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ARTICLE

Modeling the building blocks of country-level absorptive capacity: Comparing developed and emergent economies

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Abstract

Several studies analyzed the importance of absorptive capacity (AC) to achieve economic development. However, to the best of our knowledge, no study compares the building blocks (BBs) of AC between developed and emergent economies. This paper aims to identify and analyze the impact of the BBs on AC under distinct levels of development (i.e., developed vs. emerging economies) using systematic literature review (SLR) and econometrics. Specifically, both linear and nonlinear analyses were employed. Our findings show that BBs in developed and emergent regions are different. For both groups, R&D, FDI (foreign direct investment), infrastructure, and HDI (human development index) variables are BBs of AC. For developed economies, BBs also contemplate secondary education enrollments, the higher education index, and the percentage of GDP spent on higher education. Moreover, the thresholds of BBs also differ between developed and emergent economies. This identification of BBs and possible AC thresholds is valuable, as it provides information to set goals and strategies before a foreign investment attraction policy. Thus, the results facilitate the development of more suitable strategies to enhance positive productivity spillovers and avoid negative spillovers whenever possible. These results show that policymakers cannot employ the same policies for the development of developed and emerging countries.

KEYWORDS
absorptive capacity, human capital, research and development, threshold regression

JEL CLASSIFICATION
F, J24, P45

1 INTRODUCTION

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

AC enhances the ability of a region to identify, assimilate, and exploit knowledge, which allows national (i.e., domestic) companies to imitate and absorb production methods, organizational and managerial techniques from multinational companies, as well as to combine its effect with foreign investments (Apriliyanti & Alon, 2017; Cohen & Levinthal, 1989, 1990; M. Kim, 2015; Li-Ming et al., 2016; Miguelez & Moreno, 2015; Sultana & Turkina, 2020; Ubeda & Pérez, 2017; Zhang et al., 2010).

Organizational knowledge is a strategic asset, as well as an explanatory variable for the firm's performance and growth (Grant, 1996). Accordingly, some studies indicate that the effects of foreign investments on productivity growth are dependent on AC (Alfaro et al., 2004; Durham, 2004; Erickson, 2019; X. Fu, 2008; Girma, 2005; Holtbrügge & Kreppel, 2012; Kalotay, 2010; M. Kim, 2015; Li-Ming, Rui & Rui, 2016; Owusu-Nantwi & Ubeda & Pérez, 2017; Padilla-Perez & Nogueira, 2016).

The concept of AC can be found in several studies and may contemplate numerous factors, including the development of human capital (Borensztein et al., 1998; Olofsdotter, 1998), trade (Balasubramanyam et al., 1996; Olofsdotter, 1998), total factor productivity (TFP) (Girma, 2005), development of financial markets (Alfaro et al., 2004), and infrastructures such as roads and electricity generation (Kinoshita & Lu, 2006).

Since this phenomenon has been studied in several fields, it is essential to identify its building blocks (BBs). In sum, the BBs are 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 (EEs), understanding the BBs of AC is of the utmost importance.

The capacity to absorb on a national level is not a simple aggregation of the firm-level capability to exploit knowledge within an economy. It is essential to understand that while learning and absorption take place at the firm level, the success or failure of individual firms occurs in orchestration with the entire economic system. Within such a structure, there is a broader nonfirm-specific knowledge base that might best be described as "nonfirm actors" that are crucial to the country-level process of technological accumulation. Innovation involves complex interactions between a firm and its environment. The environment consists first of interactions between firms, especially between a firm and its network of customers and suppliers. Second, the environment involves broader factors shaping the behavior of firms: the social and perhaps cultural context, the institutional and organizational framework; infrastructures; and the processes that determine the generation and knowledge propagation (Cohen & Levinthal, 1989, 1990).

Because of socioeconomic and cultural conditions, it can be argued that EEs may require different capacity-building structures that allow the exploitation of external knowledge, thus allowing the absorption and recombination of knowledge (Cuervo-Cazurra & Rui, 2017; J. U. Kim, 2019).

Considering this context, this study aims to identify and validate the BBs of AC by combining a systematic literature review (SLR) through the ProKnow-C (Knowledge Development Process-Constructivist) technique and econometrics for both developed and developing countries. This investigation also identifies possible thresholds for these BBs in 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 developing economies. In other terms, we analyze whether there is a certain point where the BBs have a differentiated impact on the AC for developed and developing economies.

