thus, AC is necessary to understand and transform external knowledge streams, essential for the production of innovation and growth of recipient firms (Cohen; Levinthal, 1990).

1.1 CONTEXTUALIZATION

Cohen and Levinthal (1989) argue that increased R&D activities impact efficiency, accelerating the assimilation of technologies developed elsewhere.

In organizations, knowledge is already assumed as a strategic asset, as well as an explanatory variable for its performance and growth (Grant, 1996). In this context, Foreign Direct Investment not only has an effect on the productivity of sectors that receive FDI directly, but also spillover effects on companies that do not receive FDI directly. Thus, FDI is believed to be a determining source for increased productivity and efficiency through positive spillover effects (Kim, 2015).

Therefore, it is necessary to analyze the impact of FDI on receiving economies, especially the effects related to economic growth. Many studies, such as Ubeda and Pérez

(2017), Li-Ming, Rui and Rui (2016), Kim (2015), and Girma (2005), indicate that the effects of FDI on productivity growth are dependent on Absorptive Capacity.

Girma (2005) reports negative impacts on Total Factor Productivity (TFP) arising from FDI allocation in regions without minimum CA levels. Lucas (1988) demonstrates that FDI flows contribute to economic growth in the recipient countries, increasing the capital stock and knowledge of the countries.

The authors Silajdzic and Mehic (2015) hypothesize that FDI contributes to economic growth predominantly through knowledge spillovers and that the positive impact of FDI on economic growth is associated with the ability to absorb knowledge.

Miguelez and Moreno (2015) warn that AC is an essential element of the regions' ability to make the most of the incoming knowledge and information flows, enabling them to achieve productivity gains and competitive advantages.

Thus, FDI is perceived as a source of knowledge for the recipient economy, and in many cases has been an essential element in the development strategies of some economies. Thus, it is necessary to analyze the Buildings Blocks (BBs) of Absorptive Capacity in order to help maximize spillover effects from FDI on the productivity of nations.

It is noteworthy that, in an increasingly globalized economic context, characterized by the predominance of relations between countries, and the constant increase in international trade, science becomes strategic about the way knowledge and technologies spread among countries, as well as as the way they affect Total Factor Productivity of Factors.

1.2 OBJECTIVE

Given the context presented, this paper aims to verify the Buildings Blocks (BBs) and the Absorptive Capacity (AC) thresholds of developed and emerging or developing countries.

We chose to classify countries into two groups (developed and emerging or developing) in order to obtain more homogeneous data and also compare the most relevant BBs of each group, as well as their respective thresholds. The idea is to verify that the most important BBs for developed countries are in fact the most important for emerging and developing countries, since the groups have different socioeconomic conditions, and, therefore, it is assumed that each group has more expressive BBs.

To this end, an econometric model of Threshold Regression adapted from Girma (2005) and Hansen (2000) is applied. This method allows to find critical values (thresholds) of thresholds variables and analyzes their impact on a given dependent variable.

Therefore, the following specific objectives are defined:

1 - List AC BBs through the Systematic Review Literature;

2 - Calculate the AC by the method proposed by Girma (2005) through the Total Factor Productivity (TFP);

3 - Identify the most relevant BBs and their thresholds for developed and emerging or developing countries.

1.3 RESEARCH PROBLEM

It is believed that a certain level of Buildings Blocks is required for them to have a positive impact on Absorptive Capacity.

1.4 JUSTIFICATION

It is believed that such analysis will allow finding critical values of BBs in order to maximize the positive spillover effects from FDI on countries' productivity, as well as to compare major BBs and their thresholds for developed and developing economies.

The advantage of this econometric model over the others is the identification of AC BBs thresholds for producing positive and negative productivity spillovers.

It is worth noting that Foreign Direct Investment (FDI) has increased significantly for developing countries over the past two decades. Thus, the importance of investigating not only the factors that impact the incoming volume of FDI in a given economy, but also the effects of this capital on the economic growth of the receiving nation, given that these impacts may be conditioned to the Absorptive Capacity of this receiving market.

The main contributions of this paper consist in the detection of the main AC BBs in developed and developing countries through Systematic Review of Literature, and also in the adoption of the threshold regression approach used by Girma (2005) to countries, to verify the thresholds of each BB selected in the literature, in which no studies addressing this subject were found.

It is noteworthy that papers such as Wu and Hsu (2008), Ghosh and Wang (2010), Wu and Hsu (2012), and Yasar (2013) used the threshold regression method proposed by Girma (2005), where they analyzed whether Investment Foreign Direct is dependent on Absorptive Capacity for impact on economic growth of countries. However, the authors used proxies for

Absorption Capacity and not the method proposed by Girma (2005) to calculate Absorptive Capacity as an efficiency index.

The results to be obtained have direct implications for the formulation of industrial policies for attracting FDI, together with programs to stimulate the competitiveness of national industries, in order to increase their total productivity. Specifically, the identification of BBs and thresholds will make it possible to define goals to be achieved prior to a possible FDI attraction policy, so as to potentiate positive productivity spillovers and avoid negative competition-related spillovers for the domestic industry.

1.5 PAPER STRUCTURE

This paper is structured in six stages represented by Figure 1.

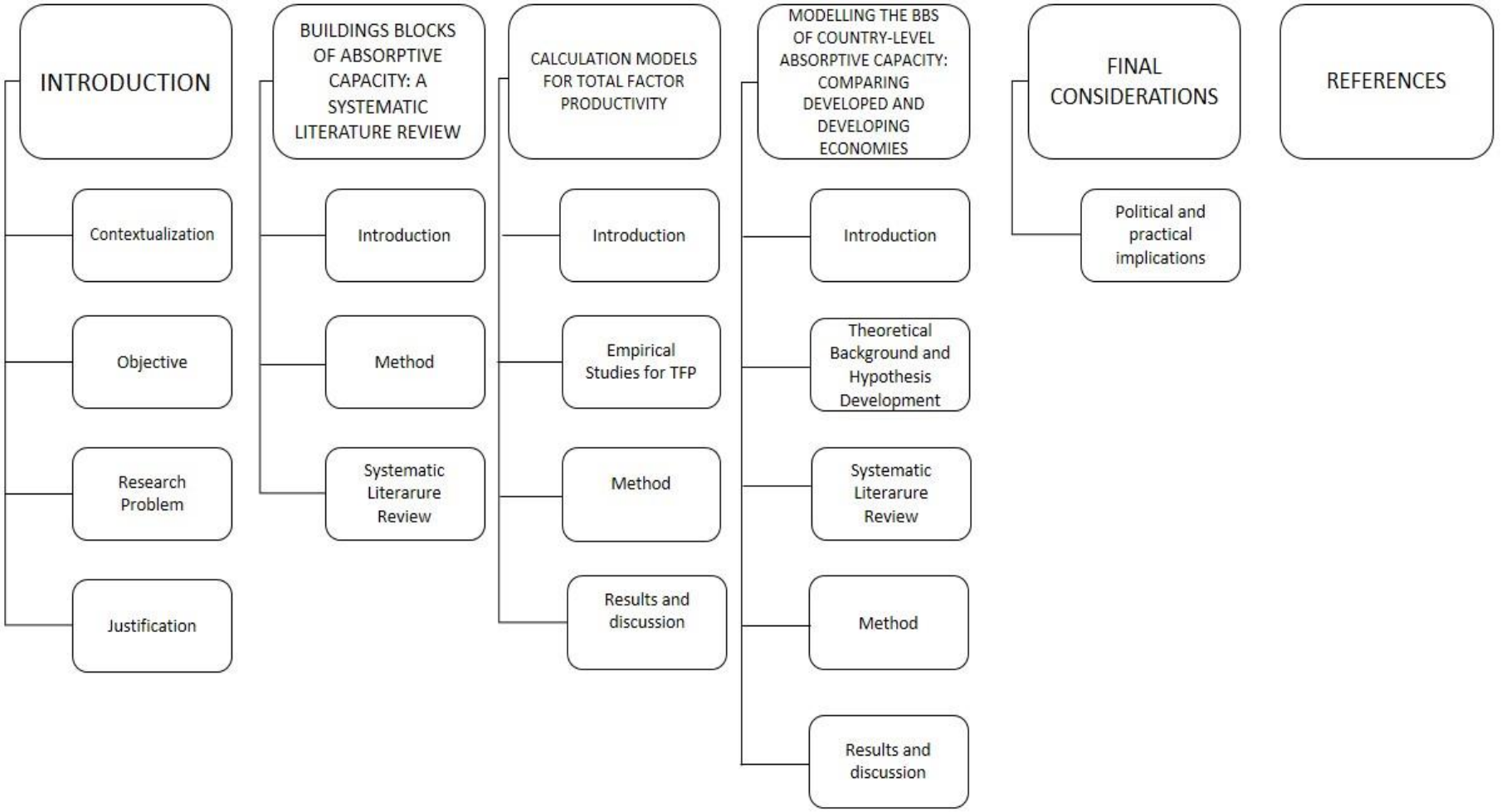


Figure 1 – Estrutura do trabalho. Fonte: Elaborado pelo autor (2019)

II BUILDINGS BLOCKS OF ABSORPTIVE CAPACITY: A SYSTEMATIC LITERATURE REVIEW

Abstract: Absorptive Capacity is necessary to understand and transform external knowledge flows, and it's essential for the production of innovation and growth of companies. **Objective:** This paper aims to conduct a Systematic Literature Review (SLR) about the Buildings Blocks (BBs) of Absorptive Capacity of developed and developing countries for the purposes of spillover of productivity derived from Foreign Direct Investment (FDI). **Originality:** There were no studies that carried out a systematic review of the BBs of Absorptive Capacity. Specifically, the identification of BBs will serve as targets to be achieved prior to a possible FDI attraction policy in order to enhance positive productivity spillovers and avoid negative spillovers relative to competition for the domestic industry. **Research method:** In order to analyze the main BBs that influence Absorptive Capacity, a Systematic Literature Review (SLR) was carried out in which the ProKnow-C Knowledge Development Process - Contructivist was applied for selection and analysis of articles. **Main results:** Through SLR 14 BBs for Absorptive Capacity were selected, with R&D activities and human capital being the most cited in the literature. It can be said that the presence of productivity spillovers depends on the investment efforts of local companies in R&D activities. These activities play an important role in knowledge transfer, in addition to its role as a means of innovation. **Implications:** The results obtained have direct implications in the formulation of industrial policies to attract FDI, along with programs to encourage the competitiveness of national industries, in order to increase their total productivity.

Keywords: Foreign Direct Investment; Productivity; Spillover of knowledge.

Resumo: A Capacidade de Absorção é necessária para entender e transformar os fluxos externos de conhecimento e é essencial para a produção de inovação e crescimento das empresas. **Objetivo:** Este trabalho tem como objetivo realizar uma Revisão Sistemática da Literatura (SLR) sobre os Blocos de Construção (BBs) da Capacidade de Absorção de países desenvolvidos e em desenvolvimento para efeitos de *spillovers* de produtividade provindo de Investimento Direto Estrangeiro (IDE). **Originalidade:** Não houve estudos que realizaram uma revisão sistemática dos BBs da Capacidade de Absorção. Especificamente, a identificação de determinantes servirá como alvos a serem alcançados

antes de uma possível política de atração de IDE, a fim de aumentar os efeitos positivos de produtividade e evitar repercussões negativas em relação à concorrência para a indústria doméstica. **Método de pesquisa:** A fim de analisar os principais BBs que influenciam a Capacidade de Absorção, foi realizada uma Revisão Sistemática da Literatura (RSL), na qual o Processo de Desenvolvimento de Conhecimento ProKnow-C - Contrutivista foi aplicado para seleção e análise de artigos. **Principais resultados:** Através da RSL foram selecionados 14 BBs, sendo as atividades de P&D e capital humano as mais citadas na literatura. Pode-se dizer que a presença de spillovers de produtividade depende dos esforços de investimento de empresas locais em atividades de P&D. Essas atividades desempenham um papel importante na transferência de conhecimento. **Implicações:** Os resultados obtidos têm implicações diretas na formulação de políticas industriais para atrair IED, juntamente com programas para incentivar a competitividade das indústrias nacionais, a fim de aumentar sua produtividade total.

Palavras-chave: Investimento Direto Externo; Produtividade; *Spillover* de conhecimento.

2.1 INTRODUCTION

Absorptive Capacity (AC) is one of the most influential concepts in management literature. First introduced by Cohen & Levinthal (1989) and then developed by Zahra & George (2002) in the context of learning and innovation of a company, and is currently a key word for a variety of strategies, administrative routines, and learning processes that influence a company's ability to exploit the external knowledge needed to build other organizational capacities (Todorova e Durisin, 2007; Zahra e George, 2002).

Cohen & Levinthal (1990) and Malaguerra (2014) define AC as the ability to recognize new information, to assimilate it and to apply it for commercial purposes. Lapan e Bardhan (1973) point out that companies need a certain level of AC before they can benefit from technologies developed by other companies. Malaguerra (2014) states that AC is important in all countries, especially for countries that seek to approach the technological frontier.

Most studies typically measure Absorptive Capacity with R&D proxies. This means for authors to ignore the dimensions of the construct and its implications for

different organizational results. The variables do not establish a time horizon or frequency of activities, and carry an R&D bias, which is not the only possibility of using external knowledge. On the other hand, they establish multiple indicators for capacity, and these indicators are based on processes/routines, and the measures are benchmarked, qualifying the level of AC.

Thus, the necessity to use knowledge and technologies from external sources is increasing, as they become a vital component of national innovation processes (Grimpe e Sofka, 2008) (King e Lakhani, 2011), allowing companies to increase their resource base and adapt to the market (Zahra e George, 2002). Therefore, Smeets (2008) emphasizes that Absorptive Capacity determines the intensity and signal of spillovers.

Lapan e Bardhan (1973) argue that companies need a certain level of Absorptive Capacity before they can benefit from technologies developed by other companies. Cohen e Levinthal (1989) argue that increasing R&D activity increases efficiency indirectly by accelerating the assimilation of technologies developed elsewhere.

The ability to attract Foreign Direct Investment (FDI), according to Sari et al. (2016), can bring immense benefits to a host country. Incoming multinational corporations provide direct and indirect benefits to the host economy. According to Barro e Sala-i-Martin (1997), FDI can contribute positively to the convergence of developed and developing countries, increasing imitation activities in developing countries. The direct benefits of foreign affiliates can take the form of new investments, productive capacity, demand for labor, demand for intermediate goods and sometimes exports that stimulate national income or economic growth, providing new opportunities and increasing revenue tributary (Takii, 2005).

As stated before, the ability to attract FDI can bring immense benefits to a host country. The direct benefits of foreign affiliates can take the form of new investments, productive capacity, demand for labor, demand for intermediate goods and sometimes exports that stimulate national income or economic growth, provide new opportunities and increase revenue tributary (Takii, 2005).

Therefore, FDI is perceived as a knowledge source for the economy, and, in many cases, has been an essential element in economic development strategies. Thus, it is necessary to analyze the BBs of Absorptive Capacity in order to maximize the effects of spillover from FDI on the productivity of nations.

In this context, this article aims to perform a Systematic Literature Review (SLR) about the BBs of Absorptive Capacity (AC) of developed and developing countries.

The results obtained have direct implications for the future formulation of industrial policies to attract FDI, along with programs to encourage the competitiveness of national industries, in order to increase their total productivity. Specifically, the identification of BBs will serve as targets to be achieved prior to a possible FDI attraction policy in order to enhance positive productivity spillovers and avoid negative spillovers relative to competition for the domestic industry.

The section is organized in three sections besides this introduction. In the second section the method related to the Systematic Literature Review (SLR) is presented. In the third section the results and discussions of the SLR are presented. Finally, the main considerations are found in the fourth section of this paper.

2.2 METHOD

A Systematic Literature Review (SLR) provides a methodical, explicit and replicable synthesis in a given topic (Reim et al., 2015). SLR is an important research endeavour by itself and not merely a review of previous writings. It responds to specific research questions, and is a methodology that locates existing studies, selects and evaluates contributions, analyses and synthesizes data, and reports the evidence in such a way that allows reasonably clear conclusions to be reached about what is and is not known (Denyer & Tranfeld, 2009).

In order to analyze the main BBs that influence the Absorptive Capacity (AC) of a country and that have some impact on the productivity of the same, a Systematic Literature Review (SLR) was carried out in the Scopus and Web of Science databases. This section represents the methodological characterization of the research tool ProKnow-C - Knowledge Development Process - Contructivist that was applied for articles selection and analysis.

2.2.1 Intervention tool - ProKnow-C

For the selection of scientific publications, the Knowledge Development Process-Constructivist (ProKnow-C), developed by the Laboratory of Multicriteria Decision Support Methodologies (LabMCDA), Federal University of Santa Catarina (UFSC) was used as an intervention tool. ProKnow-C has already been used in other scientific journals

that have investigated different contexts (Nuernberg et al., 2016; Cardoso et al., 2016; Valmorbida et al., 2015; Ensslin et al., 2014).

ProKnow-C has as main objective to provide knowledge about a fragment of scientific literature. To achieve its objective, the instrument leads the researcher (i) to select a Bibliographic Portfolio (PB) of scientific and relevant articles that answer the research topic; (ii) to perform the investigation and analysis of some characteristics of this PB, which the process calls by bibliometric analysis of PB; (iii) to reflect critically on the position of the studies based on the theoretical affiliation established by the researcher, which the process calls systemic analysis; and (iv) to point out the gaps and opportunities of future research, based on the knowledge generated in the previous two stages. All the steps require active participation of the researcher for its accomplishment. Thus, the constructivist process occurs and evolves based on the interests and delimitations established by the researcher (Ensslin et al., 2014; Silva et al., 2014; Valmorbida et al., 2015; Dutra et al., 2015). Therefore, the process is composed of four stages, as shown in Figure 2.

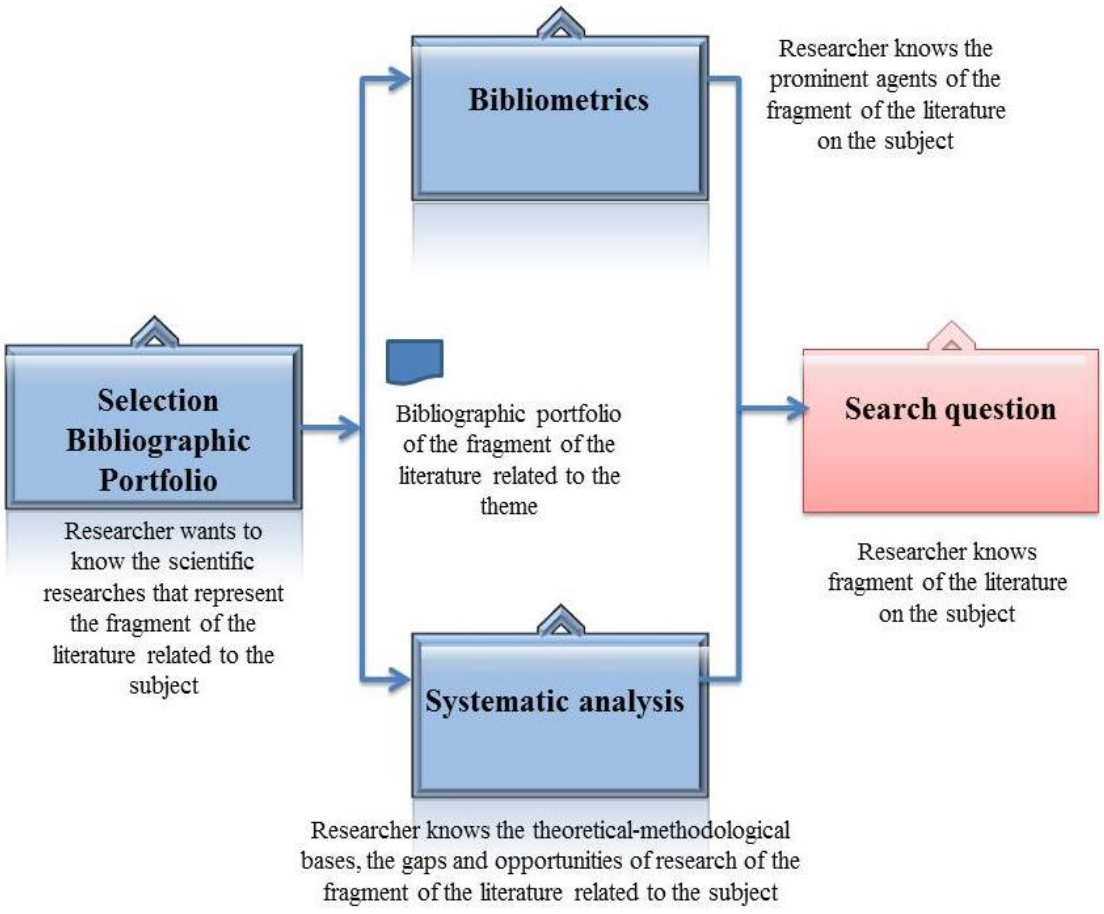


Figure 2 – Stages of the ProKnow-C methodology

In order to reach the objective of the research, the first 3 main steps of the ProKnow-C process were applied since the objective of this review is not to analyze points that have not yet been studied by authors, but to analyze the BBs of Absorptive Capacity by studies already carried out.

2.3 SYSTEMATIC LITERATURE REVIEW (SLR)

In order to analyze the main BBs that influence the Absorptive Capacity (AC) of a country and that have some impact on the productivity of the same, a Systematic Literature Review (SLR) was carried out in the Scopus and Web of Science databases. This section represents the methodological characterization of the research tool ProKnow-C - Knowledge Development Process - Contructivist that was applied for selection and analysis of articles.

2.3.1 Methodological characterization

Research based on production engineering usually begins with the selection of documents of scientific prestige for the composition of the theoretical foundation and identification of the gaps in the literature (Cauchick et al., 2010). Faced with the amount of scientific articles in the databases currently, one of the difficulties of the researcher is to find those that are of greater relevance for the subject that one wishes to research.

This research was based on qualitative and quantitative approaches (Greener, 2008; Creswell, 2007). It's qualitative because it comprises a set of procedures to obtain a portfolio of scientific articles whose analysis of the alignment of these articles to the research context is based on the perception of the researchers authors of this article. It's also quantitative because it seeks identifiable and observable objective facts, through the use and manipulation of numbers, both regarding the procedures pertinent to the identification of the bibliographic portfolio (as for example, to analyze the scientific recognition of the articles) and the bibliometric analysis of this portfolio.

From the perspective of its logic, research is inductive (Greener, 2008), because it aimed to generate knowledge - a theoretical framework for scientific research - from the identification of studies that are closely related to the BBs of Absorptive Capacity. As for the technical procedures, the research is characterized as bibliographical (Richardson

e Peres, 1999), and the data sources are of a secondary nature, since all the information was obtained from scientific publications.

The entire process of data collection and analysis was guided by the Knowledge Development Process - Constructivist (ProKnow-C), proposed in Tasca et al. (2010) as mentioned in the method.

2.3.2 Selection Bibliographic Portfolio

In this section the articles of the bibliographic portfolio and the resulting portfolio of this step are described - Selection of articles for the bibliographic portfolio.