Here, classifying the countries into two groups (Developed Economies—DEs; and emerging or developing economies—EEs) enables us to compare the most relevant BBs of each group, as well as their respective thresholds, when in the presence of nonlinearity. The idea is to verify whether the most critical BBs for developed countries are indeed the most important ones for emerging and developing countries. Therefore, since each country group has different socioeconomic conditions which can influence BBs, specific policymaking should be considered.

This study contributes to the existing literature by defining the central BBs of AC in developed and developing countries. To the best of our knowledge, there are no studies that deal with selecting AC's BBs, especially in distinct development levels. An additional novelty lies in the adoption of panel data threshold regression within a country-level framework, in order to verify the thresholds of each determinant selected in the literature.

It is noteworthy that papers such as Wu and Hsu (2008, 2012), Ghosh and Wang (2010), and Yasar (2013) used the threshold regression method proposed by Girma (2005). They analyzed whether foreign direct investment (FDI) is dependent on AC for the economic growth of countries. However, these authors did not use the frontier approach proposed by Girma (2005) but proxies to represent AC.

The literature states that FDI is positively associated with innovation efficiency in a region, and the strength of the positive effect of FDI depends on the availability of the AC in the region (Aziz et al., 2019; Bathelt & Cohendet, 2014; Cohen and Levinthal, 1989; Durham, 2004; X. Fu, 2008; Hermes & Lensink, 2003; Jayaraman et al., 2017; Khordagui & Saleh, 2016; Kostopoulos et al., 2011; X. Liu et al., 2019; Mowery & Oxley, 1995; Sanchez-Sellero et al., 2014; Smith & Thomas, 2017; Zahra & George, 2002).

FDI and AC are a source of knowledge for the recipient economy, and in many cases it has been essential elements to develop strategies. Most empirical studies focus on measuring the technological advancement caused by the FDI (Aguiar et al., 2017; De La Potterie & Lichtenberg, 2001;

Girma, 2005; Helpman, 1997; Khalifah et al., 2015; X. Liu & Wang, 2003; Pham et al., 2021; Xu, 2000). It is worth noting that FDI has increased significantly for developing countries.

In this way, it is highlighted the importance of investigating not only the factors that impact the inflow of FDI in a given economy but what are the effects of this capital on the economic growth of the receiving nation, since these impacts may be conditioned to the AC of this receiving market (Abor et al., 2008; Anyanwu, 2006; Dupasquier & Osakwe, 2003; Inekwe, 2013). Our results have straightforward implications for formulating industrial policies and attracting foreign investments.. Specifically, identifying the BBs and possible AC thresholds will provide information to set goals to be achieved before 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 SLR. In the fourth section, the method is described. In the fifth section, the results and discussions are presented. Finally, the final considerations are found in the sixth section of this paper.

2 | THEORETICAL BACKGROUND AND HYPOTHESES DEVELOPMENT

2.1 | Proxies of absorptive capacity

The employment of knowledge and technology from external sources is gaining importance, as this process is a vital component of national innovation processes (Grimpe & Sofka, 2008; King & Lakhani, 2011) allowing companies to increase their resource base and adapt to the market (Zahra & George, 2002).

Several authors such as Cohen and Levinthal (1990), L. Kim (1998), Lane and Lubatkin (1998), Malaguerra (2014), and Zahra and George (2002) define AC as the ability to recognize the 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.

Yet, measuring AC is a complex issue. Most studies usually measure AC with research and development (R&D) proxies, thus ignoring the dimensions of the construct and its implications for different organizational outcomes. However, according to the definition of AC proposed by the previous authors, possible proxies can be raised as BBs by the SRL. Table 1 provides an overview of the various AC proxies used in previous studies, both at the country and company level. It is noteworthy that for the national level, the main proxies identified belong to the group of R&D and human capital, which corroborates the results of the technical ProKnow-C (see Section 3).

Table 1 presents the predominance of R&D activities and human capital proxies for measuring AC. R&D activities can be measured using 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 (Jiménez-Barrionuevo et al., 2011; Lichtenthaler, 2016; Murovec & Prodan, 2009; Shenbarow, 2014).

Silajdzic and Mehic (2015) argue that a higher level of technological development enabled by R&D expenditure is associated with a better growth performance among EEs and that the

TABLE 1 Proxies of Absorptive Capacity

Proxies of absorptive capacity	Author(s)/year	Level
R&D activities	Cohen and Levinthal (1989); Veugelers (1997); Mangematin and Nesta (1999); Becker and Peters (2000); George et al. (2001); Meeus et al. (2001); Stock et al. (2001); Tsai (2001); Petroni and Panciroli (2002); Belderbos et al. (2004); Zahra and Hayton (2008); Murovec and Prodan (2009); Spithoven et al. (2010)	Firm level
	Mowery et al. (1996); Montinari and Rochlitz (2014); Foster-McGregor et al. (2017)	Country level
Knowledge management	Boynton et al. (1994); Lenox and King (2004); Shenbarow (2014); Lichtenthaler (2016)	Firm level
Human capital (investments in technical and academic continuing education/proportion of technical staff/employee training/employees in [illegible]	Luo (1997); Veugelers (1997); Petroni and Panciroli (2002); Muscio (2007); Murovec and Prodan (2009); Mangematin and Nesta (1999); Foster-McGregor et al. (2017); Montinari and Rochlitz (2014)	Firm level
	Mowery and Oxley (1995); Mowery et al. (1996)	Country level
Number of patents	Mowery et al. (1996); Mangematin and Nesta (1999); Ahuja and Katila (2001); George et al. (2001)	Firm level
Number of research publications	Cockburn and Henderson (1998); Mangematin and Nesta (1999)	Firm level
Number of R&D laboratories	Mangematin and Nesta (1999); Becker and Peters (2000)	Firm level
Incentive system	Van Den Bosch et al. (1999)	Firm level
Labor productivity	Mukherjee et al. (2000)	Firm level
Human Resource Management	Vinding (2006)	Firm level
Average wages of foreign companies concerning national companies	Nielsen and Pawlik (2007)	Firm level
Relative efficiency through total factor productivity	Girma (2005); Girma et al. (2008); Girma and Gong (2008)	Firm level

Source: Expanded by the author from Murovec and Prodan (2009), Jiménez-Barrionuevo et al. (2011), and Lichtenthaler (2016).

positive impact of FDI on economic growth is associated with a higher capacity of knowledge and efficiency.

Thus, the increasing importance of regional markets, improvements in 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 R&D outside their countries of origin. Therefore, the BBs of AC in the host country are essential for foreign investments to have positive effects on local economic growth. However, it is assumed that the most critical BBs for the developed countries are not the most important for the emerging and developing countries as the economies have different socioeconomic conditions. In this context, our first research hypothesis is:

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

2.2 | Absorptive capacity thresholds

There is no paper analyzing 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. For example, the works of Girma (2005) and Yasar (2013) identified the AC thresholds for manufacturing companies. Wu and Hsu (2008, 2012) have analyzed the same phenomenon for several countries.

Girma (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 nonlinearity: the productivity benefit of FDI increases with the AC up to a certain threshold, and after that 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 AC. According to the results, the companies with greater AC benefit significantly more from foreign capital. The results also suggest a limit (threshold) for such benefits. Besides, the productive contribution of skilled labor is significantly higher in companies that import foreign capital. Developing policies to increase AC 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 more in-depth when the level of AC is above a specific limit. Thus, higher AC can enable companies to maximize the benefits associated with new technologies and manufacturing techniques transferred from high-income countries.

Wu and Hsu (2008) examined the effect of FDI on economic growth. The authors used proxies for AC, such as initial gross domestic product (GDP), human capital, and trade volume. The results indicate that initial GDP and human capital are important factors to explain 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 essential 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 nonlinearity 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 (Lapan & Bardhan, 1973; Miguelez & Moreno, 2015; Zhang et al., 2010). Evidence stresses that AC must present nonlinearity on several occasions. As economies have different socioeconomic conditions, and therefore possibly more expressive BBs for economic development, it is believed that the possible thresholds are different for each BB. Besides, BBs do not represent nonlinearity for both groups.

Parallel to this, there is a need to analyze whether there are minimum levels (thresholds) of variables considered BBs 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.

3 | SYSTEMATIC LITERATURE REVIEW

In order to identify the possible BBs, we used the SLR technique. The SLR presents two advantages: (a) it provides a reliable database that represents important scientific papers in this field; and (b) it can be replicated. We used the ProKnow-C to select scientific publications, which was proposed by Tasca et al. (2010) and developed by the Laboratory of Multicriteria Methodologies of Decision Support (LabMCDA), Federal University of Santa Catarina (UFSC). The ProKnow-C technique was already employed in previous studies (Cardoso et al., 2016; Ensslin et al., 2014; Nuernberg et al., 2016).