2.3.2.1 Selection bank gross articles

The search procedures for raw articles are described in Table 1.

Table 1 – ProKnow-C Phase - Selection of the gross articles bank

ProKnow-C Phase	**International Portfolio**
Gross Items Bank Selection	
Consulted databases	Scopus and Web of Science
Keywords	Productivity AND Absorptive Capacity knowledge Spillover AND Absorptive Capacity
Delimitation	Type of publication: Journal article English language Time limit: not limited
Date of consultation	March 2018
Results	960 articles

2.3.2.2 Article bank filtering

For the filtering stage of the article bank, an RSL protocol was generated, which is in appendix A with the main information about the research, including the strategies used for searching and selecting primary studies, the criteria and procedures for selection of the studies, and process of study selection. Table 2 shows the number of papers selected in the databases.

Table 2 – ProKnow-C Phase - Filtering articles

Criteria for analysis	**Scopus**	**Web of Science**
Articles identified with keywords	219	741
Selected papers after summary analysis	55	40
Number of papers shared in both databases		35
Total articles reviewed		**60**

From the selected articles, 18.33% (11 articles) of the sample presented a nationwide study population, encompassing several countries (Aldieri et al., 2018; Foster-McGregor et al., 2017; Khordagui and Saleh, 2016; Huebler, Glas and Nunnenkamp, 2016; Miguelez and Moreno, 2015; Silajdzic and Mehic, 2015; Fracasso and Marzetti, 2014; Elmawazini, 2014; Castillo, Salem and Guasch, 2011; Krammer, 2010; and Keller, 2010.

The articles previously mentioned used the panel data structure. Of the entire sample, 50 articles (83.3%) used panel data, 5 articles (8.3%) cross-section data, and 5 articles (8.3%) were not mentioned, including this one literature reviews.

Of the sample, 31.6% (19 articles) analyzed developed countries, 56.6% (34 articles) focused on emerging countries, and 11.6% (7 articles) did not identify the study population.

2.3.2.3 Test of the representativeness of the bibliographic portfolio

When it comes to identifying the most important papers, a useful parameter for classifying them is the number of citations. However, it is important to remember that the latest articles have not yet had time to become prominent in this regard. Table 3 shows the fifteen most cited articles among the 60 selected, along with the number of citations in the Scopus and Web of Science databases in March 2018. Figure 3 illustrates graphically.

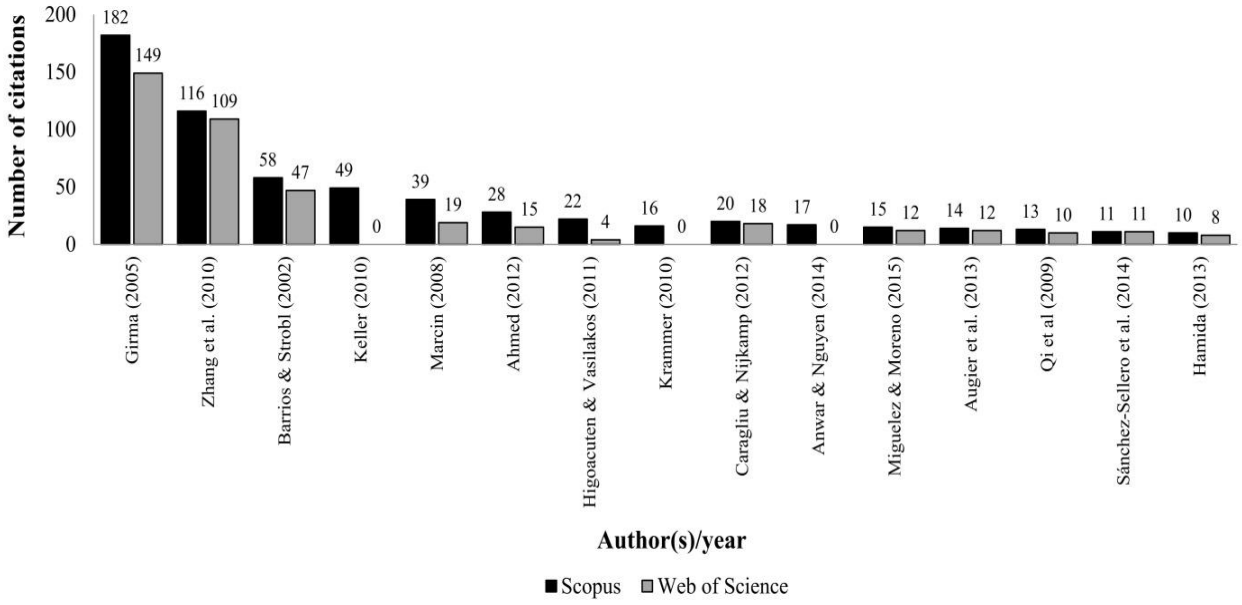


Figure 3 – Fifteen most cited articles in the literature

Table 3 – Fifteen articles most cited in the literature

Author(s)/Year	Citations in Scopus	Citation in Web of Science
Girma (2005)	182	149
Zhang et al. (2010)	116	109
Barrios and Strobl (2002)	58	47
Keller (2010)	49	**
Marcin (2008)	39	19
Ahmed (2012)	28	15
Higoacuten and Vasilakos (2011)	22	4
Krammer (2010)	16	**
Caragliu and Nijkamp (2012)	20	18
Anwar and Nguyen (2014)	17	**
Miguelez and Moreno (2015)	15	12
Augier et al. (2013)	14	12
Qi et al (2009)	13	10
Sánchez-Sellero et al. (2014)	11	11
Hamida (2013)	10	8

Consider ** (Article is not in the base)

Among the selected articles, the most cited were Girma (2005), who examined the relationship between Absorptive Capacity and technology spillovers using enterprise-level data from the UK manufacturing industry, and Zhang et al. (2010), which analyzed the effect of the diversity of origins of FDI countries on the productivity of domestic firms. It should be added that pioneering articles such as Barrios and Strobl (2002) and Marcin (2008) also show a large number of citations.

2.3.3 Bibliometric portfolio analysis

Bibliometry is characterized by the quantitative disclosure of the statistical data of a Bibliographic Portfolio that aims to manage the information and the scientific knowledge of a certain subject through document counting (Ensslin et al., 2010). In the case of this study, bibliometrics will involve the analysis of journals, publications per year, and publications by geographic regions.

Figure 4 shows the degree of relevance of the journals in the bibliographic portfolio, that is, the Journals that stand out by the number of articles selected. The Journal Economics of Innovation and New Technology stands out for 4 articles from which they were selected.

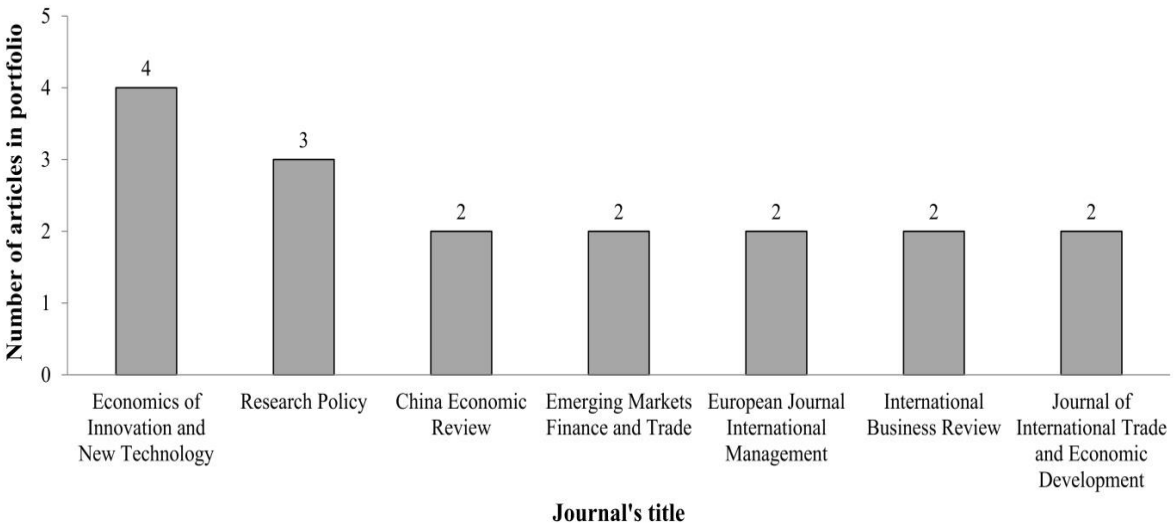


Figure 4 – Relevance of journals in the bibliographic portfolio

Figure 5 shows the number of papers published in the bibliographic portfolio, highlighting the year 2017 with the highest number of publications. It is worth noting that the year 2018 was not completed, given the possibility of increasing the number of publications of the same.

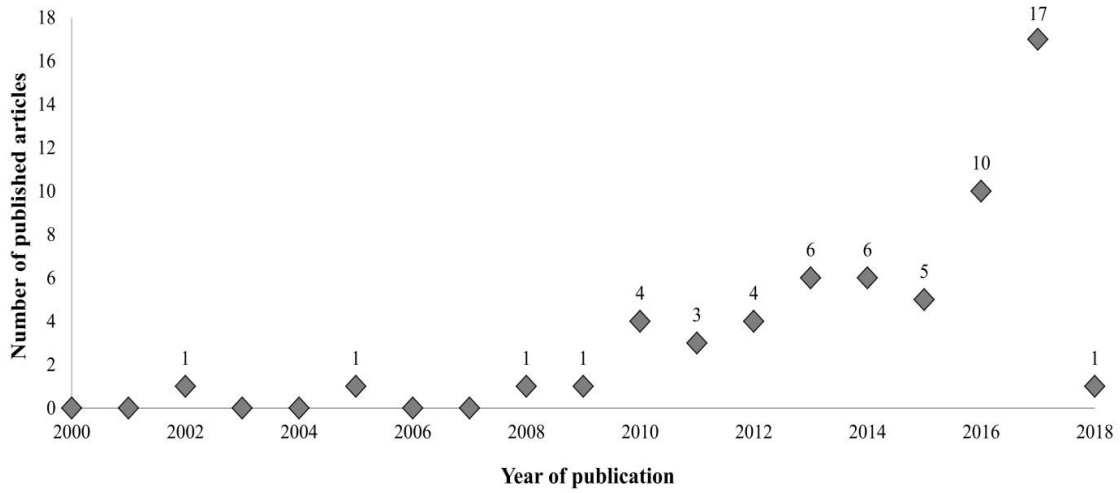


Figure 5 – Number of papers published per year in the bibliographic portfolio

Figure 6 reports the number of articles published by geographical region in the bibliographic portfolio.

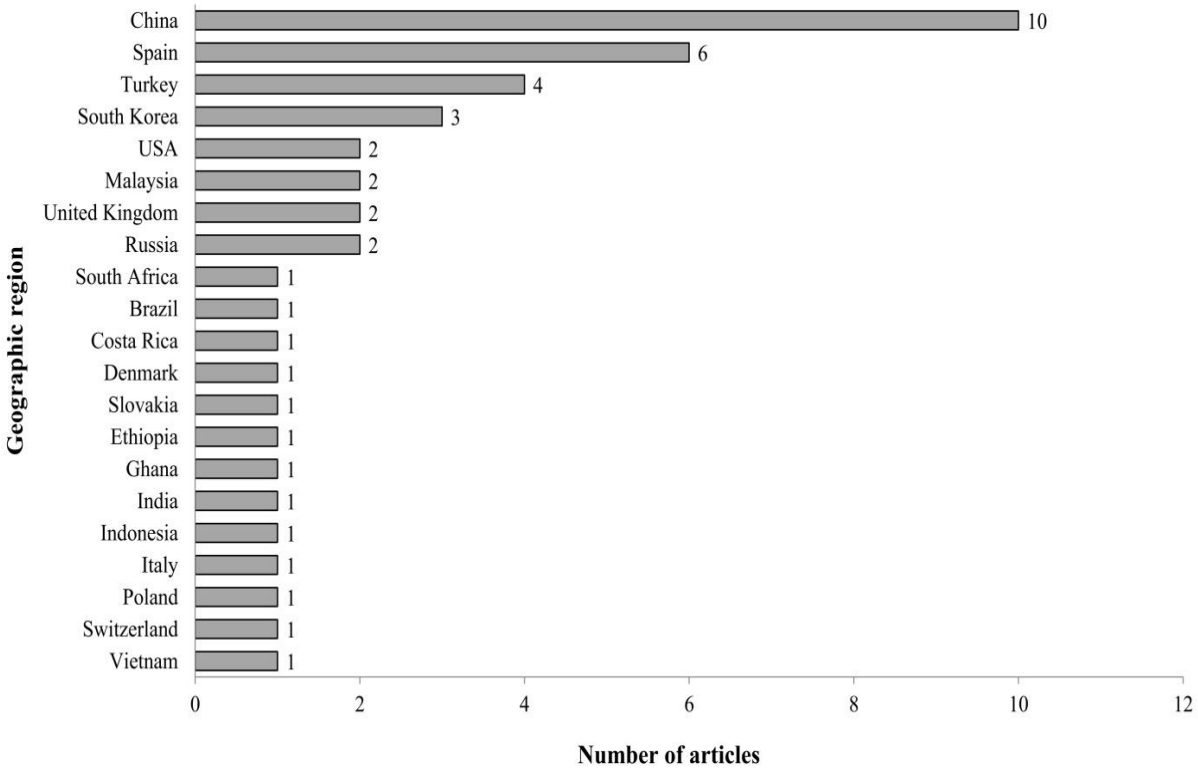


Figure 6 – Number of papers published by geographic regions in the bibliographic portfolio

According to Figure 6, China and Spain are the countries that have published the most articles of the selected sample.

2.3.4 Systemic analysis

Table 4 shows an analysis of the focus and main results/contributions of the 11 articles that presented study population at the national level, being of relevance for this study, since the population of this one are emerging and developed countries.

Table 4 – Analysis of the focus and main contributions of the 11 articles that presented study population at national level

Author(s)/Year	Objective	Buildings Blocks of AC	Limitations/Contributions/Originality
Aldieri, Sena and Vinci (2018)	Explore how firm-level Absorptive Capacity mediates the relationship between rent and R&D spillovers in three economic areas (Europe, Japan, and the USA)	R&D activities and number of patents	This article contributes to the existing literature on absorptive capacity in several ways: first, it shows the nature of knowledge issues and that companies specialize in acquiring and processing specific types of knowledge. Second, it provides a potential explanation of why some companies appear to benefit from some types of spillovers over others and relate these differences to the characteristics of absorbed knowledge. Finally, it provides some suggestive evidence of how the distance from the technological frontier influences the level of absorption of the firm.
Foster-McGregor et al (2017)	Focus on the role of international R&D spillovers by trading intermediary products at the industry level for a broad cross-section of countries, as well as	Human capital and R&D expenditure	The current study does not include countries at very low levels of development, which is characterized as a limitation of study. The results also supported studies that found that foreign R&D spillovers are stronger in countries with higher absorptive capacity

	investigating the role of absorptive capacity		
Khordagui and Saleh (2016)	This paper examines the role of human capital as a factor of absorptive capacity for emerging economies	Human capital	The contribution of this paper is that the primary, secondary and tertiary sectors are examined and the analysis is expanded to take into account the main components of the sectors
Huebler, Glas and Nunnenkamp (2016)	Identify Absorptive Capacity indicators and their role in South-North convergence through a channel of imported investment goods	Participation of highly qualified labor force; Index of Economic Freedom; Tertiary education rate; Internet rate; telephone rate; Scientific article rate; Patent fees; Trademark fee; Participation of the service sector; High-tech industry sharing	The findings of this article on absorptive capacity indicators are relatively advanced for emerging economies
Miguelez and Moreno (2015)	To assess the extent to which absorptive capacity determines the impact of knowledge flows on regional innovation	R&D activities	The authors confirmed the results of previous papers, in which both worker mobility and participation in research networks are critical means to transmit knowledge. The impact found is far from homogeneous across the EU, with more developed regions achieving greater returns from the knowledge flows received by mobile inventors, while less advanced areas rely more heavily on networks.
Silajdzic and Mehic (2015)	To analyze the exogenous impact of FDI in economic growth, as well as to study the influence of technological and innovative capacities on growth performance among economies in transition	R&D Activities; Mobility of workers; Inventor networks	We have contributed to the recent literature using a more reliable measure of FDI, while describing the character of FDI and related knowledge spillovers, as well as examining the importance of technological and innovative capabilities to explain growth performance among transition economies not previously studied.
Fracasso and Marzetti (2014)	To investigate how a country's absorptive capacity and relative backwardness affect the impact of international R&D spillovers on the TFP	Human Capital, R&D Activities, FDI	In the paper we adopted a series of updated econometric measures to make the robust inference in unspecified forms of heteroscedasticity and serial and simultaneous correlation in the data. The authors' knowledge is the first time that this method is used in an applied empirical study.
Elmawazini (2014)	Contribute to the empirical literature by investigating the hypothesis that external direct investment (FDI) flows produced positive productivity spillovers for Gulf Cooperation Council (GCC) countries during the period 1995 to 2011	GDP per capita, labor productivity, TFP, human capital, technological capacity, Human Development Index (HDI)	The results say that these three areas need further research. In the first place, it would be interesting to repeat the current study, incorporating more developing countries. Secondly, the link between labor productivity and income differences between the GCC and the OECD countries could be another document. Thirdly, the human capital gap between women and men, measured by average years of secondary schooling, should also be investigated as a gap between the OECD countries and the GCC.
Castillo, Salem and Guasch (2011)	This paper examines two sources of spillovers of global knowledge: Foreign Direct Investment (FDI) and trade	Activities in R&D, human capital, FDI	It is suggested that more general policies should be pursued which not only attract FDI but also benefit national enterprises, for example by building modern infrastructures, increasing and strengthening institutions to accelerate and sustain economic growth.
Krammer (2010)	Use the latest developments in the integration and infrastructure techniques of the panel unit to unlink the effects of international spillovers through trade and FDI inflows into Total Factor Productivity (TFP)	Activities in R&D, human capital, FDI	Current results contribute to the existing literature by looking at 27 former communist economies and quantifying the importance of the spillover channels of these Eastern European and Central Asian countries. New enhancements may consider the use of data in the industry for a better location of spillovers, which tend to cluster in certain industries. Moreover, in the case of countries in transition, their industrial mix has changed significantly throughout the 1990s from industrialized countries to a more balanced economy in which the service sector has grown tremendously. Another interesting line of research could explore the size and dynamics of the indirect effects of spillovers via IDE.
	To examine how international flows of technological knowledge affect economic	Activities in R&D	Not reported

Keller (2010)	performance in industries and companies in different countries

Figure 7 shows the BBs of AC according to the literature. They were selected based on the variables used by the authors, mode of measurement of AC, generation of spillovers, or, cited by the articles as BBs of the same. The variables were classified according to the pillars: Research; Organization; Labor; and, Finances.

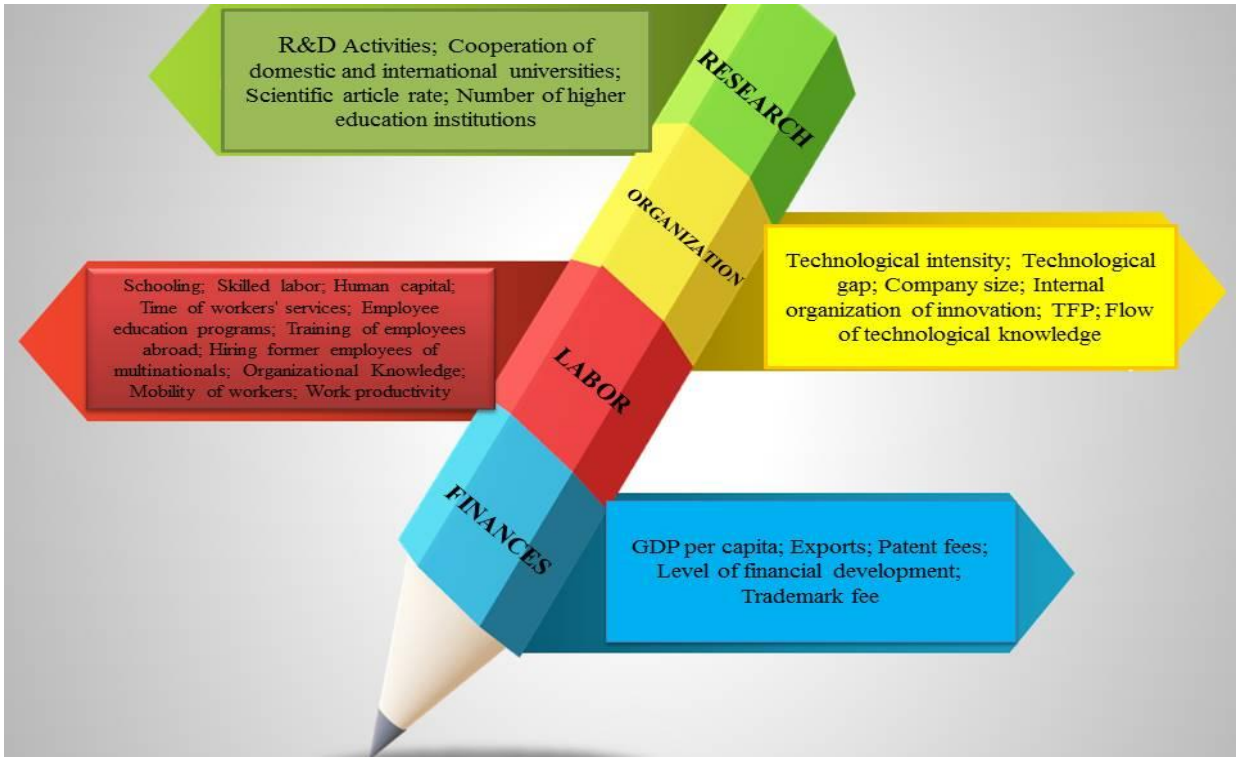


Figure 7 – BBs of AC selected by the literature - 60 articles

As this paper aimed to study both developed and emerging countries, we analyze the BBs cited by the articles that obtained the population of study at the national level, that is, analyzed variables referring to countries. The selected BBs are shown in Figure 8 and were classified according to the pillars: Human Capital; Innovation and, Economic.