ProKnow-C has the main goal of providing knowledge about a fragment of scientific literature. 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 an investigation and an analysis of the characteristics of this PB (i.e., bibliometric analysis); (iii) to critically reflect on the position of the studies, based on the theoretical affiliation established by the researcher (i.e., systematic 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 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 (Dutra et al., 2015; Silva et al., 2014). Therefore, the process is composed of four stages, as shown in Figure 1.

In order to reach the objective of the research, only the first three main stages of the ProKnow-C tool were applied since the objective of this review is not to analyze points that have not yet been studied by authors. Instead, this study aims to analyze the BBs of AC considering the research already carried out. Thus, to carry out the first three stages of the methodology, each stage was broken down into steps.

We created a protocol, which can be found in Online Appendix A, including the primary information about the research. Table 2 shows the number of papers selected in the databases.

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 et al., 2018; Castillo et al., 2011; Elmawazini, 2014; Foster-McGregor et al., 2017; Fracasso & Marzetti, 2014; Huebler et al., 2016; Khordagui & Saleh, 2016; Miguelez & Moreno, 2015; Silajdzic & Mehic, 2015). These mentioned used the panel data structure. From the whole sample, 50 articles (83.3%)

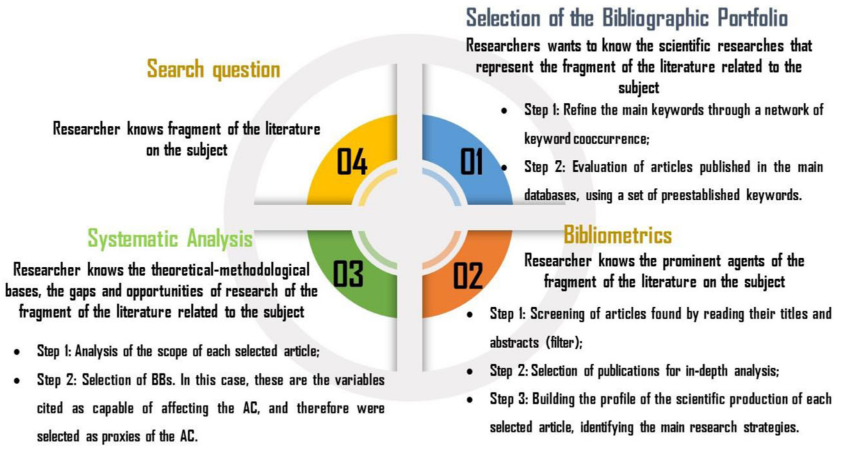

FIGURE 1 Stages of the ProKnow-C methodology [Colour figure can be viewed at wileyonlinelibrary.com]

TABLE 2 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	
Total articles: country level	11	

Source: Prepared by the authors (2019).

used panel data, five articles (8.3%) cross section, and five articles (8.3%) were not mentioned, including the recent literature reviews.

The number of citations is a useful tool for identifying the most important studies. However, recent articles did not have enough time to become prominent articles. Table 3 shows the 15 most cited articles among the 60 selected, along with the number of citations in the Scopus and Web of Science databases.

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

Table 4 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.

The main topics covered in these articles (Table 4) refer to the search for the main AC indicators. The authors claim that the ability to attract FDI can bring immense benefits to a recipient country, as it is a source of knowledge and has been an essential element in the development strategies of some economies. The authors state that the effects of FDI on productivity growth are dependent on AC.

Figure 2 shows the possible BBs of AC according to the literature, classified as economic, human capital, and innovation. We classified the BBs into three groups in order to analyze which factors

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	[a]
Marcin (2008)	39	19
Ahmed (2012)	28	15
Higoacuten and Vasilakos (2011)	22	4
Krammer (2010)	16	[a]
Caragliu and Nijkamp (2012)	20	18
Anwar and Nguyen (2014)	17	[a]
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

[a]Article not in the base.