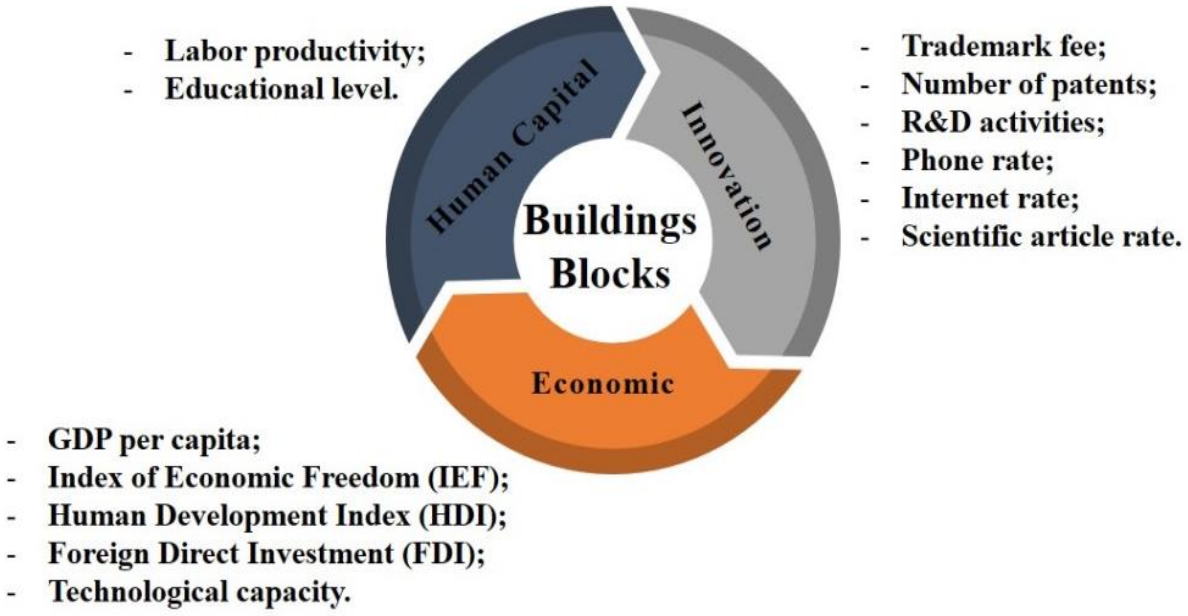


Figure 8 – AC BBs selected by the literature - 11 articles (national level)

Table 5 describes the definitions of these variables or means of measuring them according to the authors mentioned above.

Table 5 – Definitions of the variables according to the authors. * Some variables did not have their measurements defined by the authors

Author (s)/Year	BBs of AC	Definition of authors
Aldieri et al. (2018)	R&D activities and number of patents	The stock of R&D captures the cumulative nature of the learning process. Another measure is the percentage of self-credits, that is, the percentage of citations of patents issued by the same transferee.
Foster-McGregor et al. (2017)	Human capital and R&D expenditure	For the authors the variables that capture the absorptive capacity are information from the Barro-Lee[1] dataset on the average years of secondary education in the population. They followed the approach of Cohen & Levinthal (1989) using the registered R&D value of the ANBERD[2] data set as an additional indicator of absorption capacity
Khordagui e Saleh (2016)	Human capital	The human capital variable is measured by the average years of schooling for adults over 25 years of age
		Participation of highly qualified labor force - Percentage of highly skilled working time in all working hours. The higher

[1] http://www.barrolee.com/. These data were used as a measure of Absorptive Capacity in similar studies.
[2] The OECD Business Development and Analysis (ANBERD) database presents annual R&D expenditure by industry and was developed to provide analysts with comprehensive data on business R&D expenditures.

		skills of workers are commonly associated with higher education, including a better understanding of technology. Nevertheless, this indicator is related to the rate of tertiary education.
Huebler et al. (2016)	Participation of highly qualified labor force; Index of economic freedom; Tertiary education rate; Internet rate; Telephone rate; Scientific article rate; Patent fees; Trademark fee; Participation of the service sector; High-tech industry sharing	**Index of economic freedom** - The index of economic freedom in the form of registration. This index is the average of 10 sub-indices: commercial freedom, commercial freedom, monetary freedom, government size/spending, fiscal freedom, property rights, freedom of investment, financial freedom, freedom from corruption and freedom of labor. Each of the sub-indices is measured on a scale of 0 to 100, with higher numbers indicating higher degrees of freedom. **Tertiary education rate** - Gross rate of tertiary education enrollment. **Internet rate** - This is the number of Internet users per 100 people in the population. **Phone Fee** - These are the registration phone lines for 100 people of the population. **Scientific article fee** - This is the number of scientific and technical journals journal entries within a specific country per capita. This measure indicates the intensity of basic and, to some extent, applied research. **Patent Fee** - This is the number of patent application registrations (by nonresidents) in a specific country divided by the population of that country. **Trademark Fee** - This is the trademark application registration number per capita. Trademark applications are a more applied, industry-oriented measure than patents. **Service sector share** - This is the number of registered trademark applications per capita. Trademark applications are a more applied, industry-oriented measure than patents. **High-tech industry sharing** - This is the record output value of the high-tech manufacturing industries divided by the total production value of the manufacturing industry. The weight of the high-tech industry in the economy is another indicator for pre-existing technologies and technological capabilities that facilitate the adoption of new technologies.
Silajdzic e Mehic (2015)	R&D Activities	Measured as a share of R&D expenditures by the business sector in the country's GDP and by total government R&D expenditures expressed as a share in the country's GDP.

Miguelez e Moreno (2015)	R&D Activities; Mobility of workers; Inventor networks	**R&D Activities:** R&D is not only a generator of foreground, but also a means to improve the company's ability to assimilate and exploit existing information. **Mobility of workers:** Geographic mobility of knowledge workers. The evidence supports the proposition about the role of absorptive capacity in the assimilation of knowledge flows from labor mobility. **Inventor Networks:** Interregional Technology Networks. The economically least developed regions are those which benefit most from the geographical spread of knowledge through technological cooperation networks.
Fracasso e Marzetti (2014)	Human capital and R&D activities	**Human capital:** Average years of schooling. **R&D activities:** The results suggest that absorption capacity is positively associated with international repercussions of R&D.
Elmawazini (2014)	GDP per capita, labor productivity, TFP, human capital, Technological capacity, Human Development Index (HDI)	**GDP per capita:** Developed countries are expected to have a higher level of human capital and therefore benefit more from FDI than developing countries. **Labor productivity:** Foreign presence has a significant positive effect on labor productivity. **TFP:** There are negative impacts on the Total Factor Productivity resulting from the allocation of FDI in regions that do not have minimum levels of absorption capacity. AC is defined as the TFP level in the previous period divided by the maximum TFP level in the industry. It is assumed that a high level of Absorptive Capacity indicates technological congruence with industry leaders. **Human capital:** Measured by average years of schooling. Technology capability: Measured by royalty receipts and license fees. **Human Development Index (HDI):** Studies on the effects of FDI have generally used human capital, represented by the average years of schooling, as a measure of the absorption capacity of the host countries. Above all, it is argued that the Human Development Index (HDI) best captures the absorptive capacity of the host country. Skills can be acquired not only through formal education, but also through training and work experience; and this acquisition of skills is further supported by improvements in other social indicators. Recognizing that health care and economic conditions can affect the productivity

		and diffusion of technology, providing an environment conducive to innovation.
Castillo et al. (2011)	Activities in R&D, Human Capital	**R&D Activities:** The presence of productivity spillovers depends on the investment efforts of local firms in R&D activities. They play an important role in the transfer of knowledge, in addition to its role as a means of innovation. **Human capital:** There is evidence that the positive impacts of the development of FDI flows depend on the high level of human capital and hence on the existence of "good" infrastructure in host countries.
Krammer (2010)	Human capital; R&D activities	Both human capital and domestic R&D efforts increase a country's absorptive capacity and contribute to increased productivity. Human capital - average years of schooling among men over 25 years of age.
Keller (2010)	R&D Activities	The high level of R&D is consistent with the idea that countries need to develop absorptive capacity to be able to produce spillover of productivity from local firms.

Source: Prepared by the authors (2019)

2.4 FINAL CONSIDERATIONS

In this chapter the SLR performed selected 14 BBs for Absorptive Capacity, being the activities of R&D and human capital the most cited in the literature. It can be said that the presence of productivity spillovers depends on the investment efforts of local companies in R&D activities. They play an important role in knowledge transfer and are a means of innovation. There is evidence that the positive impacts of developing FDI flows depend on the high level of human capital and therefore on the existence of "good" infrastructure in host countries.

After selecting the BBs, four calculation models were selected for Total Factor Productivity for subsequent calculation of Absorptive Capacity.

III CALCULATION MODELS FOR TOTAL FACTOR PRODUCTIVITY

Abstract: Productivity measures the level of efficiency with which certain economy uses its resources to produce goods and consumer services. Increasing productivity is the fastest route to get to economic growth and social well-being, since such production gains reflect all the effectiveness of the production sector, as well as the degree of development of the company. before this context, this article is intended to present four models that were tested for calculating the Total Factor productivity (TFP) of countries, to be known: Olley and Pakes, 1996 - OP; Levinsohn and Petrin, 2003 - LP; Wooldridge, 2009 - Wool; e, Ackerberg, Caves and Frazer, 2015 - ACF. As intermediate input the per capita energy consumption was used as pointed by the literature. It can be found that though the model ACF (2015) proposes an improvement of the OP and LP models, in addition to present results with statistical meaning, the model Wool (2009) also is about an improved model of previous models, beyond have presented results near the same. However, the ACF model presented great dispersion around the models average. So, it was opened to choose as a better model, the Wool model (2009).

Keywords: Productivity; Efficiency; Developed countries; Emerging countries.

Resumo: A produtividade mede o grau de eficiência com que determinada economia utiliza seus recursos para produzir bens e serviços de consumo. O aumento da produtividade é a via mais rápida para se chegar ao crescimento econômico e ao bem-estar social, pois tais ganhos de produção refletem toda a eficácia do setor produtivo, bem como o grau de desenvolvimento da sociedade. Diante deste contexto, este artigo tem por objetivo apresentar quatro modelos que foram testados para cálculo da Produtividade Total dos Fatores (PTF) de países, a saber: Olley e Pakes, 1996 - OP; Levinsohn e Petrin, 2003 - LP; Wooldridge, 2009 - Wool; e, Ackerberg, Caves e Frazer, 2015 - ACF. Como *input* intermediário foi utilizado o consumo de energia per capita como apontado pela literatura. Pode-se constatar que embora o modelo ACF (2015) propõe um aprimoramento dos modelos de OP e LP, além de apresentar resultados com significância estatística, o modelo Wool (2009) também trata-se de um modelo aprimorado de modelos anteriores, além de ter apresentado resultados próximos com o mesmo. No entanto, o modelo ACF apresentou grande dispersão em torno da média dos modelos. Assim, optou-se por escolher como melhor modelo, o modelo de Wool (2009).

Palavras-chaves: Produtividade; Eficiência; Países Desenvolvidos; Países Emergentes.

3.1 INTRODUCTION

In an economic context characterized by the predominance of relations between countries, and the steady increase in international trade, the way knowledge and technologies spread among countries becomes strategic, as well as the way they affect the Total Factor Productivity (TFP).

Productivity measures the degree of efficiency with which a given economy uses its resources to produce consumer goods and services (Messa, 2013). Increasing productivity is the fastest way to achieve economic growth and social welfare, as such production gains reflect the effectiveness of the productive sector as well as the degree of development of society (Felema, Raiher and Ferreira, 2013).

Historically, productivity has been measured based on the relationship between the product and a single input, being known as partial factor productivity. In this sense, the most common is the measure of partial labor productivity, measured as output per worker or output per hours worked.

One justification for using this productivity measure is that it does not require the calculation of capital as the other input, whose data is often missing and therefore questionable proxies are used. However, the biggest limitation of this measure is that it measures output per unit of work rather than output per unit of all combined inputs (Vallejos and Valdivia, 2000).

The first to associate the aggregate production function with productivity was Tinbergen (1942). However, the seminal contribution to this theme was given by Solow (1956), by creating a link between the production function and an index productivity number. Assuming constant returns to scale, Solow measured the change in the production function given capital and labor levels.

Then, by arranging the terms of the production function, Solow obtained what he called relative Hicksian efficiency, that is, a more general indicator of output per unit of input, which later became known as Total Factor Productivity (TFP) or Solow Residue, which reflects technological progress and other elements that act as determinants of economic growth.

Thus, TFP intends to indicate the efficiency with which the economy combines all its resources to generate product. From this conceptualization, the dynamics of the indicator is a result of the technological progress of the economy (Messa, 2013).

Simply put, it means getting higher output with the same amount of resources employed or using fewer resources to achieve the same output. There are no different ways to see productivity. There is only one thing: to do more with less.

Thus, the classical production function has become inefficient in representing productive transformations in modern economies (Buesa et al., 2010; Hausmann et al., 2014). Several studies have developed production functions adapted using different types of variables, such as labor productivity (Sarbu, 2017), sustainability (Husniah and Supriatna, 2016), knowledge proxies (Lenox and King, 2004; Hidalgo and Hausmann 2009; Elmawazini, 2014), and energy (Olley and Pakes, 1996 - OP; Levinsohn and Petrin, 2003-LP; Wooldridge, 2009 - WOOL; and, Ackerberg, Caves and Frazer, 2015 - ACF).

Given the context presented, this paper aims to present four models that have been tested for country TFP calculation, namely: OP; LP; WOOL; and ACF. As intermediate input, the per capita energy consumption was used as pointed out in the literature.

We chose to classify countries into two groups (developed and emerging or developing) in order to obtain more homogeneous data, since the groups have different socioeconomic conditions, and, therefore, it is assumed that each group has characteristics more expressive.

With the results of the econometric models it is possible to compare them in terms of statistical significance and select the one that presents the best fit. This paper may help future work to choose the best method that fits certain research.

This article is organized into four sections in addition to this introduction. In the second section, there is the theoretical review of the empirical work on TFP. In the third section, the method is presented. In the fourth section the results and discussions are presented. Finally, the main considerations are found in the fifth section of this article.

3.2 TFP EMPIRICAL STUDIES

Several studies have theoretically and empirically identified factors that determine TFP in developed and developing countries. Table 6 shows some TFP determinants selected in the literature.

Table 6 – Determinants of TFP according to the literature

Author(s)/Year	Determinants of TFP
Danska-Borsiak (2018)	R&D activities; Infrastructure; Physical capital; Structural change; Financial system; Location of the region; Per capita income
Otsuka (2017)	Share capital; Population agglomeration
Otsuka and Natsuda (2016)	IDE; R&D; Human capital; Technology employed
Kim (2016)	Exports; Imports; R&D; Salary; Quality of work; Work hours
Akinlo and Adejumo (2016)	Commercial opening; Foreign Direct Investment; Inflation; Human capital; Unemployment rate
Harris and Moffat (2015)	Real gross production; Actual intermediate entries; Job; Capital; Age; Single plant
Giovanis and Ozdamar (2015)	Age; Size; Short term debt; Long term indebtedness; Liquidity; Value added index; Active relationship for sales; Risk proxy; Market share; Business entry; Company departure; Industry average growth
Arazmuradov et al. (2014)	GDP; Human capital; IDE; Import of machinery and equipment
Castiglionesi and Ornaghi (2013)	Index of use of new technologies; Salary; Percentage of R&D employees in total workforce; Quotas of students with higher education in relation to the total workforce; Human capital; R&D Expenses
Sheng and Song (2012)	Participation in R&D; Market share; Herfindahl Index; Export Quota
Dańska-Borsiak and Laskowska (2012)	Human capital level; R&D; Investments
Kim (2011)	Job; Capital; Training cost per skilled worker; Skilled worker; Number of higher education employment; R&D

Source: Prepared by the author (2019)

The theoretical literature suggests that human capital affects the growth of TFP, facilitating the adoption and implementation of new technologies exogenously (Nelson and Phelps 1966; Romer 1990) and/or facilitating the domestic production of technological innovations (Aghion and Howitt, 1998; Romer, 1990). However, the ability to adopt (adapt and implement) foreign technology depends not only on the quantity but also on the quality of education. This, by implication, means that for low-income countries with low government spending on education, low education, poor quality education, and low investment in research and development (R&D), human capital may not have a positive impact on growth of TFP.

It is noteworthy that the literature has argued that productivity gains will be linked to the absorption capacity of the regions. Thus, innovative producers are more receptive

to new technologies and thus are able to maximize gains and reduce costs (Felema, Raiher and Ferreira, 2013).

3.3 METHOD

3.3.1 TFP calculation

The measurement of TFP evolution from Solow's (1957) work is obtained from a Cobb-Douglas type production function with constant returns to scale and neutral technical progress.

$$Y = AL^{\alpha}K^{\beta} \quad (1)$$

Where Y = the production volume; L = the work stock; K = the capital stock. In logarithmic terms equation 1 can be described as:

$$\ln Y = \ln A + \alpha \ln K + (1-\alpha)\ln N \quad (2)$$

Where α and β are parameters with β = (1-α) and A is the exogenous technological parameter (TFP). Making the time derivatives of equation (2) we get (3):

$$\frac{dA}{A} = \frac{dY}{Y} - \left(\alpha \frac{dL}{L} + \beta \frac{dk}{k}\right) = R = PTF \quad (3)$$

Where R is the Solow residue, ie the product growth rate not explained by the growth of inputs. Thus, equation (3) provides a measure of the evolution of TFP as the difference between the change in output and the change in capital and labor stocks. Therefore, it is the measure of the evolution of production that is not explained by the growth of factor stocks, but by the evolution of its productivity.

Equation 3, in turn, provides a measure of the evolution of TFP, or Solow Residue (R), as the difference between the change in output and the change in capital and labor stocks. Thus, TFP intends to indicate the efficiency with which the economy combines all its resources to generate product. From this conceptualization, the dynamics of the indicator would be a result of the technological progress of the economy.

It is noteworthy that the primary factors of production are those that facilitate production, but are not significantly transformed by production processes, nor become part of the final product, and intermediate inputs are those created during and fully used in production. Capital and labor are considered primary factors of production, while most energy is considered an intermediary that can be “produced” by some combination of capital and labor investment (more technology) (Ayres and Warr, 2010).

The Solow model was extended by adding the energy factor and allowing a technical change of factor increase (Azar and Dowlatabadi, 1999; Löschel, 2002; Acemoglu et al., 2012). There are also examples in the relevant literature of modeling approaches that recognize and allow the role of intermediate inputs - namely energy - to directly impact economic growth (Stern and Kander, 2012).

Correct estimation of TFP is a key issue in economics and is the main theme of many seminal papers. Although models generally consider only capital and labor as independent factors of production, these models are unable to fully explain economic growth with only these two factors. Solow's pioneering work (1957) revealed that after recognizing the contributions of capital and labor to a growth accounting framework, an exogenous residual term is needed to explain more than 85 percent of US economic growth (1909-1949). It is noteworthy that TFP encompasses many components, some desired (effects of technical and organizational innovation), others unwanted (measurement error, omitted variables).

Thus, Olley and Pakes (1996) introduced a semiparametric method that controls these biases, allowing to estimate the parameters of the production function consistently and thus to obtain reliable yield estimates. Later, based on the work of Olley and Pakes (1996), Levinsohn and Petrin (2003) developed an estimator that uses intermediate inputs to represent the term of unobservable productivity. Most factory-level data sets include data on the use of intermediate inputs such as energy and materials. Therefore, the Levinsohn and Petrin estimator does not suffer from the truncation bias induced by the Olley and Pakes estimator, which requires companies to have nonzero investment levels. Thus, they used intermediate inputs as instruments rather than investment for lack of information.

Given this, several adaptations and extensions for the Olley and Pakes estimator were developed. Recently, the time assumptions underlying the semi-parametric estimators of Olley and Pakes and Levinsohn and Petrin have been questioned by Ackerberg, Caves and Frazer (2015) who suggest an alternative two-step estimator, where all relevant parameters are retrieved in the second stage, in which by adding polynomial terms the regression was better. Wooldridge (2009), on the other hand, focuses on the inefficiencies associated with the two-step estimation procedure of existing methodologies and proposes a framework in which estimates of the production function can be obtained in one step. Its structure allows the temporal assumptions of the original semiparametric estimators and the adapted structure of Ackerberg, Caves and Frazer.

Thus, this paper will test the three PTF calculation methods to analyze the best fit of the models: Levinsohn and Petrin (2003); Wooldridge (2009); and Ackerberg, Caves and Frazer (2015). As intermediate input will be used the energy consumption per capita as pointed out in the literature. It is noteworthy that for the OP model the investment variable was used as an intermediate input and later criticized by LP who used the energy proxy.

For the calculation of country TFP the variables in Table 7 were selected for the four above methods.

Table 7 – Variables for the calculation of TFP. * Data are in US dollars for constant GDP and Gross Fixed Capital Formation. ** The Gross Fixed Capital Formation variable was depreciated at an annual rate of 10% as used in the literature.

Variables	**Definition**
Constant GDP (Dependent Variable)	GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without deducting depreciation of manufactured goods or from the depletion and degradation of natural resources. Dollar to GDP values are translated from national currencies using the official 2010 exchange rates (World Bank Group, 2017).
Economically active population	Proportion of the population aged 15 and over that is economically active: All persons who provide labor for the production of goods and services during a specific period (World Bank Group, 2017).
Electricity consumption (kWh per capita)	Electricity consumption measures the production of power plants and combined heat and power plants, less transmission, distribution and transformation losses, and own use by power and heating plants (World Bank Group, 2017).
Gross Fixed Capital Formation (% of GDP)	Gross fixed capital formation includes land improvements (fences, ditches, drains, and so on); purchase of machinery, equipment and equipment; and the construction of roads, railways and the like, including schools, offices, hospitals, private residences, and commercial and industrial buildings (World Bank Group, 2017).

Source: World Bank Group (2017)

The use of log-linear regressions is proposed, as it is possible to interpret the parameters as elasticities as well as the use of panel data techniques. The software used for descriptive and econometric analysis consists of Stata15®.

Data for the calculation of TFP was taken from The World Bank website for the years 1995-2015. Only per capita electricity consumption data for 2015 was extracted from the CIA World Factbook website.

3.3.2 Descriptive Statistics - TFP

Table 8 presents descriptive statistics for all countries (n = 124) and for groups G1 (developed countries) and G2 (emerging and developing countries).

Table 8 –Descriptive statistics - Total sample (124 countries), G1 and G2. *Raw data. Data are in US dollars for constant GDP and depreciated capital. The results obtained through the xtsum (Stata) command provide further basis for the adoption of panel data models and the application of several estimators.

Variables		Mean	Standard Deviation	Minimum Amplitude	Maximum Amplitude
GDP_const	*Total sample*	4.58e+11	1.47e+12	2.07e+09	1.67e+13
	G1	1.16e+12	2.51e+12	5.56e+09	1.67e+13
	G2	1.92e+11	5.88e+11	2.07e+09	8.91e+12
Pop.econ.ativa	*Total sample*	2.24e+07	7.96e+07	131770	7.87e+08
	G1	1.43e+07	2.78e+07	146501	1.61e+08
	G2	2.54e+07	9.17e+07	131770	7.87e+08
Cap.deprec	*Total sample*	8.69e+10	3.14e+11	5.75e+07	4.36e+12
	G1	2.03e+11	4.46e+11	6.95e+08	3.23e+12
	G2	4.17e+10	2.29e+11	5.75e+07	4.36e+12
Cons.energ.pc	*Total sample*	3922.554	5318.351	13.517	54799.2
	G1	8681.331	6855.619	1992.9	54799.2
	G2	2105.567	3034.158	13.517	21508.45

Another important operation is the correlation of variables (Pearson's correlation test) in which it was performed for the total sample and for both groups (Table 9).