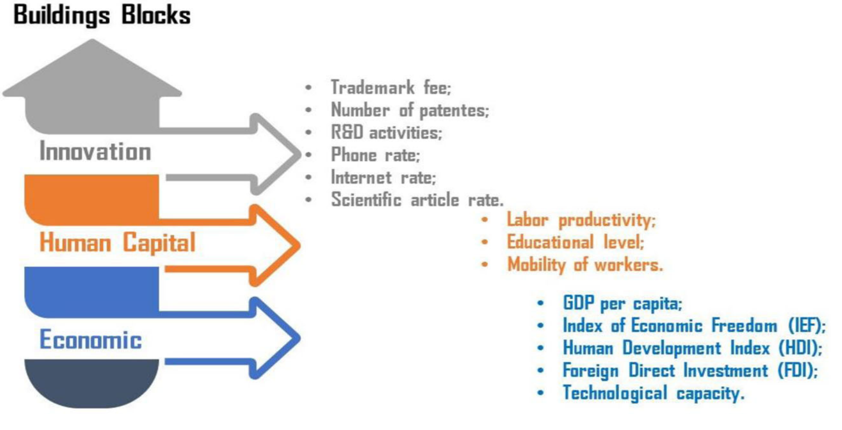

FIGURE 2 Possible AC BBs selected by the literature: 11 articles (national-level). (Source: Prepared by the author, 2019) [Colour figure can be viewed at wileyonlinelibrary.com]

have more proxies mentioned in the literature as well as to maintain order. Moreover, clustering was used to identify the weight that certain factors can offer to impact AC. These factors were selected based on the variables used by the authors, mode of measurement of AC, or cited by the articles as BBs of AC.

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

We found that R&D and human capital are considered the most frequent determinants of AC. This finding corroborates with the literature as multinational companies play an essential role in economic development by increasing their R&D efforts, especially in developing countries.

TABLE 4 Analysis of the focus and main results/contributions of the 11 articles that presented study populations on a national-level

Author(s)/year	Study population	Objective	Possible BBs of AC	Limitations/contributions/originality
Aldieri et al. (2018)	Japan, United States, Europe	Explore how firm-level absorptive capacity mediates the relationship between rent and R&D spillovers in three economic areas (Europe, Japan, and the United States)	R&D activities and the 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 relates 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)	Forty developed and developing countries	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 low levels of development, which is characterized as a limitation of the study. The results also supported studies that found that foreign R&D spillovers are more influential in countries with higher absorptive capacity

(Continues)

TABLE 4 (Continued)

Author(s)/year	Study population	Objective	Possible BBs of AC	Limitations/contributions/originality
Khordagui and Saleh (2016)	Thirty emerging economies	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 et al. (2016)	Thirty-nine developed and developing countries	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

(Continues)

TABLE 4 (Continued)

Author(s)/year	Study population	Objective	Possible BBs of AC	Limitations/contributions/originality
Miguelez and Moreno (2015)	Two hundred seventy-four European regions of 27 countries	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, with more developed regions achieving higher returns from the knowledge flows received by mobile inventors, while less advanced areas rely more heavily on networks.
Silajdzic and Mehic (2015)	Ten Central and East European countries	To analyze the exogenous impact of foreign direct investment 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 foreign direct investment while describing the character of foreign direct investment 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.

(Continues)

TABLE 4 (Continued)

Author(s)/year	Study population	Objective	Possible BBs of AC	Limitations/contributions/originality
Fracasso and Marzetti (2014)	Twenty-four OECD countries	To investigate how a country's absorptive capacity and relative backwardness affect the impact of international R&D spillovers on the total factor productivity	Average years of schooling; R&D Activities; foreign direct investment	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)	Gulf Cooperation Council (GCC) countries	Contribute to the empirical literature by investigating the hypothesis that external direct investment flows produced positive productivity spillovers for the GCC countries during the period 1995–2011	GDP per capita labor productivity; total factor productivity; 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 et al. (2011)	Sixteen Latin American countries	This paper examines two sources of spillovers of global knowledge: foreign direct investment and trade	Activities in R&D; Average years of schooling; foreign direct investment	It is suggested that more general policies should be pursued which not only attract foreign direct investment but also benefit national enterprises, for example, by building modern infrastructures, increasing and strengthening institutions to accelerate and sustain economic growth.

(Continues)

TABLE 4 (Continued)

Author(s)/year	Study population	Objective	Possible BBs of AC	Limitations/contributions/originality
Krammer (2010)	Twenty-seven emerging and 20 developed countries	Use the latest developments in the integration and infrastructure techniques of the panel unit to unlink the effects of international spillovers through trade and foreign direct investment I inflows into total factor productivity	Activities in R&D; average years of schooling; foreign direct investment	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 specific 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 foreign direct investment.
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).