Table 9 – Pearson correlation test

Variables	GDP_cons (Total)	GDP_cons (G1)	GDP_cons (G2)
Pop.Econ.Ativa	0.4133	0.9906	0.8113
Cap.deprec	0.9247	0.9894	0.9184
Cons.Energ.pc	0.2243	0.0819	0.0678

Based on Table 9, the Economically Active Population variable was strongly correlated in G1 and G2, and with moderate correlation in the total sample. The Depreciated Capital variable provided a high correlation in the three samples. Intermediate input (Energy Consumption), in turn, showed a low correlation with constant GDP, however, in the total sample showed a higher correlation.

As for the collinearity analysis between the explanatory variables, the variables Depreciated Capital and Economically Active Population presented a high correlation when analyzed in groups. However, in the total sample they showed a moderate correlation (0.54). Intermediate input, however, showed a low correlation with Depreciated Capital and Economically Active Population.

To avoid the multicollinearity problem, that is, when the independent variables have a high level of linear association with each other, which may result in significant loss of precision of the regression estimators (Brooks, 2008), the total sample was used to calculate the TFPs. This avoids the possible collinearity problem, obtaining more robust results.

3.4 RESULTS AND DISCUSSION

In this section we find the estimated parameter results for the TFP calculation of the models selected in the literature: Olley and Pakes (1996); Levinsohn and Petrin (2003); Wooldridge (2009); Ackerberg, Caves and Frazer (2015).

3.4.1 Estimated model parameters

Table 10 shows the results of the TFP models.

Table 10 - Results of TFP models - Total sample (developed countries). Panel data (1995-2015) - Coefficients β. Consider: * p <0.1; ** p <0.05; *** p <0.01. ** OP model calculated for comparison with LP parameter results, since OP used as intermediate input investments

	Olleys and Pakes (OP) (1996)	**Levinsohn and Petrin (LP) (2003)**	**Wooldridge (WOOL) (2009)**	**Ackerberg, Caves and Frazer (ACF) (2015)**
Ln_Pop.Econ.Ativa	0.3354657***	0.3283395***	0.3410329***	0.1592553***
Ln_Cap.deprec	0.3598284***	0.3618283***	0.3656545***	0.8565273***

Productivity is often estimated as the deviation between observed production and forecasted production by an Ordinary Least Aquares (OLS) estimated Cobb-Douglas production function.

The results of OP were extremely close to LP, however, the OP model was calculated only for comparison with the other models, as it is noteworthy that LP is an enhancement of OP, since it may present the problem of zero investment for many sample entities. Thus, in the OP model presented in Table 19, the variable Investment was used as an intermediate input, which is criticized by LP.

The LP results show a statistically significant and positive effect for the Economically Active Population and Depreciated Capital variables on constant GDP. Thus, the 1% increase in the economically active population impacts 0.33% of GDP, and the 1% increase in depreciated fixed capital impacts GDP by 0.36%. The LP model was statistically significant at 1%.

Levinsohn and Petrin (2003) argue that the productivity shock seems to vary in units over time. Thus, LP proposes a modification of the OP approach to solve the problem of irregular investment through the use of intermediate inputs to represent unobserved productivity.

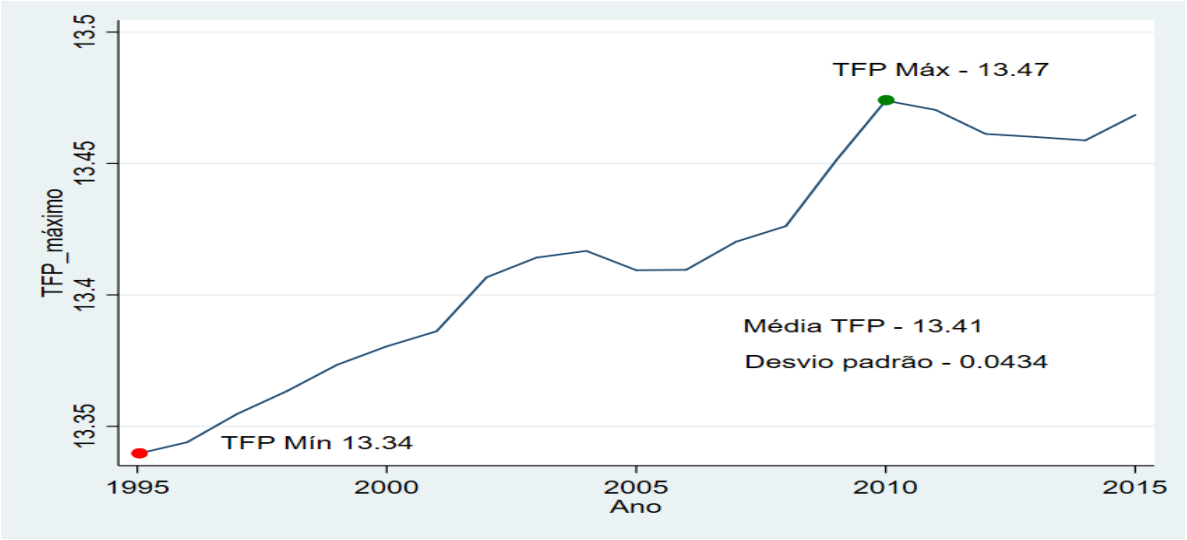
Therefore, Wooldridge (2009) proposes an improvement for such methods (OP and LP). The results of the Wooldridge (2009) model also showed results similar to the above models, where the 1% increase in the Economically Active Population has a 0.34% impact on GDP, and the 1% increase in depreciated capital impacts the GDP by 0.37%. The WOOL model was also statistically significant at 1%.

The ACF model, in turn, proposes a hybrid of the OP and LP approaches, along with assumptions about the timing of input choice decisions. According to the result, the model was statistically significant at 1% and with positive parameter, however, a 1% increase in the Active Economic Population impacts 0.16% in constant GDP, and a 1% increase in depreciated capital causes positive impact of 0.87% on GDP.

3.4.2 Model Choice

Although the ACF (2015) model proposes an improvement of the OP and LP models, and still presented results with statistical significance, the WOOL (2009) model, besides improving the LP model, presented close results with the same. In addition, the ACF model showed large dispersion around the mean as observed. Thus, we chose to analyze the WOOL model. Figure 9 reports the maximum TFP found for G1 each year and its corresponding country. It is noted that the United States was the largest TFP in all years of the sample (1995-2015), thus characterizing itself as the benchmarking country.

Figura 9 – Maximum TFPs of each year (United States) - Total Sample - Wooldridge Model (2009). * Min TFP represents lowest index among maximum TFPs

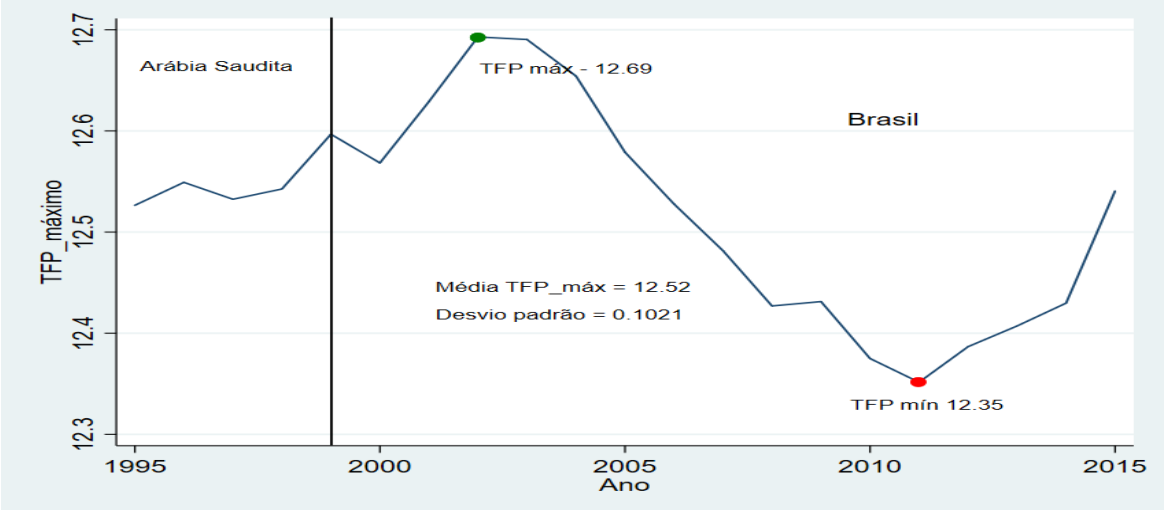


According to Figure 9, the US had the highest TFP (13.47) in 2010 and the lowest in 1995 (13.33). The results are similar to Alvim (2009) who also computed the TFP of some countries, where all reached productivity below the US.

Brazil, in turn, had higher productivity than many of the developed countries, such as Cyprus, Slovenia, Estonia, Iceland, Latvia, Malta and Portugal, but also lower than many countries like Germany, Belgium, Canada, Italy, Japan and Norway. Brazil had the highest TFP in 2002 (12.69292) and has an average of 12.49847 and standard deviation 0.108135.

For G1, as the US is a developed country, it has the highest TFP for the total sample in all years, so it is benchmarking for developed countries. For G2, the maximum PTF (Wool Model) value of each year was verified and are shown in Figure 10.

Figura 10 – Maximum TFPs of each year - G2 - Wooldridge Model (2009). *Min TFP represents lowest index among maximum TFPs



As can be seen in Figure 10, Saudi Arabia presented itself as G2 benchmarking from 1995 to 1999, and subsequently from 2000 to 2015 Brazil presented itself as benchmarking. Brazil showed a decrease in productivity from 2002 to 2011, but after 2011 showed a growing productivity behavior.

The study by Mation (2013) analyzed the evolution of TFP in Brazil, and in light of this diagnosis, it is clear that the main explanatory factor of Brazilian economic growth was the incorporation of factors of production, especially the labor factor. As the economy is at historically high levels of employment and participation rates, it is difficult to continue sustained growth along these lines. As such, policies that help identify barriers to increased productivity are key.

3.5 FINAL CONSIDERATIONS

This chapter aims to present four models that have been tested for country TFP calculation, namely: Olley and Pakes (1996); Levinsohn and Petrin (2003); Wooldridge (2009); and Ackerberg, Caves and Frazer (2015). As intermediate input, the per capita energy consumption was used as pointed out in the literature.

It was decided to classify countries into two groups (developed and emerging or developing) in order to obtain more homogeneous data, since the groups have different socioeconomic conditions, and, therefore, it is assumed that each group has characteristics more expressive.

Although the ACF (2015) model proposes an improvement of the OP and LP models, and still presented results with statistical significance, the WOOL (2009) model, besides improving the LP model, presented close results with the same. In addition, the ACF model showed large dispersion around the mean as observed. Thus, we chose to choose the best model, the model of WOOL (2009).

IV MODELLING THE BUILDING BLOCKS OF COUNTRY-LEVEL ABSORPTIVE CAPACITY: COMPARING DEVELOPED AND DEVELOPING ECONOMIES

Abstract: This paper aims to identify and validate the Building Blocks (BBs) of Absorptive Capacity (AC) by combining a Systematic Literature Review (SLR) and econometric models for developed and developing countries. The investigation also identifies possible thresholds of these BBs using the fixed-effect panel threshold model. The results demonstrate that BBs and their respective more expressive thresholds for developed countries are in fact not the most important for emerging and developing countries, as groups have different socioeconomic conditions, and therefore assume that that each group has more expressive BBs.

Keywords: Threshold Regression; Developed countries. Developing countries. Total Factor Productivity. R&D Activities.

4.1 INTRODUCTION

Knowledge is one of the main drivers of economic growth as it leads to a more national, qualified workforce able to absorb knowledge and new technologies developed in other countries (Foster-McGregor et al., 2017; Khordagui and Saleh, 2016; Huebler, Glas and Nunnenkamp, 2016; Silajdzic and Mehic, 2015) and foreign companies (Ying-Chun et al. 2009), and adapts techniques from other sectors (Kim, 2015). The economic literature calls this phenomenon Absorptive Capacity (Cohen and Levinthal, 1990; Kim, 1998; Lane and Lubatkin, 1998; Zahra and George, 2002).

Absorptive Capacity (AC) enhances the ability of a region to identify, assimilate and exploit knowledge, which allows national companies to imitate and absorb production methods, organizational and managerial techniques from multinational companies, as well as to combine its effect with foreign investments (Lapan and Bardhan, 1973; Cohen and Levinthal, 1989, 1990; Kim, 1998; Lane and Lubatkin, 1998; Zahra and George, 2002; Gorg and Greenaway, 2004; Girma, 2005; Haskel et al., 2007; Liu and Buck, 2007; Todorova; Durisin, 2007; Blalock and Simon, 2009; Zhang et al, 2010;

Damijan et al., 2013; Ascani and Gagliardi, 2015; Kim, 2015; Miguelez and Moreno, 2015; Li-Ming et al., 2016; Apriliyanti and Alon, 2017; Ubeda and Pérez, 2017).

In fact, organizational knowledge is already assumed as a strategic asset, as well as an explanatory variable for its performance and growth (Grant, 1996). Some studies indicate that the effects of foreign investments on productivity growth are dependent on AC (Alfaro et al., 2004; Bevan and Estrin, 2004; Bevan et al., 2004; Kim, 2015; Girma, 2005; Ayanwale, 2007; Dikova and Van Witteloostuijn, 2007; Kalotay, 2010; Holtbrügge and Kreppel, 2012; Estrin and Uvalic, 2016; Li-Ming, Rui and Rui, 2016; Padilla-Perez and Nogueira, 2016; Ubeda and Pérez, 2017; Owusu-Nantwi and Christopher Erickson, 2019).

The concept of AC can be found in several studies that examine numerous factors, including the development of human capital (Borensztein et al., 1998; Olofsdotter, 1998), trade (Balasubramanyam et al., 1996; Olofsdotter, 1998), Total Factor Productivity (Girma, 2005), development of financial markets (Alfaro et al., 2004), and infrastructures such as roads and electricity generation (Kinoshita and Lu, 2006).

Thus, since it is a phenomenon studied in several fields, it is important to identify its Building Blocks (BBs), that is, the determinants of AC, factors that create the capacity to acquire and exploit knowledge from other places as innovation capacity faces several restrictions, especially in emerging economies.

The capacity to absorb on a national level is a function of not just the firms within an economy. It is important to understand that while learning and absorption take place at the firm level, the success or failure of individual firms occurs in orchestration with an entire “system”. Within any system, there exists a broader nonfirm-specific knowledge base within what might best be described as “non-firm actors” that are crucial to a country-level understanding of the process of technological accumulation. Innovation involves complex interactions between a firm and its environment. The environment consists firstly of interactions between firms especially between a firm and its network of customers and suppliers. Secondly, the environment involves broader factors shaping the behaviour of firms: the social and perhaps cultural context; the institutional and organizational framework; infrastructures; the processes which create and distribute scientific knowledge, and so on.

Due to socioeconomic and cultural conditions, it can be argued that emerging economies may require different capacity-building structures that allow the exploitation

of external knowledge, thus allowing the absorption of technology and the recombination of knowledge (Cuervo-Cazurra and Rui, 2017; Kim, 2019).

Considering the aforementioned context, this study aims to identify and validate the building blocks of AC by combining a Systematic Literature Review (SLR) and econometric models for developed and developing countries.

The investigation also identifies possible thresholds of these BBs for both groups. This analysis will enable us to find critical values (thresholds) of the BBs, as well as compare the main blocks and their respective thresholds in developed and undeveloped economies. That is, we intend to analyze if there is a certain point where the Buildings Blocks have a differentiated impact on the AC.

In order to carry this out, a fixed-effect panel threshold model adapted from Girma (2005) and Hansen (2000) was used. This method tests the existence and significance of AC threshold levels in the relationship of productivity growth from foreign investments. Thus, threshold regression allows us to find threshold values of thresholds and analyzes their impact on a given dependent variable.

Classifying the countries into two groups (developed and emerging or developing) enables us to compare the most relevant Building Blocks of each group, as well as their respective thresholds, when in the presence of non-linearity. The idea is to verify whether the most important BBs for developed countries are indeed the most important ones for emerging and developing countries as the groups have different socioeconomic conditions, and therefore, it is assumed that each group has more expressive BBs.

Thus, the main contributions of this paper are to detect the main BBs of AC in developed and developing countries through an SLR as no studies were found that deal with selecting AC BBs in the aforementioned groups, and also adopting the threshold regression approach used by Girma (2005) for countries, in order to verify the thresholds of each determinant selected in the literature, in which there were also no studies that address this topic.

It is noteworthy that papers such as Wu and Hsu (2008), Ghosh and Wang (2010), Wu and Hsu (2012), and Yasar (2013) used the threshold regression method proposed by Girma (2005), where they analyzed whether Foreign Direct Investment is dependent on Absorptive Capacity for county-level economic growth of countries. However, the authors used proxies for Absorptive Capacity and not the method proposed by Girma (2005) to calculate Absorptive Capacity as an efficiency index.

The results to be obtained have direct implications in terms of formulating industrial policies to attract foreign investments, as well as programs to encourage the competitiveness of national industries to increase their total productivity. Specifically, identifying the BBs and possible AC thresholds will provide information to set goals to be achieved prior to a possible foreign investment attraction policy in order to enhance positive productivity spillovers and avoid negative spillovers related to competition for the domestic industry.

This paper is organized into five sections besides the Introduction. In the second section, a theoretical revision of the theoretical antecedents is carried out and the hypotheses are developed. The third section presents the results of the Systematic Literature Review (SLR). In the fourth section, the method is described. In the fifth section, the results and discussions are presented. Finally, the main considerations are found in the sixth section of this paper.

4.2 THEORETICAL BACKGROUND AND HYPOTHESIS DEVELOPMENT

4.2.1 Proxies of Absorptive Capacity

R&D Investments enable innovation and simultaneously allow the internalization of knowledge produced by other sources, especially foreign companies, as the ability of companies to recognize and assimilate new knowledge stems, to a large extent, from the individual capacities of their workers (Murovec and Prodan, 2009; Jiménez-Barrionuevo, García-Morales and Molina, 2011; Shenbarow, 2014; Lichtenthaler, 2016).

Thus, using knowledge and technology from external sources is increasingly a requirement, as these become a vital component of national innovation processes (Grimpe and Sofka, 2008; King and Lakhani, 2011) allowing companies to increase their resource base and adapt to the market (Zahra and George, 2002).

Several authors such as Cohen and Levinthal (1990), Kim (1998), Lane and Lubatkin (1998), Malaguerra (2014) and Zahra and George (2002) define AC as the ability to recognize value and apply it for commercial purposes. Lapan and Bardhan (1973) and Girma (2005) emphasize that companies need a certain level of AC before they can benefit from the technologies developed by other companies.

Most studies typically measure Absorptive Capacity with R&D proxies, therefore ignoring the construct dimensions and its implications for different organizational results. However, according to the definition of AC proposed by the previous authors, possible proxies can be raised as Buildings Blocks by the SLR. Table 11 provides an overview of the various Absorptive Capacity proxies used in previous studies.

Table 11 – Proxies of Absorptive Capacity

Proxies of Absorptive Capacity	**Author(s)/Year**
R&D Activities	Cohen and Levinthal (1989); Mowery et al. (1996); Veugelers (1997); Mangematin and Nesta (1999); Becker and Peters (2000); George et al. (2001); Meeus, Oerlemans and Hage (2001); Stock, Greis and Fischer (2001); Tsai (2001); Petroni and Panciroli (2002); Belderbos et al. (2004); Zahra and Hayton (2008); Murovec and Prodan (2009); Spithoven et al. (2010)
Knowledge Management	Boynton, Zmud and Jacobs (1994); Lenox and King (2004); Shenbarow (2014); Lichtenthaler (2016)
Human capital (investments in technical and academic continuing education/ proportion of technical staff/employee training/employees in R&D/number of researchers)	Mowery and Oxley (1995); Mowery et al. (1996); Luo (1997); Veugelers (1997); Petroni and Panciroli (2002); Muscio (2007); Murovec and Prodan (2009); Mangematin and Nesta (1999)
Number of patents	Mowery et al (1996); Mangematin and Nesta (1999); Ahuja and Katila (2001); George et al. (2001)
Number of research publications	Cockburn and Henderson (1998); Mangematin and Nesta (1999)
Number of R&D laboratories	Mangematin and Nesta (1999); Becker and Peters (2000)
Incentive system	Van Den Bosch, Volberda and De Boer (1999)
Labor productivity	Mukherjee, Mitchell and Talbot (2000)
Human resource Management	Vinding (2006)

Average wages of foreign companies in relation to national companies	Nielsen and Pawlik (2007)
Relative efficiency through Total Factor Productivity - TFP	Girma (2005); Girma, Gorg and Pisu (2008); Girma and Gong (2008)

Source: Expanded by the author from Murovec and Prodan (2009), Jiménez-Barrionuevo, García-Morales and Molina (2011), Shenbarow (2014) and Lichtenthaler (2016)

Table 1 presents the predominance of R&D activities and human capital proxies for measuring AC. R&D activities can be measured by means of investment expenditures, workforce, or professional training; and human capital can be measured through the average years of study or by a certain level of knowledge embodied in the workforce, such as the number of people who studied at a Higher Education level (Murovec and Prodan, 2009; Jiménez-Barrionuevo, García-Morales and Molina, 2011; Shenbarow, 2014; Lichtenthaler, 2016).

Silajdzic and Mehic (2015) affirm the hypothesis that the higher level of technological development enabled by R&D expenditure is associated with a better growth performance among emerging economies and that the positive impact of Foreign Direct Investment (FDI) on economic growth is associated with a higher capacity of knowledge and efficiency.

Thus, the increasing importance of regional markets, improving communication technologies, the flexibility to physically move equipment and people, as well as the qualifications of the workforce and the cost pressure, among others, have led multinationals to increasingly invest in Research and Development (R&D) outside their countries of origin.

Therefore, the BBs of AC in the host country are important for foreign investment to have positive effects and impact on economic growth. However, it is assumed that the most important BBs for the developed countries are not really the most important for the emerging and developing countries as the economies have different socioeconomic conditions. In this context, the first research hypothesis is:

H_1: The most significant Building Blocks of Absorptive Capacity differ for developed and developing economies

4.2.2. Absorptive Capacity Thresholds

No papers were found that deal with the thresholds of possible BBs of AC, but there are articles in which AC thresholds were analyzed as moderators of foreign investment spillover effects on productivity. A paper by Girma (2005) and Yasar (2013) identified the AC thresholds for manufacturing companies, and Wu and Hsu (2008, 2012) for several countries.

Girma´s paper (2005) analyzed whether the effect of FDI on productivity growth depends on the AC using threshold regression techniques. In the manufacturing sectors where the multinationals that exploit technology are predominant, the results point to the presence of non-linearity: the productivity benefit of FDI increases with the AC up to a certain threshold, and thereafter the FDI impact on productivity becomes lower.

Yasar (2013) also adopted the threshold regression method in manufacturing firms. The author analyzed the productive impact of imported capital input, emphasizing its interaction with the Absorptive Capacity. According to the results, the companies with greater AC gain significantly more from importation of foreign capital. The results also suggest a limit for such benefits (threshold). In addition, the productive contribution of skilled labor is significantly higher in companies that import foreign capital. Developing policies to increase absorptive capacity will help companies in developing countries gain benefits associated with imported capital.