TABLE 5 Building blocks of absorptive capacity

Author (s)/year	Possible absorptive capacity building blocks	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[a] dataset on the average years of secondary education in the population. They followed the approach of Cohen and Levinthal (1989) using the registered R&D value of the ANBERD[b] data set as an additional indicator of absorptive capacity.
Khordagui and Saleh (2016)	Human capital	The human capital variable is measured by the average years of schooling for adults over 25 years of age.
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 i sharing	*Participation of highly qualified labor force*: Percentage of highly skilled working time in all working hours. The higher skills of workers are commonly associated with higher education, including a better understanding of technology. *Index of economic freedom*: The index of economic freedom in the form of registration. This index is the average of 10 subindices: 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. *Tertiary education rate*: The 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. *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. *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 preexisting technologies and technological capabilities that facilitate the adoption of new technologies.
Silajdzic and 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.

(Continues)

TABLE 5 (Continued)

Author (s)/year	Possible absorptive capacity building blocks	Definition of authors
Miguelez and 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 AC in the assimilation of knowledge flows from labor mobility. *Inventor networks*: Interregional technology networks.
Fracasso and Marzetti (2014)	Human capital and R&D activities	*Human capital*: Average years of schooling. *R&D activities*: The results suggest that absorptive capacityis positively associated with international repercussions of R&D.
Elmawazini (2014)	GDP per capita, labor productivity, total factor productivity, human capital, technological capacity, human development index	*GDP per capita*: Developed countries are expected to have a higher level of human capital and therefore benefit more from foreign direct investment than developing countries. *Labor productivity*: Foreign presence has a significant positive effect on labor productivity. *Total factor productivity* (TFP): There are negative impacts on the TFP resulting from the allocation of FDI in regions that do not have minimum levels of absorptive capacity. Absorptive capacity is defined as the TFP level in the previous period divided by the maximum TFP level in the industry. *Human capital*: Measured by average years of schooling. *Technology capability*: Measured by royalty receipts and license fees. *Human Development Index*
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 their 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 AC to be able to produce spillover of productivity from local firms.

[a]http://www.barrolee.com/. These data were used as a measure of absorptive capacity in similar studies. [b]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.

R&D activities can be measured through investments in the area, workforce training, or professionals linked to this type of activity. Human capital can be measured through average years of study or by the level of knowledge diffused in the region (e.g., the number of people with higher education; Jiménez-Barrionuevo et al., 2011; Lichtenthaler, 2016; Murovec & Prodan, 2009; Shenbarow, 2014).

Furthermore, human capital is one of the most important determinants of AC. This finding is in line with the literature since Murovec and Prodan (2009) showed that companies' skills in recognizing and assimilating new knowledge derive, to a large extent, from the individual capabilities of their workers. Moreover, according to Castillo et al. (2011), human capital is important because there is evidence that the positive impacts of the development of FDI flows depend on the high level of human capital. Miguelez and Moreno (2015) comment on the positive role of AC in assimilating knowledge flows from workers' geographical mobility.

Identifying the BBs of AC facilitates achieving goals before a possible FDI attraction policy. This analysis brings tools to enhance positive productivity spillovers and avoid negative spillovers related to competition for the domestic industry. From the systematic review of the literature, the articles with possible BBs at the national level were identified (11 articles in Table 4). In addition, these possible country-level BBs of AC were evaluated and structured in categories (3 categories and 14 indicators of Figure 2). All of this substantiated the choices made in our method (variables, databases, sample, etc.) to conduct the later econometric analyzes that will answer our research hypotheses.

4 | METHOD

4.1 | Data sources and group classification

The classification of countries by the International Monetary Fund (IMF) divides the world into two groups: DEs; and emerging and developing economies (EEs). The IMF uses three criteria to divide countries. First of all, they use the per capita income level of each country. Second, IMF considers export diversification because several countries, like the oil exporters, have high per capita GDP, although they cannot be considered developed because the economy concentrates exportation of a few products, especially commodities. The third criterion takes into account the degree of integration into the global financial system.

In relation to the economy, developed countries have a very high degree of industrialization, with a predominance of the tertiary (trade activities) and quaternary (knowledge-based services and information-sharing) sectors. A relevant factor in relation to economic development is the GDP, which represents the monetary value of goods and services produced by a country in one year, which is one of the main indicators of a nation's economic potential. Per capita income, which represents the average salary per person, is also considered in a nation's development classification. In developed countries, GDP and income per capita are high, and income distribution is generally homogeneous.

Emerging countries are those whose society's quality of life varies between medium and high and whose industrial sector, being recent, is in development. They are generally less industrialized than developed countries and more industrialized than underdeveloped countries. The economies of these countries are dependent on the great powers, and the distribution of income is still heterogeneous.