Thus, according to the theoretical predictions of the existing literature, the study conducted by Yasar (2013) concludes that the productive impact of imports does not increase monotonously and that the impact is deeper when the level of AC is above a certain limit. Thus, greater AC can enable companies to maximize the benefits associated with new technologies and manufacturing techniques transferred from high-income countries.

Wu and Hsu (2008) also found thresholds for AC. This paper examined whether the effect of FDI on economic growth depends on different internalization capacities. The authors used the following as proxies for AC: Initial Gross Domestic Product (GDP); human capital; and trade volume. The results indicate that initial GDP and human capital are important factors in explaining FDI. It has a positive and significant impact on growth when recipient countries have better levels of initial GDP and human capital. Thus, initial GDP and human capital are important factors for FDI that are consistent with the paper of Blomstrom et al. (1994) and Borensztein et al. (1998). In a similar study, Wu and Hsu

(2012) analyzed the effects of FDI on income inequality, subject to the hypothesis of non-linearity of AC. The results indicate that FDI is detrimental to the income distribution of recipient countries with low levels of AC. In contrast, the results support the view that FDI has little effect on income inequality in the case of countries with better AC.

It is worth noting that the literature points to the need for a certain level of AC to enable countries to benefit from foreign investments (Miguelez and Moreno, 2015; Zhang et al., 2010; Lapan and Bardhan, 1973).

Evidence stresses that AC must present non-linearity on several occasions. As economies have different socioeconomic conditions, and therefore possibly more expressive Building Blocks for economic development, it is believed that the possible thresholds are different for each Building Block. In addition, Buildings Blocks do not represent non-linearity for both groups.

Parallel to this, there is a need to analyze if there are minimum levels (thresholds) of variables considered Building Blocks for the AC, in which they have a positive impact on it. In this context, another hypothesis can be proposed:

H_2: The thresholds of the AC Building Blocks differ for developed and developing economies

4.2.3 Systematic Literature Review (SLR)

In order to identify the possible Building Blocks, we used an SLR. To select scientific publications, the Knowledge Development Process-Constructivist (ProKnow-C) was used, proposed by Tasca et al. (2010) and developed by the Laboratory of Multicriteria Methodologies of Decision Support (LabMCDA), Federal University of Santa Catarina (UFSC). It had already been used in other scientific publications that investigated different contexts of this (Nuernberg et al., 2016; Cardoso, Ensslin and Dias, 2016; Ensslin et al., 2014).

The main objective of ProKnow-C is to provide knowledge about a fragment of scientific literature. To meet the objective, the instrument leads the researcher (i) to select a Bibliographic Portfolio (BP) of scientific and relevant articles that address the research topic, (ii) to carry out research and analysis of some characteristics of this BP, that the process calls BP bibliometric analysis (iii) to reflect critically on the position of the studies based on the theoretical affiliation established by the researcher, which the process

calls systemic analysis, and (iv) to point out the gaps and opportunities of future research, based on the knowledge generated in the previous two stages. All the steps require the researcher's active participation to carry it out. Thus, the constructivist process occurs and evolves based on the interests and delimitations established by the researcher (Ensslin et al., 2014; Silva et al., 2014; Dutra et al., 2015).

In order to meet the objective of the research, 3 out of the 4 main steps of the ProKnow-C process were followed since the purpose of this review is not to analyze points that have not yet been studied by authors, but to analyze the building blocks of absorptive capacity by studies already done.

For the filtering stage of the article bank, an SRL protocol was generated, which can be found in Appendix A including the main information about the research, such as strategies for searching for and selecting primary studies and the criteria and procedures for selecting studies (exclusion/inclusion criteria). Table 12 shows the number of papers selected in the databases.

Table 12 – ProKnow-C Phase - Article Filtering

Criteria for analysis	Scopus	Web of Science
Articles identified with keywords	219	741
Selected papers after summary analysis	55	40
Number of papers shared in both databases	35	
Total articles reviewed	60	

Source: Prepared by the authors (2019)

The set of selected articles presented the following distribution: 18.33% (11 articles) of the sample presented study population at the national level, encompassing several countries (Aldieri, Sena and Vinci, 2018; Foster-McGregor et al., 2017; Khordagui and Saleh, 2016; Huebler, Glas and Nunnenkamp, 2016; Silajdzic and Mehic, 2015; Miguelez and Moreno, 2015; Fracasso and Marzetti, 2014; Elmawazini, 2014; Castillo, Salem and Guasch, 2011; Krammer, 2010; and, Keller, 2010). These mentioned used the panel data structure. From the whole sample, 50 articles (83.3%) used panel data, 5 articles (8.3%) cross-section, and 5 articles (8.3%) were not mentioned, including the latter literature reviews.

Table 13 presents an analysis of the focus and main contributions of the 11 articles that presented the study population at the national level, which is of relevance to this study, since the study populations of this study are emerging and developed countries.

Figure 11 shows the Buildings Blocks of AC according to the literature, classified as: Economic; Human Capital; and, Innovation. They were selected based on the variables used by the authors, mode of measurement of AC, or cited by the articles as Buildings Blocks of AC.

Table 13 – Analysis of the focus and main results/contributions of the 11 articles that presented study populations on a national level

Author(s)/Year	Objective	Buildings Blocks of AC	Limitations/Contributions/Originality
Aldieri, Sena and Vinci (2018)	Explore how firm-level Absorptive Capacity mediates the relationship between rent and R&D spillovers in three economic areas (Europe, Japan, and the USA)	R&D activities and number of patents	This article contributes to the existing literature on absorptive capacity in several ways. First, it shows the nature of knowledge issues and that companies specialize in acquiring and processing specific types of knowledge. Second, it provides a potential explanation of why some companies appear to benefit from some types of spillovers over others and relate these differences to the characteristics of absorbed knowledge. Finally, it provides some suggestive evidence of how the distance from the technological frontier influences the level of absorption of the firm.
Foster-McGregor et al (2017)	Focus on the role of international R&D spillovers by trading intermediary products at the industry level for a broad cross-section of countries, as well as investigating the role of absorptive capacity	Average years of secondary education and R&D expenditure	The current study does not include countries at very low levels of development, which is characterized as a limitation of study. The results also supported studies that found that foreign R&D spillovers are stronger in countries with higher Absorptive Capacity
Khordagui and Saleh (2016)	This paper examines the role of human capital as a factor of absorptive capacity for emerging economies	Average years of schooling for adults over 25 years of age	The contribution of this paper is that the primary, secondary and tertiary sectors are examined and the analysis is expanded to take into account the main components of the sectors
Huebler, Glas and Nunnenkamp (2016)	Identify Absorptive Capacity indicators and their role in South-	Participation of highly qualified labor force; Index of Economic Freedom; Tertiary	The findings of this article on absorptive capacity indicators are relatively advanced for emerging economies

	North convergence through a channel of imported investment goods	education rate; Internet rate; telephone rate; Scientific article rate; Patent fees; Trademark fee; Participation of the service sector; High-tech industry sharing	
Miguelez and Moreno (2015)	To assess the extent to which absorptive capacity determines the impact of knowledge flows on regional innovation	R&D activities	The authors confirmed the results of previous papers, in which both worker mobility and participation in research networks are critical means to transmit knowledge. The impact found is far from homogeneous across the European Union (EU), with more developed regions achieving greater returns from the knowledge flows received by mobile inventors, while less advanced areas rely more heavily on networks.
Silajdzic and Mehic (2015)	To analyze the exogenous impact of FDI in economic growth, as well as to study the influence of technological and innovative capacities on growth performance among economies in transition	R&D Activities; Mobility of workers; Inventor networks	We have contributed to the recent literature using a more reliable measure of FDI, while describing the character of FDI and related knowledge spillovers, as well as examining the importance of technological and innovative capabilities to explain growth performance among transition economies not previously studied.
Fracasso and Marzetti (2014)	To investigate how a country's absorptive capacity and relative backwardness affect the impact of international R&D spillovers on the TFP	Average years of schooling; R&D Activities; FDI	In the paper, we adopted a series of updated econometric measures to make the robust inference in unspecified forms of heteroscedasticity and serial and simultaneous correlation in the data. The authors' knowledge is the first time that this method is used in an applied empirical study.
Elmawazini (2014)	Contribute to the empirical literature by investigating the hypothesis that external direct investment (FDI) flows produced positive productivity spillovers for Gulf	GDP per capita labor productivity; TFP; human capital; technological capacity; Human	The results say that these three areas need further research. In the first place, it would be interesting to repeat the current study, incorporating more developing countries. Secondly, the link between labor productivity and income differences between the GCC and the OECD countries could be another document. Thirdly, the human capital gap between women and men, measured by average years of secondary schooling, should

	Cooperation Council (GCC) countries during the period 1995 to 2011	Development Index (HDI)	also be investigated as a gap between the OECD countries and the GCC.
Castillo, Salem and Guasch (2011)	This paper examines two sources of spillovers of global knowledge: Foreign Direct Investment (FDI) and trade	Activities in R&D; Average years of schooling; FDI	It is suggested that more general policies should be pursued which not only attract FDI but also benefit national enterprises, for example by building modern infrastructures, increasing and strengthening institutions to accelerate and sustain economic growth.
Krammer (2010)	Use the latest developments in the integration and infrastructure techniques of the panel unit to unlink the effects of international spillovers through trade and FDI inflows into Total Factor Productivity (TFP)	Activities in R&D; Average years of schooling; FDI	Current results contribute to the existing literature by looking at 27 former communist economies and quantifying the importance of the spillover channels of these Eastern European and Central Asian countries. New enhancements may consider the use of data in the industry for a better location of spillovers, which tend to cluster in certain industries. Moreover, in the case of countries in transition, their industrial mix has changed significantly throughout the 1990s from industrialized countries to a more balanced economy in which the service sector has grown tremendously. Another interesting line of research could explore the size and dynamics of the indirect effects of spillovers via IDE.
Keller (2010)	To examine how international flows of technological knowledge affect economic performance in industries and companies in different countries	Activities in R&D	Not reported

Source: Prepared by the authors (2019)

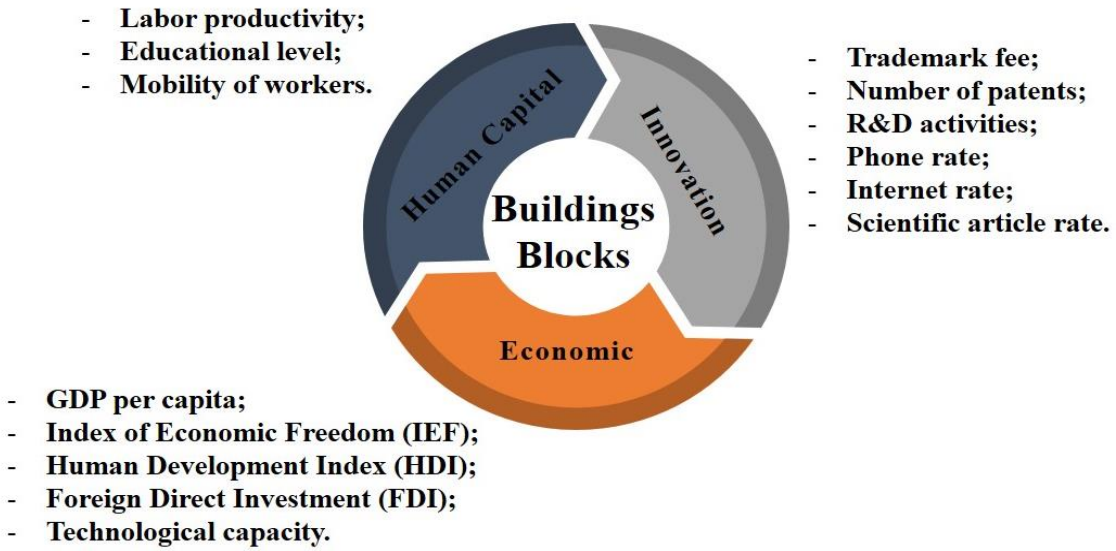


Figure 11 - AC Building Blocks selected by the literature - 11 articles (national level). Source: Prepared by the author (2019)

4.3 METHOD

4.3.1 Data Sources and Group Classification

The classification of countries by the International Monetary Fund divides the world into two groups: developed economies (DE); and emerging and developing economies (EE). We chose to classify the countries into two groups in order to obtain more homogeneous data and to compare the most relevant determinants of each group, as well as their respective thresholds.

According to the International Monetary Fund, 39 countries are considered developed and 151 emerging and developing countries. However, due to the unavailability of data from some countries, the total sample of this paper comprises 34 developed countries and 90 emerging and developing countries for the Total Factor Productivity (TFP) calculation. Data were collected from the World Bank Group for the 1995-2015 time limit. Thus, the study population consists of 124 countries described in Appendix B.

4.3.2 AC estimation

Girma (2005) proposed a new method, measuring the Absorptive Capacity dividing the Total Factor Productivity (TFP) of the previous period divided by the maximum TFP level among all regions as presented in (1). TFP demonstrates why one region is able to produce more than other regions, which can be explained by development and people's average income through the efficient use of inputs. According to Porcile et al. (2005), TFP stands out among productivity multifactor indicators as it identifies the share of output change 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 estimated parameters for TFP prediction followed previous literature that lists Olley and Pakes (1996), Levinsohn and Petrin (2003), Wooldridge (2009), Ackerberg, Caves and Frazer (2015). Although the model by Ackerberg, Caves and Frazer (2015) proposes an improvement of the models by Olley and Pakes (1996), Levinsohn and Petrin (2003) and still presents results with statistical significance, we decided to select the Wooldridge (2009) model for later calculation of the CA. In addition, the ACF model showed great dispersion around the mean. Thus, the AC calculation consists of calculating the relative efficiency that is given by the performance indicator and the maximum value that this indicator can achieve in the sample (Lovell, 1993). Therefore, the AC calculation proposed by Girma (2005) consists of measuring the degree of success of the decision unit through the effort to generate the maximum possible amount of output, from a given set of inputs. Thus, if two countries had the same amounts of physical capital and human capital, and country A could generate more output than "B", it would have a higher per capita income. It is as if the technology of country "A" were superior. Thus, it is assumed that countries that can use their resources more efficiently having a greater AC as they are able to benefit more from foreign investments, which not only brings foreign capital but an improvement in productive capacity. Thus, using the Girma (2005) methodology to calculate the AC is justified, and not only the use of proxies to replace this factor, which may become very limited.

The AC, in turn, is defined as the TFP level in the previous period divided by the maximum TFP level among the countries. The maximum TFP level in countries at time t-1 by TFP*it-1, the country AC can then be expressed as

$$AC_{it} = \frac{TFP_{it-1}}{TFP*_{it-1}} \quad (1)$$

TFP is given as the difference between the change in output and the change in capital and labor stocks. Thus, the TFP intends to indicate the efficiency with which the economy combines the totality of its resources to generate product.

The Solow (1957) model was extended by adding the energy factor and allowing a technical change of factor increase (Azar and Dowlatabadi, 1999; Löschel, 2002; Acemoglu et al., 2012). There are also examples in the relevant literature of modeling approaches that recognize and allow the role of intermediate inputs - namely, energy - to directly impact economic growth (Stern and Kander, 2012).

Thus, Olley and Pakes (1996) introduced a semiparametric method that controls these biases, enabling us to estimate the parameters of the production function consistently and, thus, obtain reliable estimates of productivity. Later, based on a paper by Olley and Pakes (1996), Levinsohn and Petrin (2003) developed an estimator that uses intermediate inputs to represent the term of unobservable productivity.

In view of this, several adaptations and extensions for the Olley and Pakes estimator were developed. Ackerberg, Caves and Frazer (2015) suggest an alternative two-step estimator where all relevant parameters are recovered in the second stage. They found the regression was better by adding polynomial to it. Wooldridge (2009), on the other hand, focuses on the inefficiencies associated with the two-step estimation procedure of existing methodologies and proposes a structure in which estimates of the production function can be obtained in a single step. Its structure allows the temporal assumptions of the original semiparametric estimators and the adapted structure of Ackerberg, Caves and Frazer (2015).

Thus, in this paper the three methods to calculate the TFP to analyze the best fit of the models were tested: Levinsohn and Petrin (2003); Wooldridge (2009); and, Ackerberg, Caves and Frazer (2015). Intermediate input was used per capita energy consumption as indicated in the literature.

In order to calculate the country TFP, the variables in Table 14 were selected for the four aforementioned methods.

Table 14 – Variables to calculate the TFP

Variables	Definition
Constant GDP (Dependent variable)	GDP at purchaser prices is the sum of the gross value added by all resident producers in the economy plus any taxes on products and less any subsidies not included in the value of the products. It is calculated without deducting depreciation of manufactured goods or by the depletion and degradation of natural resources. The dollar to GDP values is converted from national currencies using the official 2010 exchange rates (World Bank Group, 2017).
Economically Active Population	Proportion of the population aged 15 or over who is economically active: all persons providing labor for the production of goods and services during a specific period (World Bank Group, 2017)
Electricity consumption (kWh per capita)	Electricity consumption measures the production of power plants and combined heat and power plants, minus transmission, distribution and transformation losses, and own use by power and heating plants (World Bank Group, 2017).
Gross Fixed Capital Formation (% of GDP)	Gross fixed capital formation includes land improvements (fences, trenches, drains and so on); purchase of machinery, equipment and equipment; and construction of roads, railroads, and the like, including schools, offices, hospitals, private residences and commercial and industrial buildings (World Bank Group, 2017).

Note: Data are in US dollars for constant GDP and Gross Fixed Capital Formation. *The variable Gross Fixed Capital Formation was depreciated at an annual rate of 10% as used in the literature. Source: World Bank Group (2017)

The data for the TFP calculation were extracted from The World Bank website for 1995-2015. Only per capita electricity consumption data for 2015 were extracted from the CIA World Factbook website.

4.3.3 AC Building Blocks

The threshold regression requires a balanced panel data for estimation. Thus, we selected only countries with all available data in the selected sample, which resulted in a panel data of 45 countries (23 developed and 22 emerging) ranging from 2007 to 2015. The countries analyzed for both groups are shown in Appendix C.

The data of AC Building Blocks found in the SLR are secondary and were extracted from the Index of Economic Freedom, The Global Competitiveness Report, The World Investment Report, the World Bank Group, and the Human Development Report. The Building Blocks defined for analysis are shown in Table 15.

Table 15 – Explanatory and threshold variables

Pillar	Building Blocks	Definition
Innovation	BB1 - Investments in R&D (% GDP) – *ln_R&D*	Research and Development (R&D) internal expenditures, expressed as a percentage of GDP. They include capital and current expenditure in the four main sectors: business, government, higher education and private non-profit. R&D covers basic research, applied research and experimental development (World Bank Group).
Human Capital	BB2 - School enrollment, secondary (% gross) – *ln_SecEdu*	The gross enrollment ratio is the ratio of total enrollments, regardless of age, to the population of the age group that officially corresponds to the level of schooling shown. Secondary education completes the provision of basic education that began at the primary level and aims to lay the foundations for lifelong learning and human development by offering more subject-oriented instruction or skill using more specialized teachers (World Bank Group).
Human Capital	BB3 - Higher Education – *ln_HigherEdu*	This pillar measures enrollment rates in secondary and higher education, as well as the quality of education assessed by business leaders. Extension of staff training is also taken into account because of the importance of continuing vocational training at work - which is neglected in many economies - to ensure a constant improvement in workers' skills (The Global Competitiveness Report).
Human Capital	BB4 – Government expenditure on education, total (% of GDP) – *ln_EduExpend*	General government expenditure on education (current, capital, and transfers) is expressed as a percentage of GDP. It includes expenditure funded by transfers from international sources to the government. General government usually refers to local, regional and central governments (World Bank Group).
Economic	BB5 – Index of Economic Freedom (IEF) – *ln_IEF*	Economic freedom is the fundamental right of every human being to control his/her own work and property. In an economically free society, individuals are free to work, produce, consume and invest in whatever way they want. In economically free societies, governments allow labor, capital and goods to move freely, and refrain from coercion or restriction of freedom beyond the extent necessary to protect and maintain one's freedom. The IEF measures economic freedom based on 12 quantitative and qualitative factors, grouped into four broad categories, or pillars, of economic freedom (Index of Economic Freedom).
Economic	BB6 - Foreign Direct Investment (FDI) – million dollars – *ln_FDI*	Any subsidy from outside that is applied in the domestic productive structure of a country (World Investment Report).
Economic	BB7 – Infrastructure Index – *ln_Infra*	Index of effective modes of transport, including roads, railways, ports and high quality air transport. Savings also depend on electricity supplies that are free from disruption and scarcity, so that companies and factories can work without restrictions. Finally, a robust and extensive telecommunication network enables rapid and free flow of information (The Global Competitiveness Report).
Economic	BB8 – Human Development Report (HDI) – *ln_IDH*	The Human Development Index (HDI) is a comparative measure used to rank countries by their degree of "human development" and to help classify countries as developed (very high human development), developing (medium and high human development) and underdeveloped (low human development). Statistics comprise life expectancy data at birth, education and per capita GDP (as an indicator of the standard of living) collected at the national level (Human Development Report).

As for Human Capital, the variables School enrollment, secondary (% gross), Higher Education, and Government expenditure on education, total (% of GDP) were collected to represent this pillar. However, for group 2, only the variable Higher education was collected due to unavailability of data for undeveloped countries.

For the Innovation pillar, the variable R&D activities was selected for both groups to represent the BB of this pillar. The variables Trademark fee, Number of patents, Phone rate, Internet rate, and Scientific article rate were also collected, but due to the high correlation with the other variables proposed as BB, we decided to select R&D activities as it is the most cited proxy for AC in the literature.

For the Economic pillar, the Index of Economic Freedom (IEF), Human Development Index (HDI) and Foreign Direct Investment (FDI) were collected to represent the BBs of this pillar. The GDP per capita variable was also collected, however due to the high correlation with the other variables of the model we chose not to use it. For the variable Tecnological capacity, the variable Infrastructure Index for proxy of this BB was collected. Table 16 presents the BBs' descriptive statistics.

Table 16 – Descriptive statistics of Building Blocks

Building Blocks	**Group**	**mean**	**min**	**max**	**sd**
BB1 - Investments in R&D (% GDP) – *ln_R&D*	DE	0.0211268	0.0038601	0.0440546	0.0104961
	EE	0.0066445	0.0004518	0.0206558	0.0040611
BB2 - School enrollment, secondary (% gross) – *ln_SecEdu*	G1	109.6565	90.66246	163.9305	16.07739
	G2	-	-	-	-
BB3 - Higher Education – *ln_HigherEdu*	G1	5.301208	4.37	6.27	0.4264256
	G2	4.256566	3.35	5.04	0.3470972
BB4 – Government expenditure on education, total (% of GDP) – *ln_EduExpend*	G1	5.485551	3.3	8.55955	1.100235
	G2	-	-	-	-
BB5 – Index of Economic Freedom (IEF) – *ln_IEF*	G1	71.54348	62.1	82.6	4.315792
	G2	59.95404	44.1	71.7	6.234451
BB6 - Foreign Direct Investment (FDI) – *ln_FDI*	G1	27650.67	50	379894	53414.36
	G2	18582.87	14	135610	27496.88
BB7 – Infrastructure Index – *ln_Infra*	G1	5.345507	3.64	6.65	0.70985
	G2	3.833838	2.43	5.31	0.5918743
BB8 – Human Development Report (HDI) – *ln_IDH*	G1	0.8806184	0.804	0.949	0.0336865
	G2	0.7476212	0.556	0.855	0.060245

Note: G1 – Developed countries; G2 – Developing and emerging countries

4.3.4 Econometric models and estimation strategy

The Panel Threshold Regression model was introduced by Hansen (1999). In this paper, threshold regression methods are developed for panels with fixed effects (Hurlin, 2018).

Thus, for analysis of AC thresholds, equation (2) was applied.

$$AC = \beta_i{}'X_{it} + \sum_{i=1}\beta_i BB_i + \beta_k BB_{kt} I(BB_K \leq \lambda) + \beta_k BB_{kt} I(BB_k > \lambda) + \alpha_i + \varepsilon_i \quad (2)$$

Where,

X are country-level control variables; BB_i are the Building Blocks selected through the literature review; BB_k is the Building Block subject to the nonlinearity hypothesis; *I(.)* is the indicator function; λ is the Threshold for the Absorptive Capacity of each Building Block; α_i is the fixed effect; and, $\mathcal{E}_{ij}$ is the stochastic disturbance.

Specifically, several variables were elected as possible country-level controls, such as: Exports of goods and services (% of GDP), High-technology exports, Patent applications, Number of scientific and technical journal articles, and, GDP per capita. However, due to the high correlation with the selected Building Blocks, they were not set in the econometric model in order to avoid multiconlinearity. The correlation matrix of the variables is given in Appendix D.

We estimate a fixed-effect panel threshold model based on the method proposed by Hansen (2000), by fitting the fixed-effect panel threshold model given the threshold estimator, which requires a balanced panel data (Wang, 2015). In addition, the computations to be presented use robust estimates to heteroscedasticity.

In 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 residuals (SSR), 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 lowest SSR, as presented in (3).

$$\hat{\alpha} = \arg_{\alpha} \min S(\alpha) \quad (3)$$

Therefore, Girma (2005) proposes the use of quantiles of the threshold variable to calculate the threshold values resulting in 393 quantiles. After computing the parameter, it is necessary to test the threshold effect, i.e., if there are actually two regimes for the regime-dependent variable according to the threshold variable. This is done by testing the null hypothesis ($H_0: \alpha_1 = \alpha_2$) using likelihood ratio test statistics and their bootstrapped p-values on 150 replications for each estimation.

4.4 RESULTS AND DISCUSSION

A Feasible Generalized Least Squares (FGLS) data panel was estimated, which incorporates an AR(1) structure into the stochastic disturbance, and heteroscedasticity robust white residuals, considering that heteroscedasticity was detected in the model according to the White and Breusch-Pagan tests, and autocorrelation by the Wooldridge test (2002). Moreover, evidence of multicollinearity was found as mean Variance Inflation Factors (VIF) presented values of 2.64 and 1.51 for groups G1 and G2's chosen model, respectively.

Alternative model specifications were suggested by adding and subtracting variables as shown in Table 17. Some variables were lagged in one year for the theoretical adequacy of the model.

Table 17 - Models estimated by FGLS - G1 and GMM - G2

Building Blocks	Pillar	Model 1 – G1	Model 1 – G2 (instrumented FDI)	Model 2 – G1	Model 2 – G2	Model 3 – G1	Model 3 – G2	Model 4 – G1	Model 4 – G2
ln_R&D	Innovation	0.0094***	0.0089***						
ln_R&D(t-1)				0.0111***	0.0103***	0.0124***	0.0074***	0.0116***	0.0094***
ln_SecEdu	Human Capital	0.0183***		0.0134***		0.0177***			
ln_SecEdu(t-1)								0.0081	
ln_HigherEdu		0.0287***	-0.0024	0.0171**	-0.0285	0.0164*	-0.0022	0.0144	0.0257
ln_EducExpend		0.0281***		0.0271***					
ln_EducExpend(t-1)						0.0277***		0.0271***	
ln_IEF	Economic	-0.0159	-0.0316	-0.0002	-0.0127	-0.0033	-0.0338	-0.0014	-0.0347
ln_FDI		0.0004*	0.0136***	0.0003*	0.0154***	0.0005**		0.0005*	
ln_FDI(t-1)							0.0129***		0.0126***
ln_Infra		0.0295***	0.0404***	0.0300***	0.0505***		0.0414***		
ln_Infra(t-1)						0.0179**		0.0202***	0.0209*
ln_IDH		0.1029***	0.1349***	0.1219***	0.1780***	0.1142***	0.1369***	0.1385***	0.1313***
Cons		-0.6090***	-722.3849	-0.6086***	-0.0781	-0.6011***	-0.0254	-0.5550***	-0.0224
BIC		-1066.612	-744.5783	-950.882	-733.8202	-955.8988	-722.5892	-955.8624	-719.0044
VIF		2.64	1.57	2.65	1.57	2.68	1.58	2.68	1.58

Consider: * p <0.1; ** p <0.05; *** p <0.01

According to Table 7, some models were estimated by FGLS. To compare the goodness-of-fit of each model, the Bayesian Information Criteria (BIC) was applied. The results show that according to the information criterion analysis, model 1 presents the best goodness-of-fit results for G1 (BIC = -1066.612) and G2 (BIC = -744.5783).

Regarding the analysis of potential endogeneity, a fixed-effect GMM model was estimated (Mark, 2005). The C statistic (inference from two Sargan-Hansen statistics) indicates that the explanatory variables are exogenous, with the exception of the FDI variable for G2 that was endogenous. Thus, the issue was corrected by instrumenting FDI with its lagged value following (Kwok and Tadesse 2006; Dang, 2011).

4.4.1 General remarks about BBs

According to Table 9, the BB R&D Investments, which represents the Innovation pillar, has a positive impact on AC for G1. The one-year lagged R&D presented in model 2 was statistically significant at 1%, where the 1% increase in R&D has a 0.01% impact on AC. Thus, the time lag of R&D investments is statistically significant to explain AC. For G2, the BB R&D Investments also had a positive impact on AC, but with slightly lower elasticity.

The results corroborate the literature that states that investments in R&D enable innovation and at the same time allow the internalization of knowledge produced by other sources, especially foreign companies (Murovec and Prodan, 2009; Jiménez-Barrionuevo et al., 2011; Shenbarow, 2014; Lichtenthaler, 2016).

It can be said that some developing countries with robust infrastructure, highly trained workforce, reasonable intellectual property protection - especially in Asia and the Pacific - have attracted R&D FDI. The increasing importance of regional markets, improved communication technologies, the flexibility to physically move equipment and people, as well as workforce qualification and cost pressure, among others, have led multinationals to invest increasingly in Research and Development (R&D) outside their home countries.

Another BB is the Number of enrollments in secondary education that represents one of the variables of the Human Capital pillar. According to the results, this BB has a statistical significance at 1% with AC.

Another variable for Human Capital is the Higher Education Index, which measures the quality of education assessed by business leaders. Thus, companies invest

directly in AC when they send their staff for training at advanced levels, because an organization's AC depends on the individuals who are at its interface and external environment, or at the interface between subunits within the organization (Schmidt, 2005).

These results corroborate the research by Huebler, Glas and Nunnenkamp (2016) which states that the resulting improvement in existing knowledge makes it easier to absorb new technologies.

For G2, the Higher Education Index variable was not statistically significant. China stands out as all higher education has grown substantially, while other countries have not been able to catch-up. However, developing countries have difficulties with quality control. Science & Engineering Indicators (2018) report highlights that Americans retain leadership in many aspects of scientific production, but have been losing ground in world competition, especially for developing countries. Brazil, for instance, ranks 12th among the countries with the largest number of published papers, with 53,000 articles in 2016 - the Chinese in the same year had 426,000 publications. Brazil has seen a significant increase in the number of articles published, nevertheless it is far behind the emerging economies in the top ten, and investments in science and technology have been falling sharply in recent years.

Thus, scientific and technological development depends on continued, permanent investment, and it is essential to define national priorities, as China defines in some sectors. Countries that are betting on continued and permanent investment, with consolidated policy, are advancing. Brazil had a beginning in this issue and, although there were many difficulties, was in a growing process. Unfortunately, Brazil, such as other developing countries, has seen a deconstruction of this aspect.

Another variable for Human Capital is government expenditure on education. According to Schmidt (2005), the more training an employee receives, the greater his or her ability to assimilate and use new knowledge. As AC depends on employees, the level of education, experience, and training has a positive influence on companies' AC level.

As the literature points out, companies 'abilities to recognize and assimilate new knowledge largely derive from their workers' individual capacities (Schmidt, 2005; Leiponen, 2005; Murovec and Prodan, 2009; Jiménez-Barrionuevo et al., 2011; Shenbarow, 2014; Lichtenthaler, 2016).

Regarding the BB Economic Freedom Index (EFI), it did not present statistical significance with AC for both groups. It can be said that in economically free societies,

governments allow labor, capital and goods to move freely, and this freedom to do business, even in technology-oriented areas, facilitates innovation and adoption of new technologies, However, the index representing economic freedom does not appear to affect country-level AC.

Another Building Block analyzed is the FDI, which had a positive impact on AC for both groups. The 1% increase in government expenditure on education has an impact of 0.0004% and 0.014% on AC for G1 and G2, respectively. This result corroborates the literature that states that foreign investments affect the AC of countries (Dupasquier and Osakwe, 2003; Alfaro et al., 2004; Bevan and Estrin, 2004; Bevan et al., 2004; Kim, 2015; Girma, 2005; Anyanwu, 2006; Ayanwale, 2007; Dikova and Van Witteloostuijn, 2007; Abor et al., 2008; Ying-Chun, Shuxian e Qian, 2009; Kalotay, 2010; Holtbrügge and Kreppel, 2012; Inekwe, 2013; Estrin and Uvalic, 2016; Li-Ming, Rui and Rui, 2016; Padilla-Perez and Nogueira, 2016; Ubeda and Pérez, 2017; Owusu-Nantwi and Christopher Erickson, 2019).

Regarding the Infrastructure Index of the countries in which it had a positive impact, the 1% increase in the index value has an impact of 0.029% and 0.040% for G1 and G2 on AC, respectively. It can be said that countries with robust infrastructure, highly trained workforce and reasonable intellectual property protection benefit from the opportunities arising from the growing demand of multinationals for inexpensive talent and developing markets. The country's infrastructure considered the relevance of the availability and quality of local production, physical distribution efficiency, finance-related services, marketing and distribution.

Another variable analyzed is the HDI of the countries in which it had a positive impact. The 1% increase in the value of the index has an impact of 0.10% and 0.13% of G1 and G2 on AC, respectively. Thus it can be said that countries that can absorb more knowledge are also those that can achieve higher life expectancy, higher education and higher incomes.

The results found for the group Building Blocks accept H_1: the most significant Building Blocks of Absorptive Capacity differ for developed and developing economies. For both groups, the R&D Investment, FDI, Country Infrastructure Index, and HDI variables can be considered Buildings Blocks for AC.

However, for G1, BB also considers the Number of secondary education enrollments, the Higher Education Index and the percentage of GDP spent on higher

education, which are the three variables classified in the Human Capital Pillar. It is noteworthy that the EFI variable was not detected as an AC BB in any of the groups.

Thus, for the Innovation pillar, R&D Investments are considered as a BB for both groups. For the Human Capital pillar, the Number of Secondary Enrollment, the Higher Education Index, and the percentage of GDP spent on higher education are reported as BB for G1, and for G2, the Higher Education Index is said as BB. Finally, for the Economic pillar, the FDI, the country's Infrastructure Index, and the HDI are rated as BB for both groups.

4.4.2 AC Threshold Analysis

Model 1, which was chosen by the BIC Information Criterion, was applied to analyze the nonlinearity of Groups 1 and 2 respectively, through a fixed-effect threshold regression model according to Tables 18 and 19, respectively.

Table 18 – Thresholds of each Building Block - G1

AC	ln_R&D	ln_SecEdu	ln_HigherEdu	ln_EducExpend	ln_IEF	ln_FDI	ln_Infra	ln_HDI
ln_R&D		0.0102***	0.0090***	0.0066**	0.0096***	0.0087***	0.0070**	0.0079***
ln_SecEdu	0.0123**		0.0133**	0.0187***	0.0143***	0.0143**	0.0122**	0.0207***
ln_HigherEdu	0.0044	0.0098		0.0166	0.0151	0.0212**	0.0148	0.0162
ln_EducExpend	-0.0070*	-0.0103**	-0.0067*		-0.0071*	-0.0070*	-0.0077*	-0.0069*
ln_IEF	-0.0211	-0.0295**	-0.0299**	-0.0352***		-0.0360**	-0.0335**	-0.0302**
ln_FDI	0.0006**	0.0006**	0.0005**	0.0008***	0.0006**		0.0005*	0.0158**
ln_Infra	0.0256***	0.0138**	0.0180***	0.0150**	0.0177***	0.0151**		0.0005*
ln_HDI	-0.0621*	-0.0442	-0.0739*	-0.0516	-0.0650*	-0.0653*	-0.0524	
Cons	-0.1015	0.0797	-0.0338	-0.0785	0.0163	-0.0419	-0.0291	-0.0939
Threshold	-5.4026***	4.7424***	1.5994***	1.9081***	4.3215***	10.5935***	1.4061***	-0.1020***
<Threshold	0.0071**	-0.0110	-0.0030	-0.0010	-0.0483***	0.0002	0.0064	-0.0664*
>Threshold	0.0053*	-0.0094	-0.0007	-0.0039	-0.0472***	0.0005*	0.0095	-0.0093

Consider: * p <0.1; ** p <0.05; *** p <0.01

Table 19 – Thresholds of each Building Block – G2

AC	ln_R&D	ln_HigherEdu	ln_IEF	ln_FDI	ln_Infra	ln_HDI
ln_R&D		-0.0005	-0.0013	-0.0014	-0.0020*	-0.0012
ln_HigherEdu	-0.0057		-0.0098	-0.0054	-0.0033	0.0036
ln_IEF	-0.0001	0.0035		0.0036	0.0108	0.0069
ln_FDI	-0.0013**	-0.0015***	-0.0009*		-0.0008	-0.0012**
ln_Infra	0.0216***	0.0208***	0.0217***	0.0230***		0.0223***
ln_HDI	0.1463***	0.1314***	0.1407***	0.1320***	0.1480***	
Cons	-0.0357	-0.0268	-0.1073**	-0.0806	-0.1177**	-0.1077**
Threshold	- 7.2178***	1.3029***	4.2327***	7.3796***	1.3661***	- 0.5430***
<Threshold	-0.0004	-0.0426***	0.0139	0.0001	0.03212***	0.1237***
>Threshold	0.0015	-0.0306***	0.0119	-0.0006	0.0277***	0.1005***

Consider: * p <0.1; ** p <0.05; *** p <0.01

R&D investment BB was statistically significant for both regimes regarding G1. It is worth noting that one of the most recent points emphasized in the economic literature about multinational companies is the increasing internationalization of their R&D efforts.

Cantwell (1995) provides evidence that the internationalization of R&D was pioneered by leading companies in their respective fields and, thus responded to the internationalization process of capital. Therefore, the consequence was the need to adapt processes, products and materials to the set of externally developed activities.

Indeed, R&D activities are becoming increasingly decentralized and are being carried outside the company's home country. Although production, marketing and distribution activities are much more internationalized than technology activities, the internationalization of R&D deserves special attention (Fernandes, 2008). Seeking to take advantage of market opportunities and advantages granted by certain countries, internationalizing companies has been particularly intense in recent decades.

Thus, R&D activities are included in the feasibility and relevance assessment process to be performed internally or externally. Although the EU is threatened by internal and external economic problems, investment in R&D in general appears not to have been greatly affected. Consistent with the international trend, the EU is expanding collaborations with Asian countries, especially with China. Therefore, according to the results presented, investments in R&D internally are recommended up to a certain point, making the internationalization of R&D activities of these countries important.

Regarding G2, R&D investment BB did not present statistical significance according to the threshold test. Therefore, it can be said that R&D Investments can be considered a BB for AC of emerging and developing countries, although it does not present a nonlinearity for G2.

However, it is worth mentioning China for G2. While the country's economy has grown between 9% and 10% in recent years, investments in R&D have increased by around 12%. China has achieved significant gains in total patents and scientific articles. The government facilitates tax deductions for R&D investments, and local governments have created monetary awards for inventors of patented products outside of China, with smaller awards for Chinese patent holders. China has made efforts to make academic standards more consistent with western counterparts and there are also cash incentives for authors of impact articles in the country. In addition, the country's government encourages the transfer of R&D achievements to commercial and production practices for faster economic returns.

The growth of the R&D sector in Asian countries reflects the rapid economic growth, the large population and the formation of more scientists and engineers. Partnerships from research organizations with other countries has proved to be an advantage for Asian developing economies, as well as for developed countries. Close partnership has been established between the US and South Korea in various technology areas and also with India in the development of clean technology.

For G1, no statistically significant nonlinearity was found for BBs in the Human Capital pillar - Number of secondary school enrollments; Higher Education Index; and percentage of GDP spent on higher education. Thus, it can be said that although these variables did not present nonlinearity, they are pointed out as BBs for AC. For G2, the variable analyzed for the Human Capital pillar was the Higher Education Index, which presented statistical significance, however with a negative sign. According to the literature, companies' abilities to assimilate new knowledge derive largely from the individual capacities of their workers (Murovec and Prodan, 2009; Jiménez-Barrionuevo, García-Morales and Molina, 2011; Shenbarow, 2014; Lichtenthaler, 2016).

In relation to the Economic pillar, the FDI for G1 stands out, presenting statistical significance for the regime above the threshold value ($ 3,987,481 - million), in which the impact of the FDI is approximately 0.0005% on AC, with a 1% increase. For G2, the FDI BB showed no nonlinearity.

World Investment Report indicators can be interpreted not only as short-term data, but also as structural changes in the global economic scenario, with developing economies becoming more relevant in the world economy rather than the falling centrality of developed country economies, mainly from the European region.

This structural change provides opportunities for greater insertion of countries in developing economies as the source and output of the FDI. Another relevant point is that China's rise in the world economy presents a new alternative for developing countries to build new trade and political relations, reducing the centrality and dependence on the United States, as has been the strategy adopted in recent years by Brazil (Lima and Oliveira, 2015). Therefore, there is a linearity of FDI BB with AC, especially for emerging and developing countries.

Another BB that stands out is the Infrastructure Index, which showed significance for both regimes for G2. For G1, no nonlinearity was detected. Above the threshold (3.6 - index) for G2, the 1% increase has an impact of 0.027% on AC, and below the threshold, the 1% increase on BB has a 0.032% impact on AC. Therefore, according to the results,

there is a point where the impact of Infrastructure on AC becomes smaller due to the inefficiencies of undeveloped countries to benefit from improved infrastructure.

Inadequate infrastructure can often be said to result in obstacles and other inefficiencies that create social discontent and barriers to growth and development. Investment in infrastructure boosts production capacity, improves competitiveness and expands export capacity. Well-planned infrastructure can also help countries better prepare for natural disasters and climate risk.

Finally, BB HDI presented both regimens with statistical significance for G2. The results indicate that there is a certain point (0.58 - HDI index) where the impact on AC becomes a little smaller.

The results found for the Thresholds accept to H_2: The thresholds of the AC Building Blocks differ for developed and developing economies. For G1, the Innovation pillar stands out, with BB Investments in R&D with nonlinearity. For G2, the Economic pillar stands out, with the BBs Country Infrastructure Index and HDI showing nonlinearity.

4.5 FINAL CONSIDERATIONS

This study aimed to verify AC Building Blocks by combining Systematic Literature Review and econometric models for developed and developing countries. The study also identified possible thresholds for these Building Blocks using the panel data Threshold Regression model. This analysis enabled us to find critical values (thresholds) of BBs, as well as to compare the main blocks and their respective thresholds in developed and developing economies.

The main contributions of this paper were to detect the main Building Blocks of AC in developed and developing countries through the SLR, since there were no studies that dealt with the selection of AC BBs in the aforementioned groups, and also in the adoption of the threshold regression approach used by Girma (2005) for countries, in order to verify the thresholds of each determinant selected in the literature.

For the BB analysis, the results confirm H_1: the most significant Building Blocks of absorptive capacity differ for developed and developing economies. For both groups, the R&D Investment, FDI, Country Infrastructure Index, and HDI variables can be considered Buildings Blocks for AC. However, for G1, BB also considers the Number of secondary education enrollments, the Higher Education Index and the percentage of GDP

spent on higher education, these three variables classified in the Human Capital Pillar. It is noteworthy that the EFI variable was not detected as an AC BB in any of the groups.

Thus, for the Innovation pillar, R&D Investments are considered as a BB for both groups. For the Human Capital pillar, the Number of Secondary Enrollment, the Higher Education Index, and the percentage of GDP spent on higher education are reported as BB for G1, and for G2, the Higher Education Index is said to be BB. And finally, for the Economy pillar, the FDI, the country's Infrastructure Index, and the HDI are rated as BB for both groups.

For the threshold analysis, the results also confirm H_2: the thresholds of the AC Building Blocks differ for developed and developing economies. For G1, the Innovation pillar stands out, with BB Investments in R&D with nonlinearity. For G2, the Economic pillar stands out, with the BBs Country Infrastructure Index and HDI showing nonlinearity.

Therefore, it can be argued that the most significant BBs for developed countries are in fact not the most important for emerging and developing countries as groups have different socioeconomic conditions, and therefore it is assumed that each group has more expressive BBs.

4.5.1 Implications for policy and practice

In terms of policy implications, the results suggest that formulators should develop strategies to increase human capital in areas where foreign companies are located. In addition, the FDI policy strategy should consider areas that the country is aware of to improve its productive structure, as available knowledge and foreign investment can improve a diversified structure by providing valuable and technological goods and achieving international competitiveness.

The results to be obtained have direct implications for the formulation of industrial policies to attract FDI, together with programs to encourage the competitiveness of national industries, in order to increase their total productivity. Specifically, identifying BBs and thresholds makes it possible to define goals to be achieved prior to a possible FDI attraction policy, so as to enhance positive productivity spillovers and avoid negative competition-related spillovers for the domestic industry.

Although the results are in agreement with the literature, the study has some limitations. Threshold regression requires a balanced panel for estimates, accordingly

only countries with all available data were selected in the selected sample, which ultimately limited the number of countries analyzed, especially developing countries, whose data are scarce. Another limitation is the use of control variables in the econometric model which was limited due to the high correlation with the other variables of the model. In order to avoid the problem of multicollinearity, their use was limited.