According to the IMF, 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 (TFP calculation, which will be further used to measure AC. Data were collected from the World Bank Group for the 1995–2015 time span. Thus, the study population consists of 124 countries described in Online Appendix B.

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

4.2 | AC computation

The method described by Girma (2005) allows a test for the existence and significance of threshold levels of AC in the relationship of productivity growth coming from FDI. AC, in turn, is defined as the TFP level in the previous period divided by the maximum TFP level among countries. Denoting the maximum level of TFP in countries at time t - 1 by TFP * it −1, the AC of the country can then be expressed as

$$AC_{it} = \frac{TFP_{it-1}}{TFP*_{it-1}}. \tag{1}$$

Girma (2005) employs a TFP-based technology frontier proxy for AC, as presented in (1). TFP demonstrates why one region can 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). 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. In this way, if two countries have the same amounts of physical capital and human capital, and country A managed to generate more product than B, it would have a higher per capita income. Country A is arguably superior in technology. Thus, it is assumed that countries that can invest their resources more efficiently resulting in a higher AC, as they can benefit more from foreign investments. Thus, the use of Girma's approach (2005) for the calculation of AC is justified instead of employing a single proxy variable to represent AC.

However, the aforementioned AC computation requires the estimate of country-level TFP. The first to associate the aggregate production function with productivity was Tinbergen (1942). Yet, the seminal contribution to this theme was given by Solow (1957) by creating a link between the production function and a productivity index 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, a more general indicator of output per unit of input, which later became known as TFP or Solow residue, reflecting technological progress and other elements that act as determinants of economic growth.

Thus, TFP intends to measure the efficiency of an economy when combining all its resources to generate a product. Based on this concept, the dynamics of the indicator is the result of technological progress in the economy (Messa, 2013). Accordingly, the classic production function has become inefficient in representing the 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 (Feng et al., 2018; Sarbu, 2017), sustainability (S. Chen & Golley, 2014; Husniah & Supriatna, 2016; B. G. Liu et al., 2016; Wei et al., 2020; Zhang et al., 2020), knowledge proxies (Bhattacharya et al., 2021; Elmawazini, 2014; Hidalgo & Hausmann, 2009; Lenox & King, 2004), and energy (Ackerberg et al., 2015; Levinsohn & Petrin, 2003; Mirza et al., 2021; Olley & Pakes, 1996; Wooldridge, 2009).

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.

$$Y = AL^{\alpha} K^{\beta}, \tag{2}$$

where Y is the production volume, L is the work stock, and K is the capital stock. In logarithmic terms, Equation (1) can be described as

$$\ln Y = \ln A + \alpha \ln K + (1 - \alpha) \ln N, \tag{3}$$

where α and β are parameters with $\beta = (1 - \alpha)$ and A is the exogenous technological parameter (TFP). Making the time derivatives of Equation (3) is obtained (4):

$$\frac{dA}{A} = \frac{dY}{Y} - \left(\alpha \frac{dL}{L} + \beta \frac{dk}{k} \right) = R = TFP, \tag{4}$$

Where R is the Solow residue (i.e., the product growth rate not explained by the growth of inputs). Thus, Equation (4) 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 (4) 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 the product. From this conceptualization, the dynamics of the indicator would be a result of the technological progress of the economy.

Olley and Pakes (1996) developed a two-stage procedure where, in the first stage, a reduced production function is estimated with the investment used as a proxy for the productivity shocks observed by the company and correlated with variable inputs. Later, based on the paper 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 datasets 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 investments for lack of information.

Given this, several adaptations and extensions of the Olley and Pakes estimator were developed. Recently, the time assumptions underlying the semiparametric estimators of Olley and Pakes and Levinsohn and Petrin have been questioned by Ackerberg et al. (2015) who suggest an alternative two-step estimator, where all relevant parameters are retrieved in the second stage, in which the addition of polynomial terms into the regression generates a better estimate. 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 et al.

Thus, this paper will compare three TFP calculation methods: Levinsohn and Petrin (2003), Wooldridge (2009), and and Ackerberg et al. (2015). As intermediate input, the energy consumption per capita is chosen, as pointed out in the literature. It is noteworthy that for the Olleys and Pakes (OP) model, the investment variable was used as an intermediate input and later criticized by Levinsohn and Petrin (LP), who used the energy proxy.