As suggestions for future studies, we propose comparing Girma's (2005) AC calculation method with other AC proxies, such as R&D activities (Cohen and Levinthal 1989; Mowery et al. 1996; Petroni and Panciroli 2002; Murovec and Prodan 2009) and human capital (Elmawazini 2014; Huebler et al. 2016), which are the most cited in the literature.

Another suggestion is to find critical AC values, subject to the hypothesis of non-linearity of the FDI, in order to maximize the positive spillover effects from the FDI on country productivity.

REFERENCES

Abor, J., Adjasi, C. K. D., Hayford, M. C. 2008. How does foreign direct investment affect the export decisions of firms in Ghana? Africa Development Review, 20(03), 446-465.

Acemoglu, D., Aghion, P., Bursztyn, L., Hemous, D. 2012. The environment and directed technical change. American Economic Review, 02(01), 131–166.

Ackerberg, D., Caves, K., Frazer, G. 2015. Identification Properties of Recent Production Function Estimators. Econometrica, 83(06), 2411-2451.

Aghion, P.; Howitt, P. 1998. Endogenous growth theory. Cambridge, MA: MIT Press.

Ahuja, G., Katila, R. 2001. Technological acquisitions and the innovation performance of acquiring firms: A longitudinal study. Strategic Management Journal, 22(03), 197-220.

Akinlo, A. E., Adejumo, O. O. 2016. Determinants of Total Factor Productivity Growth in Nigeria, 1970–2009. Global Business Review, 17(02), p.257-270.

Aldieri, L., Sena, V., Vinci, C. P. 2018. Domestic R&D spillovers and absorptive capacity: Some evidence for US, Europe and Japan. International Journal of Production Economics, 198, 38-49.

Alfaro, L., Chanda, A., Kalemli-Ozcan, S., Sayek, S. 2004. FDI and economic growth: the role of local financial markets. Journal of International Economics, 64, 89–112.

Alvim, C. F. 2009. A produtividade dos Fatores em Alguns Países. Economia & Energia, n.73.

Anyanwu, J. 2006. Promoting of investment in Africa. African Development Review, 18(1), 42-71.

Apriliyanti, I. D., Alon, I. 2017. Bibliometric analysis of absorptive capacity. International Business Review, 26(05), 896-907.

Arazmuradov, A., Martini, G., Scotti, D. 2014. Determinants of total factor productivity in former Soviet Union economies: A stochastic frontier approach. Economic Systems, 38(01), p.115-135.

Ascani, A., Gagliardi, L. 2015. Inward FDI, and local innovative performance. An empirical investigation on Italian provinces. Review of Regional Research, 35(01).

Ayanwale, A. B. 2007. FDI and Economic Growth: Evidence from Nigeria. African Economic Research Consortium Paper 165, Nairobi.

Ayres, R. U., Warr, B. 2010. The Economic Growth Engine: How Energy and Work Drive Material Prosperity. Edward Elgar Publishing, Cheltenham, UK.

Azar, C., Dowlatabadi, H. 1999. A review of technical change in assessment of climate policy. Annual Review of Energy and the Environment, 24(01), 513–544.

Balasubramanyam, V. N., Salisu, M., Sapsford, D. 1996. Foreign direct investment and growth in EP and IS countries. The Economic Journal, 106, 92–105.

Barrios, S., Strobl, E. 2002. Foreign direct investment and productivity spillovers: Evidence from the Spanish experience. Weltwirtschaftliches Archiv, 138(03), p.459-481.

Barro, R, J., Sala-i-Martin, X. 1997. Technological diffusion, convergence, and growth. The Journal of Economic Growth, 02, p.01–27.

Becker, W., Peters, J. 2000. Technological opportunities, absorptive capacities and innovation. Paper presented at the Eighth International Joseph A. Schumpeter Society Conference, Centre for Research in Innovation and Competition (CRIC), Manchester.

Belderbos, R., Carrew, M., Lokshin, B. 2004. Cooperative R&D and firm performance. Research Policy, 33, 1477–1492.

Bevan, A. A., Estrin, S. 2004. The determinants of foreign direct investment into European transition economies. Journal of Comparative Economics, 32, 775–787.

Bevan, A. A., Estrin, S., Meyer, K. 2004. Foreign investment location and institutional development in transition economies. International Business Review, 01, 43–64.

Blalock, G., Simon, D. H. 2009. Do all firms benefit equally from downstream FDI? The moderating effect of local suppliers' capabilities on productivity gains. Journal of International Business Studies, 40(07), 1095-1112.

Blomstrom, M., Lipsey, R. E., and Zejan, M. 1994. What explains developing country growth? In Baumol, W.; Nelson, R.; Wolff, E. (eds.), Convergence and Productivity: Gross-National Studies and Historical Evidence, 246–262, Oxford: Oxford University Press.

Borensztein, E., De Gregorio, J., Lee, J. W. 1998. How does foreign direct investment affect economic growth? Journal of International Economics, 45, 115–135.

Boynton, A. C, Zmud, R. W., Jacobs, G. C. 1994. The influence of IT management practice on IT use in large organizations. MIS Quarterly Review, 18(03), 299-318.

Brooks, C. 2008. Introductory Econometrics for Finance. 2 ed. Chris Brooks The ICMA Centre, University of Reading.

Buesa M., Heijs J., Baumert, T. 2010. The determinants of regional innovation in Europe: A combined factorial and regression knowledge production function approach. Research Policy, 39, p.722–735.

Cantwell, J. 1995. The globalisation of technology: what remains of the product cycle model. Cambridge Journal of Economics, 19, 155–174.

Cardoso, T. L., Ensslin, S. R., Dias, J. 2016. Avaliação de desempenho da sustentabilidade financeira da Universidade do Mindelo (Cabo Verde): um modelo multicritério construtivista. Revista Eletrônica de Estratégia & Negócios, 09(02), 234-264.

Castiglionesi, F., Ornaghi, C. 2013. On the determinants of total factor productivity growth: Evidence from Spanish manufacturing firms. Macroeconomic Dynamics, 17(03), p.501-530.

Castillo, L. L., Salem, D. S., Guasch, J. L. 2011. Innovative and Absorptive Capacity of International Knowledge: An Empirical Analysis of Productivity Sources in Latin American Countries. Latin American Business Review, 12(04), 309-335.

Cauchick et al. 2010. Metodologia de pesquisa em engenharia de produção e gestão de operações. Rio de Janeiro: Elsevier.

Cockburn, I. M., Henderson, R. N. 1998. Absorptive capacity, coauthoring behaviour, and the organization of research in drug discovery. Journal of Industrial Economics, 46(02), 157-182.

Cohen, W. M., Levinthal, D. A. 1990. Absorptive capacity: a new perspective on learning and innovation. Admin. Sci. 35(129).

Cohen, W., Levinthal, D. 1989. Innovation and learning: the two faces of R&D. Economic Journal, 99(397), 569-596.

Creswell, J. W. 2007. Projeto de pesquisa: métodos qualitativo, quantitativo e misto. 2.ed. Porto Alegre: Artmed.

Damijan, J., Rojec, M., Majcen, B., Knell, M. 2013. Impact of firm heterogeneity on direct and spillover effects of FDI: Micro-evidence from ten transition countries. Journal of Comparative Economics, 41(03), 895-922.

Dang, V. A. 2011. Leverage, Debt Maturity and Firm Investment: An Empirical Analysis. Journal of Business Finance & Accounting 38(1-2), 225-258.

Danska-Borsiak, B. 2018. Determinants of total factor productivity in Visegrad Group nuts-2 regions. Acta Oeconomica, 68(01), p.31-50.

Dańska-Borsiak, B., Laskowska, I. 2012. The Determinants of Total Factor Productivity in Polish Subregions. Panel Data Analysis. Comparative Economic Research, 15(04), p.17-29.

Denyer, D., Tranfeld, D. 2009. "Producing a Systematic Review." In The Sage Handbook of Organizational Research Methods, edited by D. Buchanan and A. Bryman, 671–689 London: Sage.

Dikova, D., Van Witteloostuijn, A. 2007. Foreign direct investment mode choice: entry and establishment modes in transition economies. Journal of International Business Studies, 38(06), 1013-1033.

Dupasquier, C., Osakwe, P. N. 2003. Performance, Promotion, and Prospects for Foreign Investment in Africa: National, Regional, and International Responsibilities. UN Economic Commission for Africa.

Dutra, A., Ripoll-Feliu, V. M., Fillol, A. G., Ensslin, S. R., Ensslin, L. 2015. The construction of knowledge from the scientific literature about the theme seaport performance evaluation. International Journal of Productivity and Performance Management, 64(02), 243-269.

Elmawazini, K. 2014. FDI Spillovers, Efficiency Change and Host Country Labor Productivity: Evidence from GCC Countries. Atlantic Economic Journal, 42(04), 399-411.

Ensslin, L. et al. 2010. Avaliação do desempenho de empresas terceirizadas com o uso da metodologia multicritério de apoio à decisão-construtivista. Pesquisa operacional, 30(01), p.125-152, 2010.

Ensslin, S.R., Ensslin, L., Imlau, J.M., Chaves, L.C. 2014. Processo de mapeamento das publicações científicas de um tema: portfólio bibliográfico e análise bibliométrica sobre avaliação de desempenho de cooperativas de produção agropecuária. Revista de Economia e Sociologia Rural (Impresso), 52(01), 587-608.

Estrin, S., Uvalic, M. 2016. Foreign direct investment in the Western Balkans: what role has it played during the transition? Comparative Economic Studies.

Felema, J., Raiher, A. P., Ferreira, C. R. 2013. Agropecuária brasileira: desempenho regional e determinantes de produtividade. Revista de Economia e Sociologia Rural, 51(03), p.555-574.

Fernandes, D. B. M. 2008. O Brasil no contexto da internacionalização de P&D e na disputa pelo investimento estrangeiro das empresas transnacionais. Mestrado (Administração). Faculdade de Economia, Administracao e Contabilidade de Ribeirão Preto, Ribeirão Preto.

Foster-McGregor, N., Pöschl, J., Stehrer, R. 2017. The importance of absorptive capacities: productivity effects of international R&D spillovers through intermediate inputs. Economics of Innovation and New Technology, 26(08), 719-733.

Fracasso, A., Vittucci Marzetti, G. 2014. International R&D Spillovers, Absorptive Capacity and Relative Backwardness: A Panel Smooth Transition Regression Model. International Economic Journal, 28(01), 137-160.

George, G., Zahra, S. A., Wheatley, K. K., Khan, R. 2001. The effects of alliance portfolio characteristics and absorptive capacity on performance. A study of biotechnology firms. The Journal of High Technology Management Research, 12(02), 205–226.

Ghosh, M., Wang, W. 2010. Does FDI Accelerate Economic Growth? The OECD Experience Based on Panel Data Estimates for the Period 1980-2004. Global Economy Journal, 09(04).

Giovanis, E., Ozdamar, O. 2015. Determinants of total factor productivity: Evidence from US Compustat firms and Triadic Patent Families. International Journal of Economics and Business Research, 10(03), p.258-272.

Girma, S. 2005. Absorptive Capacity and Productivity Spillovers from FDI: A Threshold Regression Analysis. Oxford Bulletin of Economics and Statistics, 67(03), 281-306.

Girma, S., Gong, Y. 2008. FDI, linkages and the effciency of state-owned enterprises in China. Journal of Development Studies, 44(05), 728-749.

Girma, S., Gorg, H., Pisu, M. 2008. Exporting, linkages and productivity spillovers from foreign direct investment. Canadian Economics Association, 41(01), 320-340.

Gorg, H., Greenaway, D. 2004. Much Ado about Nothing? Do Domestic Firms Really Benefit from Foreign Direct Investment? *The World Bank Research Observer*, 19(02), 171–197.

Grant, R. M. 1996. Prospering in dynamically competitive environments: organizational capability as knowledge integrations. Organization Science, 07(04), 375-387.

Greener, S. 2008. Business research methods. London: BookBoon.

Griliches, Z. 1998. R&D and Productivity: The Econometric Evidence. American Economic Review, v.84, n.01, p.9-21.

Grimpe, C., Sofka, W. 2008. Search patterns and absorptive capacity: Low- and high technology sectors in European countries. Research Policy, 38(03), 495-506.

Hansen, B. E. 1999. Threshold efects in non-dynamic panels: estimation, testing, and inference. Journal of Econometrics, 93, 334-368.

Hansen, B. E. 2000. Sample splitting and threshold estimation. Econometrica, 68, 575-603.

Harris, R., Moffat, J. 2015. Plant-level determinants of total factor productivity in Great Britain, 1997–2008. Journal of Productivity Analysis, 44(01).

Haskel, J., Pereira, S. C., Slaughter, M. J. 2007. Does Inward Foreign Direct Investment Boost the Productivity of Domestic Firms? The Review of Economics and Statistics, 89(03), 482-496.

Hausmann R., Hidalgo, C. A., Bustos, S., Coscia, M., Simoes A., Yildirim, M. A. 2014. The atlas of economic complexity: Mapping paths to prosperity: MIT Press.

Hidalgo, C. A., Hausmann, R. 2009. The building blocks of economic complexity. Proceedings of the National Academy of Sciences of the United States of America, 106(26), p.10570-10575.

Holtbrügge, D., Kreppel, H. 2012. Determinants of outward foreign direct investment from BRIC countries: an explorative study. International Journal of Emerging Markets, 07(01), 4-30.

Huebler, M., Glas, A., Nunnenkamp, P. 2016. Indicators of Absorptive Capacity and Import-induced South–North Convergence in Labour Intensities. World Economy, 39(11), 1756-1791.

Hurlin, C. 2018. Panel Threshold Regression Models. School of Economics and Management - University of Orléans.

Husniah H., Supriatna A. K. 2016. Optimal number of fishing fleet for a sustainable fishery industry with a generalized logistic production function. Proceedings of 2015 International Conference on Industrial Engineering and Systems Management, IEEE IESM 2015, 7380211, 546-554.

Inekwe, J. 2013. FDI, Employment and Economic Growth in Nigeria. Research and Development in the Social Sciences and Humanities, 25(4), 421-433.

Jiménez-Barrionuevo, M. M., García-Morales, V. J., Molina, L. M. 2011.Validation of an instrument to measure absorptive capacity. Technovation, 31(5/6), 190-202.

Kalotay, K. 2010. The Future of Russian Outward Foreign Direct Investment and the Eclectic Paradigm: What Changes After the Crisis of 2008-2009? (June 1, 2010). Competitio (University of Debrecen), 09(01), 31-54.

Keller, W. 2010. International trade, foreign direct investment, and technology spillovers. Handbook of the Economics of Innovation, 02(01), 793-829.

Khordagui, N., Saleh, G. 2016. Absorptive capacity factors that mediate foreign direct investment spillovers: A sector-level analysis from emerging economies. International Journal of Business and Globalisation, 16(02), 188-201.

Kim, L. 1998. Crisis construction and organizational learning: Capability building in catching-up at Hyundai Motor. Organization Science, 09(04), 506-521.

Kim, M. 2015. Productivity spillovers from FDI and the role of domestic firm`s absorptive capacity in South Korean manufacturing industries. Empirical Economics, 50(04), 807-827.

Kim, S. 2011. Factor determinants of total factor productivity growth in the malaysian hotel industry: A stochastic frontier approach. Cornell Hospitality Quarterly, 52(01), p.35-47.

Kim, S. 2016. Factor determinants of total factor productivity growth for the japanese manufacturing industry. Contemporary Economic Policy, 34(03), p.572-586.

King, A., Lakhani, K. R. 2011. The Contingent Effect of Absorptive Capacity: An Open Innovation Analysis. Working Knowledge – Business Research for Business Leaders, 1–34.

Kinoshita, Y., Lu, C. H. 2006. On the Role of Absorptive Capacity: FDI Matters to Growth. Working paper.

Krammer, S. M. S. 2010. International R&D spillovers in emerging markets: The impact of trade and foreign direct investment. The Journal of International Trade & Economic Development, 19(04).

Kwok, C. C. Y., Tadesse S. 2006. The MNC as an agent of change for host-country institutions: FDI and corruption. Journal of International Business Studies 37(6), 767-785.

Lane, P. J., Lubatkin, M. 1998. Relative absorptive capacity and interorganizational learning. Strategic Management Journal, 19(05), 461-477.

Lapan, H., Bardhan, P. 1973. Localized Technical Progress and Transfer of Technology and Economic Development. Journal of Economic Theory, 06, 585-595.

Leiponen, A. 2005. Skills and innovation. International Journal of Industrial Organization, 23(5-6), 303-323.

Lenox, M., King, A. 2004. Prospects for developing absorptive capacity through internal information provision. Journal of Strategic Management, 25(04), 331-345, 2004.

Levinsohn, J., Petrin, A. 2003. Estimating Production Functions Using Inputs to Control for Unobservables. Review of Economic Studies, 70, 317-342.

Lichtenthaler, U. 2016. Determinants of absorptive capacity: the value of technology and market orientation for external knowledge acquisition. Journal of Business and Industrial Marketing, 31(05), 600-610.

Lima, U. M., Oliveira, I. T. M. 2015. A Trajetória Recente dos Fluxos de Investimento Externo Direto entre Brasil e Estados Unidos: características setoriais e condicionantes econômicos. In: Boletim de Economia e Política Internacional (BEPI), 20.

Li-Ming, X., Rui, J., Rui, J. 2016. Productivity Spillovers from FDI, Absorptive Capacity and Self-innovation Capabilities of Resource Area: Evidence from 1992–2013 in Shanxi, China. Science, Technology and Society, 21(02), 149-180.

Liu, X., Buck, T. 2007. Innovation performance and channels for international technology spillovers: Evidence from Chinese high-tech industries. Research Policy, 36(03), 355-366.

Löschel, A. 2002. Technological change in economic models of environmental policy: a survey. Ecological Economics, 43(02), p.105–126.

Lovell, C. A. K. 1993. Productions frontiers and productive efficiency. In the Measurement of productive efficiency. Techniques and applications. New York, Oxford: Oxford University Press.

Lucas, R. E. 1988. On the mechanics of economic development. Journal of Monetary Economics, 22(01), p.03– 42.

Luo, Y. 1997. Partner selection and venturing success: the case of Joint Ventures with firms in the People's Republic of China. Organization Science, 08(06), 648-662.

Malaguerra, N. M. P. 2014. A Importância da Capacidade de Absorção e Inovação para o Crescimento Económico. Coimbra, Dissertação (Mestrado) – Faculdade de Economia, Universidade de Coimbra.

Mangematin, V., Nesta, L. 1999. What kind of knowledge can a firm absorb? International Journal of Technology Management, 18(3–4), 149–172.

Marcin, K. 2008. How does FDI infow affect productivity of domestic firms? The role of horizontal and vertical spillovers, absorptive capacity and competition. Journal of International Trade and Economic Development, 17(01), p.155-173.

Mation, L. 2013. Produtividade Total dos Fatores no Brasil: impactos na educação e comparações internacionais. Boletim Radar – IPEA, 28, 39-46.

Meeus, M. T. H., Oerlemans, L. A. G., Hage, J. 2001. Patterns of interactive learning in a high-tech region. Organization Studies, 22(01), p.145-172.

Messa, A. 2013. Indicadores de produtividade: Uma breve revisão dos principais métodos de cálculo. Radar: Tecnologia, Produção e Comércio Exterior, n.28.

Miguelez, E., Moreno, E. 2015. Knowledge flows and the absorptive capacity of regions. Research Policy, 44(04), 833-848.

Mowery, D. C., Oxley, J. E. 1995. Inward technology transfer and competitiveness: the role of national innovation systems. Cambridge Journal of Economics, 19(01), 67–93.

Mowery, D. C., Oxley, J. E., Silverman, B. S. 1996. Strategic alliances and interfirm knowledge transfer. Strategic Management Journal, 17, 77-91.

Mukherjee, A., Mitchell, W., Talbot, F. B. 2000. The impact of new manufacturing requirements on production line productivity and quality at a focused factory. Journal of Operations Management, 18, 139-168.

Murovec, N., Prodan, I. 2009. Absorptive capacity, its determinants, and influence on innovation output: Cross-cultural validation of the structural model. Technovation, 29(12), 859-872.

Muscio, A. 2007. The impact of absorptive capacity on smes' collaboration. Economics of Innovation and New Technology, 16(08), 653-668.

Nelson, R., Phelps, E. 1966. Investment in humans, technological diffusion, and economic growth. American Economic Review, 56(1/2), p.69–75.

Nielsen, J. U., Pawlik, k. 2007. The Export Intensity of Foreign Affiliates in Transition Economies: The Importance of the Organization of Production. Economics of Transition, 15(03), 603-624.

Nuernberg, E. G., Ensslin, S. R., Cardoso, T. L., Valmorbida, S. M. 2016. Gestão Universitária: identificação e análise dos indicadores utilizados na literatura. Revista Contemporânea de Economia e Gestão, 14(03).

Olley, S., Pakes, A. 1996. The Dynamics of Productivity in the Telecommunications Equipment Industry. Econometrica, 64, 1263-1295.

Olofsdotter, K. 1998. Foreign direct investment, country capabilities and economic growth. Review of World Economics, 134, 534–547.

Otsuka, A. 2017. Regional determinants of total factor productivity in Japan: stochastic frontier analysis. Annals of Regional Science, 58(03), p.579-596.

Otsuka, K., Natsuda, K. 2016. The determinants of total factor productivity in the malaysian automotive industry: are government policies upgrading technological capacity? Singapore Economic Review, 61(04).

Owusu-Nantwi, V., Erickson, C. 2019. Foreign direct investment and economic growth in South America. Journal of Economic Studies, 46(02), 383-398.

Padilla-Perez, R., Nogueira, C. G. 2016. Outward FDI from small developing economies: Firm-level strategies and home-country effects. International Journal of Emerging Markets, 11(04), 693-714.

Petroni, A., Panciroli, B. 2002. Innovation as a determinant of suppliers' roles and performances: an empirical study in the food machinery industry. European Journal of Purchasing & Supply Management, 08(03), 135-149.

Porcile, G., Vaz Sampaio, A., Curado, M. 2005. Produtividade Total dos Fatores: Aspectos Teóricos e Evidências Brasileiras. Economia e Tecnologia**,** 03.

Reim, W., Parida, V. E., Örtqvist, D. 2015. Product – Service Systems (PSS) business models and tactis – Systematic Literature Review. Journal of Cleaner Production, 97(1), 61-75.

Richardson, R. J., Peres, J. A. 1999. Pesquisa social: métodos e técnicas. 3.ed. São Paulo: Atlas.

Romer, P. M. 1990. Endogenous technological change. Journal of Political Economy, 98(05), p.71–102.

Sarbu, M. 2017. Does Social Media Increase Labour Productivity? Journal of Economics and Statistics, 237(02), p.81–113.

Sari, D. W., Khalifah, N. A., Suyanto, S. 2016. The spillover effects of foreign direct investment on the firms' productivity performances. Journal of Productivity Analysis, 46(02-03), p.199-233.

Schmidt, T. 2005. Absorptive Capacity – One Size Fits All? A Firm-Level Analysis of Absorptive Capacity for Different Kinds of Knowledge, ZEW Discussion Paper (05-72), Mannheim.

Shenbarow, A. A. 2014. Absorptive capacity and organizational determinants: Evidence of associations. International Conference on Engineering, Technology and Innovation: Engineering Responsible Innovation in Products and Services, ICE 2014 6871600.

Sheng, Y., Song, L. 2012. China's iron and steel industry performance: Total factor productivity and its determinants. The Chinese Steel Industry's Transformation: Structural Change, Performance and Demand on Resources, p.69-88.

Silajdzic, S., Mehic, E. 2015. Knowledge spillovers, absorptive capacities and the impact of FDI on economic growth: empirical evidence from transition economies. World Conference on Technology, Innovation and Entrepreneurship, 614-623.

Silva, R. V., Ensslin, S. R., Ripoll-Feliu, V. M., Soler, C. C. 2014. E-government and Public Accounting Information: Bibliometric and Systemic Analysis. International Research Journal of Finance and Economics, 01(122), 76-91.

Smeets, R. 2008. Collecting the pieces of the FDI knowledge spillovers puzzle. World Bank Res, 23(02), p.107-138.

Solow, R. 1956. A contribution to the theory of economic growth. Quarterly Journal of Economics, 70(01), p.65-94.

Solow, R. 1957. Technical Change and the Aggregate Production Function. Review of Economics and Statistics, 39(03), 312-320.

Spithoven, A., Clarysse, B., Knockaert, M. 2010. Building absorptive capacity to organize inbound open innovation in traditional industries. Technovation, 30, 130–141.

Stern, D. I., Kander, A. 2012. The role of energy in the industrial revolution and modern economic growth. Energy Journal, 33(03), 125.

Stock, G. N., Greis, N. P., Fisher, W. A. 2001. Absorptive capacity and new product development. The Journal of High Technology Management Research, 12(01), 77-91.

Takii, S. 2005. Productivity spillovers and characteristic of foreign multinational plants in Indonesian manufactuiring. Journal of Development Economics, 76(02), p.521-542.

Tasca, J. E., Ensslin, L., Rolim Ensslin, S., Alves, B. M. 2010. An approach for selecting a theoretical framework for the evaluation of training programs. Journal of European Industrial Training, 34(07), 631–655.

Tinbergen, J. 1942. A teoria do desenvolvimento econômico de longo prazo. Review of World Economics, 55(01), p.511-549.

Todorova, G., Durisin, B. 2007. Note Absorptive Capacity. Valuing A, 32(03), 774–786.

Tsai, W. 2001. Knowledge transfer in intra-organizational networks: effects of networks position and absorptive capacity on business unit innovation and performance. Academy of Management Journal, 44(05), 996-1004.

Ubeda, F., Pérez, H. F. 2017. Absorptive Capacity and Geographical Distance Two Mediating Factors of FDI Spillovers: a Threshold Regression Analysis for Spanish Firms. Journal of Industry, Competition and Trade, 17(01), 1-28.

Vallejos, L., Valdivia, L. 2000. Productivity growth in Peru: 1950 – 1998. Santiago: Interamerican Development Bank, 2000. (Serie de Documentos de Trabajo nº 355).

Valmorbida, S. M. I., Cardoso, T. L., Ensslin, S. R. 2015. Rankings Universitários: Análise dos Indicadores Utilizados. Sociedade, Contabilidade e Gestão, 10(2).

Van Den Bosch, F. A. J., Volberda, H. W., De Boer, M. 1999. Coevolution of Firm Absorptive Capacity and Knowledge Environment. Organization Science, 10(05), 551-568.

Veugelers, R. 1997. Internal R&D expenditures and external technology sourcing. Research Policy, 26(03), 303–315.

Vinding, A. L. 2006. Absorptive capacity and innovative performance: A human capital approach. Economics of Innovation and New Technology, 15(04-05), 507-517.

Wang, Q. 2015. Fixed-effect panel threshold model using Stata. Stata Journal 15(1), 121-134.

Wooldridge, J. M. 2002. Econometric analysis of cross section and panel data. Massachusetts: Cambridge.

Wooldridge, J. M. 2009. On estimating firm-level production functions using proxy variables to control for unobservables. Economics Letters, 104, 112-114.

Wu, J. Y, Hsu, C. C. 2012. Foreign direct investment and income inequality: Does the relationship vary with absorptive capacity? Economic Modelling, 29, 2183–2189.

Wu, J. Y., Hsu, C. C. 2008. Does foreign direct investment promote economic growth? Evidence from a threshold regression analysis. Economics Bulletin, 15(12).

Yasar, M. 2013. Imported capital input, absorptive capacity, and firm performance: evidence from firm-level data. Economic Inquiry, 51(01), 88-100.

Ying-Chun, W., Shuxian, H., Qian, W. 2009. Technology spillovers of FDI and technology absorptive capacity: The case of China. 2nd International Conference on Future Information Technology and Management Engineering, FITME 2009, 107-110.

Zahra, S. A., George, G. 2002. Absorptive Capacity : A Review, Reconceptualization, and Extension. The Academy of Management Review, 27(02), 185–203.

Zahra, S. A., Hayton, J. C. 2008. The effect of international venturing on firm performance: the moderating influence of absorptive capacity. Journal of Business Venturing, 23(02), 195–220.

Zhang, Y., Li, H., Li, Y., Zhou, L. A. 2010. FDI spillovers in an emerging market: The role of foreign firms' country origin diversity and domestic firms' absorptive capacity. Strategic Management Journal, 31(09), 969-989.

APPENDIX A - SYSTEMATIC REVIEW PROTOCOL (PROKNOW-C)

Objective: To analyze the building blocks of Absorptive Capacity from External Direct Investment

Formulation of the research question: What are the building blocks of Absorptive Capacity?

Items related to the scope and specificities of the research question:

- Control: Collection of articles published in Journals
- Population: Countries/states/regions/cities

Strategies for searching and selecting primary studies:

The resources and strategies for research and selection of studies were defined and selected based on four fundamental items:
- Search sources: database (Scopus/Web of Science)
- English language
- Keywords: (Productivity OR knowledge spillover) AND absorptive capacity
- Date of publication: No lower or upper limits were established for the date of publication of articles.

Criteria and procedures for selection of studies:

Inclusion criteria
(I) Did the article consider the absorptive capacity as one of the variables that impact the productivity of units?
(II) Does the article consider that the generation of externalities with FDI inflows depends on the absorptive capacity?
(III) Publication in English.

Exclusion Criteria
(I) The article does not focus on productivity spillovers
(II) The article does not consider the absorptive capacity important for the productivity of units

Selection process of studies

Preliminary selection process

Articles will be selected by reading the abstracts.

Final selection process

The articles selected by the abstract will be reviewed according to the inclusion and exclusion criteria.

APPENDIX B - STUDY POPULATION

Developed countries	Developing countries	
Germany	South Africa	Kuwait
Australia	Albania	Lebanon
Austria	Angola	Macedonia
Belgium	Saudi Arabia	Malaysia
Canada	Algeria	Morocco
Cyprus	Argentina	Mauritius
South Korea	Armenia	Mexico
Denmark	Azerbaijan	Moldavia
Slovakia	Bahrain	Mongolia
Slovenia	Bangladesh	Montenegro
Spain	Benin	Mozambique
United States	Belarus	Namibia
Estonia	Bolivia	Nepal
Finland	Botswana	Nicaragua
France	Bosnia and Herzegovina	Niger
Greece	Brazil	Nigeria
Hong Kong	Brunei	Oman
Iceland	Cambodia	Pakistan
Ireland	Shrimp	Panama
Israel	Kazakhstan	Paraguay
Italy	Chile	Peru
Japan	China	Poland
Latvia	Colombia	Kenya
Lithuania	Costa Rica	Kyrgyzstan
Malta	Costa do Marfim	Congo Republic
New Zealand	Croatia	Democratic Republic of Congo
Norway	United Arab Emirates	Dominican Republic
Netherlands	Ecuador	Romania
Portugal	Egypt	Russia
United Kingdom	El Salvador	Senegal
Czech Republic	Philippines	Serbia
Singapore	Gabon	Sri Lanka
Sweden	Georgia	Sudan
Switzerland	Ghana	Suriname
	Guatemala	Thailand
	Haiti	Tajikistan
	Honduras	Tanzania
	Hungary	Togo
	Yemen	Tunisia
	Indonesia	Turkey
	India	Turkmenistan
	Will	Ukraine
	Iraq	Uruguay
	Jamaica	Uzbekistan
	Jordan	Vietnam

Source: International Monetary Fund (2017)

http://www.imf.org/external/pubs/ft/weo/2017/01/weodata/groups.htm#wa

APPENDIX C - COUNTRIES SELECTED FOR ANALYSIS OF BUILDING BLOCKS AND THRESHOLDS (2007-2015)

G1 – DEVELOPED COUNTRIES	G2 – DEVELOPING COUNTRIES
Germany	South Africa
Austria	Saudi Arabia
Belgium	Argentina
Cyprus	Armenia
South Korea	Azerbaijan
Denmark	Brazil
Slovakia	Kazakhstan
Spain	China
United States	Colombia
Estonia	Croatia
Finland	Hungary
France	India
Ireland	Macedonia
Israel	Mexico
Japan	Moldavia
Latvia	Poland
Lithuania	Romania
Norway	Russia
Netherlands	Thailand
Portugal	Tunisia
United Kingdom	Turkey
Czech Republic	Ukraine
Sweden	

APPENDIX D - CORRELATION MATRIX – CONTROL AND INSTRUMENTAL VARIABLES

	LnR&D	lnPatents	lnArticle	lnIEF	lnHDI	lnEducation	lnInternet	lnCel	lnTFP	lnBrand	lnFDI	LnTaxfem	LnTaxmale	LnGDP
LnR&D	1.0000													
lnPatentes	0.7015	1.0000												
lnArtigos	0.6633	0.8965	1.0000											
lnIEF	0.0917	0.0885	0.1389	1.0000										
lnIDH	0.6783	0.5924	0.6351	0.3975	1.0000									
lnEnsino	0.1244	-0.1281	0.0745	0.0595	0.3175	1.0000								
lnInternet	0.4087	0.3154	0.3896	0.4028	0.6582	0.2222	1.0000							
lnCelular	0.0672	-0.3141	-0.1556	0.1403	0.1128	0.0669	0.3149	1.0000						
lnTFP	0.6455	0.8425	0.9249	0.1492	0.7451	0.2050	0.3617	-0.2503	1.0000					
lnMarcas	0.4596	0.8403	0.8048	-0.0936	0.2955	-0.1300	0.1212	-0.3659	0.7014	1.0000				
lnIDE	-0.3127	-0.4757	-0.3598	0.1844	-0.0705	0.3250	-0.1127	0.0704	-0.2693	-0.5208	1.0000			
lnTaxafem	0.1059	-0.1388	0.0618	0.0625	0.2768	0.9911	0.1822	0.0372	0.1900	-0.1120	0.3249	1.0000		
lnTaxamas	0.1423	-0.1135	0.0869	0.0541	0.3556	0.9892	0.2614	0.0977	0.2173	-0.1454	0.3167	0.9610	1.0000	
lnPIB	0.6086	0.9054	0.9757	0.1347	0.6460	0.0812	0.3476	-0.2738	0.9644	0.8210	-0.3508	0.0716	0.0899	1.0000
lnPopEcon	0.5110	0.9027	0.9581	0.0761	0.4624	-0.0576	0.2550	-0.2992	0.8603	0.8807	-0.4213	-0.0624	-0.0512	0.9605
lnR&D(t-1)	0.9122	0.6724	0.6024	0.0583	0.5913	0.0944	0.3382	-0.0404	0.6018	0.4435	-0.3022	0.0792	0.1093	0.5647
lnR&D(t-2)	0.8151	0.6190	0.5417	0.0353	0.5053	0.0780	0.2811	-0.1011	0.5549	0.4154	-0.2905	0.0646	0.0911	0.5189
lnPatente(t-1)	0.6157	0.9196	0.7913	0.1057	0.5113	-0.1482	0.2553	-0.3491	0.7514	0.7825	-0.4306	-0.1549	-0.1376	0.8112
lnPatente(t-2)	0.5224	0.8059	0.6824	0.1280	0.4419	-0.1601	0.2237	-0.3102	0.6532	0.6976	-0.3768	-0.1675	-0.1489	0.7088
lnArtigo(t-1)	0.5902	0.8443	0.9038	0.1445	0.5458	0.0502	0.2925	-0.2382	0.8487	0.7626	-0.3373	0.0443	0.0551	0.8926
lnArtigo(t-2)	0.5181	0.7674	0.8090	0.1488	0.4638	0.0229	0.2360	-0.2520	0.7641	0.7053	-0.3043	0.0186	0.0264	0.8050
lnIEF(t-1)	0.0637	0.0720	0.1062	0.8223	0.3251	0.0544	0.2833	0.0766	0.1306	-0.0980	0.1743	0.0566	0.0501	0.1076
lnIEF(t-2)	0.0309	0.0364	0.0592	0.6954	0.2618	0.0346	0.1738	0.0358	0.1025	-0.1193	0.1631	0.0396	0.0272	0.0687
lnIDH(t-1)	0.5949	0.5551	0.5528	0.3218	0.8442	0.2593	0.4519	-0.0582	0.6788	0.2652	-0.0796	0.2250	0.2912	0.5788
lnIDH(t-2)	0.5201	0.5086	0.4821	0.2624	0.6986	0.2040	0.3015	-0.1767	0.6158	0.2402	-0.0817	0.1770	0.2283	0.5201
lnEnsino(t-1)	0.0882	-0.1064	0.0718	-0.0180	0.2307	0.8545	0.0603	-0.0698	0.2035	-0.0935	0.3308	0.8471	0.8447	0.0882
lnEnsino(t-2)	0.0860	-0.0847	0.0721	-0.0685	0.1691	0.7435	-0.0389	-0.1533	0.2032	-0.0678	0.3035	0.7432	0.7278	0.0931
lnTFP(t-1)	0.5615	0.7874	0.8310	0.1364	0.6350	0.1567	0.2457	-0.3145	0.9089	0.6627	-0.2259	0.1472	0.1637	0.8792
lnTFP(t-2)	0.4869	0.7103	0.7381	0.1384	0.5443	0.1232	0.1896	-0.3142	0.8130	0.6077	-0.1848	0.1155	0.1285	0.7896
lnMarcas(t-1)	0.4038	0.7687	0.7103	-0.0212	0.2582	-0.1281	0.1065	-0.3714	0.6210	0.9191	-0.4801	-0.1073	-0.1466	0.7312
lnMarcas(t-2)	0.3509	0.6819	0.6240	0.0392	0.2356	-0.1242	0.1211	-0.3151	0.5421	0.8266	-0.4153	-0.1085	-0.1374	0.6440
lnIDE(t-1)	-0.2163	-0.4259	-0.2850	0.1560	-0.0339	0.3532	-0.0752	0.1518	-0.2251	-0.4742	0.6640	0.3529	0.3437	-0.2951
lnIDE(t-2)	-0.1343	-0.3574	-0.2137	0.0923	-0.0051	0.3066	-0.0440	0.1736	-0.1780	-0.4062	0.5306	0.3074	0.2967	-0.2398

Note: Correlation Matrix – Control and Instrumental Variables - Developed Countries - Continued...

	lnPopEcon	lnR&D(t-1)	lnR&D(t-2)	lnPatent(t-1)	lnPatent(t-2)	lnArticle(t-1)	lnArticle(t-2)	lnIEF(t-1)	lnIEF(t-2)	lnHDI(t-1)	lnHDI(t-2)	lnEducation(t-1)	lnEducation(t-2)	lnTFP(t-1)
lnPopEcon	1.0000													
lnR&D(t-1)	0.4782	1.0000												
lnR&D(t-2)	0.4419	0.9021	1.0000											
lnPatente(t-1)	0.8159	0.7010	0.6554	1.0000										
lnPatente(t-2)	0.7162	0.6052	0.7042	0.8960	1.0000									
lnArtigo(t-1)	0.8836	0.6657	0.6056	0.8930	0.7849	1.0000								
lnArtigo(t-2)	0.8042	0.5919	0.6746	0.8290	0.8914	0.9050	1.0000							
lnIEF(t-1)	0.0578	0.0866	0.0474	0.0975	0.1105	0.1447	0.1376	1.0000						
lnIEF(t-2)	0.0211	0.0534	0.0897	0.0739	0.1178	0.0966	0.1550	0.8510	1.0000					
lnIDH(t-1)	0.4169	0.6782	0.5925	0.5905	0.5170	0.6329	0.5485	0.4082	0.3368	1.0000				
lnIDH(t-2)	0.3790	0.6016	0.6778	0.5582	0.5900	0.5576	0.6318	0.3274	0.4198	0.8465	1.0000			
lnEnsino(t-1)	-0.032	0.1115	0.0922	-0.1513	-0.1667	0.0621	0.0380	0.0673	0.0519	0.3098	0.2603	1.0000		
lnEnsino(t-2)	-0.016	0.1092	0.1416	-0.1221	-0.1471	0.0587	0.0603	-0.0006	0.0785	0.2384	0.3212	0.8684	1.0000	
lnTFP(t-1)	0.7916	0.6435	0.5988	0.8366	0.7375	0.9228	0.8395	0.1609	0.1370	0.7455	0.6837	0.1997	0.1994	1.0000
lnTFP(t-2)	0.7164	0.5636	0.6512	0.7746	0.8369	0.8272	0.9193	0.1439	0.1839	0.6425	0.7516	0.1545	0.2039	0.9038
lnMarcas(t-1)	0.7886	0.4544	0.4274	0.8371	0.7583	0.7992	0.7470	-0.0890	-0.1101	0.2842	0.2616	-0.1524	-0.1220	0.6955
lnMarcas(t-2)	0.6987	0.3955	0.4507	0.7554	0.8347	0.7104	0.7946	-0.0283	-0.0755	0.2572	0.2780	-0.1557	-0.1610	0.6117
lnIDE(t-1)	-0.365	-0.2938	-0.2713	-0.4796	-0.4115	-0.3545	-0.3243	0.1865	0.1800	-0.0683	-0.0816	0.3869	0.3417	-0.2604
lnIDE(t-2)	-0.301	-0.1950	-0.2813	-0.4156	-0.4795	-0.2883	-0.3540	0.1694	0.1786	-0.0406	-0.0685	0.3337	0.3392	-0.2223

Note: Correlation Matrix – Control and Instrumental Variables - Developed Countries - Continued...

	lnTFP(t-2)	lnBrand(t-1)	lnBrand(t-2)	lnFDI(t-1)	lnFDI(t-2)
lnTFP(t-2)	1.0000				
lnMarcas(t-1)	0.6476	1.0000			
lnMarcas(t-2)	0.6952	0.9096	1.0000		
lnIDE(t-1)	-0.2174	-0.5307	-0.4751	1.0000	
lnIDE(t-2)	-0.2608	-0.4712	-0.5291	0.6369	1.0000

Note: Correlation Matrix – Control and Instrumental Variables - Developed Countries – End.

	LnR&D	LnPatent	lnArticle	IEF	lnHDI	lnInternet	lnCel	lnTFP	lnFDI	lnPIB	lnPopEcon	lnR&D(t-1)	lnR&D(t-2)	lnPatent(t-1)
LnR&D	1.0000													
lnPatentes	0.5719	1.0000												
lnArtigos	0.6893	0.8489	1.0000											
lnIEF	-0.2298	-0.2105	-0.0332	1.0000										
lnIDH	0.0259	-0.1238	0.0506	0.1843	1.0000									
lnInternet	0.1009	-0.0947	0.1541	0.2559	0.6819	1.0000								
lnCelular	0.1045	0.0191	0.2008	0.2680	0.6336	0.8067	1.0000							
lnTFP	0.3827	0.7190	0.7881	0.0939	0.2988	0.1815	0.2563	1.0000						
lnIDE	-0.1972	-0.2372	-0.3008	0.1598	0.1236	-0.0660	0.0197	-0.2333	1.0000					
lnPIB	0.4582	0.9039	0.8961	-0.0385	0.0391	0.0632	0.1637	0.9064	-0.2664	1.0000				
lnPopEcon	0.4357	0.9347	0.8233	-0.2082	-0.2924	-0.1764	-0.0780	0.6684	-0.2845	0.9084	1.0000			
lnR&D(t-1)	0.8747	0.5179	0.6082	-0.2231	-0.0182	0.0406	0.0315	0.3336	-0.2089	0.4044	0.3982	1.0000		
lnR&D(t-2)	0.7398	0.4671	0.5281	-0.2295	-0.0557	-0.0126	-0.0277	0.2865	-0.1816	0.3527	0.3608	0.8778	1.0000	
lnPatente(t-1)	0.5000	0.8925	0.7358	-0.1973	-0.1344	-0.1097	-0.0142	0.6301	-0.2128	0.7964	0.8344	0.5673	0.5151	1.0000
lnPatente(t-2)	0.4264	0.7884	0.6280	-0.1931	-0.1397	-0.1193	-0.0363	0.5433	-0.1827	0.6925	0.7359	0.4961	0.5636	0.8925
lnArtigo(t-1)	0.6225	0.7723	0.8880	-0.0453	0.0140	0.0732	0.0888	0.7123	-0.2939	0.7999	0.7442	0.6798	0.6009	0.8487
lnArtigo(t-2)	0.5541	0.6932	0.7773	-0.0709	-0.0159	-0.0002	0.0012	0.6337	-0.2527	0.7044	0.6639	0.6140	0.6723	0.7713
lnTFP(t-1)	0.3405	0.6599	0.7034	0.0760	0.2471	0.1004	0.1574	0.9135	-0.2053	0.8209	0.6086	0.3586	0.3120	0.7112
lnTFP(t-2)	0.2997	0.5999	0.6220	0.0604	0.2078	0.0396	0.0961	0.8241	-0.1715	0.7374	0.5483	0.3162	0.3359	0.6526
LnIDE(t-1)	0.3405	0.6599	0.7034	0.0760	0.2471	0.1004	0.1574	0.9135	-0.2053	0.8209	0.6086	0.3586	0.3120	0.7112
lnIDE(t-2)	0.2997	0.5999	0.6220	0.0604	0.2078	0.0396	0.0961	0.8241	-0.1715	0.7374	0.5483	0.3162	0.3359	0.6526

Note: Correlation Matrix – Control and Instrumental Variables - Emerging and Developing Countries - Continued ...

	lnPatent(t-2)	lnArticle(t-1)	lnArticle(t-2)	lnTFP(t-1)	lnTFP(t-2)	LnFDI(t-1)	lnFDI(t-2)
lnPatente(t-2)	1.0000						
lnArtigo(t-1)	0.7355	1.0000					
lnArtigo(t-2)	0.8483	0.8873	1.0000				
lnTFP(t-1)	0.6230	0.7811	0.7050	1.0000			
lnTFP(t-2)	0.7044	0.6958	0.7736	0.9129	1.0000		
LnIDE(t-1)	0.6230	0.7811	0.7050	-0.2693	-0.2396	1.0000	
lnIDE(t-2)	0.7044	0.6958	0.7736	-0.2628	-0.2811	0.5958	1.0000

Note: Correlation Matrix – Control and Instrumental Variables - Emerging and Developing Countries – End.