For the calculation of country TFP, the variables in Table 6 were selected for the four above methods. Table 7 shows the results of the TFP models. The LP results demonstrate that the economically active population and depreciated capital variables have a positive and statistically significant effect on the constant GDP. The LP model was statistically significant at a 1% level (*F* statistic). The results of the Wooldridge (2009) model also showed similar estimates to the OP and LP models. In this sense, 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%. According to the result, the Ackerberg, Caves, and Frazer (ACF) model was statistically significant at 1% level, and with a positive parameter. Moreover, the 1% increase in depreciated capital affects GDP by 0.87%.

Although the ACF (Ackerberg et al., 2015) model proposes an improvement of the OP and LP models and still presented results with statistical significance, the WOOL (Wooldridge, 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, it was chosen to analyze the WOOL model.

4.3 | AC building blocks

We only selected countries with full data availability, which resulted in a panel with 45 countries (23 developed and 22 emerging countries) ranging from 2007 to 2015. We used balanced panel data because the threshold regression technique requires all data available to estimate the AC's BBs. The countries analyzed for DE and EE groups are shown in Online Appendix C.

All the possible national-level BBs found in the SLR were initially considered. The data on BBs are secondary and were extracted from the economic freedom index (EFI), the Global Competitiveness Report, the World Investment Report, the World Bank Group, and the Human Development Report. Then, through a data-driven approach, the final BBs were selected (BBs that did not substantially reduce countries samples or that were not highly correlated with each other). These BBs defined for analysis are shown in Table 8.

Additional variables were collected for the innovation category (e.g., trademark fee, number of patents, phone rate), but discarded due to high collinearity. In any case, R&D information was employed, as this variable is the most cited proxy for AC. Also, GDP per capita was excluded for the high collinearity with other economic variables. Table 9 presents the descriptive statistics of the BBs analyzed.

TABLE 6 Variables to calculate the total factor productivity

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 the 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	The 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).

TABLE 7 Results of total factor productivity models

Variables (ln)	Olleys and Pakes (OP) (1996)	Levinsohn and Petrin (LP) (2003)	Wooldridge (WOOL) (2009)	Ackerberg, Caves, and Frazer (ACF) (2015)
Economically A. Pop.	0.3354***	0.3283***	0.3410***	0.1592***
Cap.deprec	0.3598***	0.3618***	0.3656***	0.8565***

Source: Authors. Panel data (1995–2015) - Coefficients β. Consider: *** $p < 0.01$.

4.4 | Econometric models and estimation strategy

Initially, a panel data feasible generalized least squares (FGLS) was estimated incorporating 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, the variance inflation factors (VIF) did not show multicollinearity to developed countries' model (2.64) nor emergent economies' model (1.51) (the Correlation Matrix is presented in Appendix D). The results from the FGLS allow us to test distinct model specifications and decide the better suited model to be further analyzed for nonlinearity.

Therefore, to continue with the analyzing process, following Hansen (1999), we applied the fixed-effects panel threshold regression method (Hurlin, 2018). Thus, for analysis of AC thresholds, Equation (5) was applied.

$$AC = {\beta_i}' X_{it} + \sum_{i=1} \beta_i BB_i \; + \beta_k BB_{kt} I\left(BB_K \leq \lambda\right) + \beta_k BB_{kt} I\left(BB_k > \lambda\right) + \alpha_i + \varepsilon_{ij}, \qquad (5)$$

where X is country-level control variables, BB_i is the building blocks selected through the SLR presented in Section 3, BB_k is the building block subject to the nonlinearity hypothesis, $I(.)$ is the indicator function, λ is the threshold for the AC of each building block, α_i is the fixed effect, and $\mathcal{E}_{ij}$ is the stochastic disturbance.

We estimate a panel threshold model based on the method proposed by Hansen (2000), by fitting the fixed-effect panel threshold model, which requires balanced panel data (Wang, 2015). Besides, the computations used heteroskedasticity consistent (White) standard errors.

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 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.

However, in both the linear and nonlinear estimations, a possible problem is endogeneity. Accordingly, the explanatory variables were tested for endogeneity using the C-statistic test (sometimes called the difference-in-Sargan test). To test for endogeneity, we employed both lagged values of the explanatory variables, and additional instruments (i.e., instruments highly correlated with the explanatory variable but somewhat uncorrelated with the dependent variable) when data were available. As shown in Table 10, FDI seems to be endogenous in EEs. Therefore, 1-year lagged values were employed in the estimations to avoid possible endogeneity issues

TABLE 8 Explanatory and threshold variables

Dimension	Building blocks (BB)	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 nonprofit. 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 dimension 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 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. The general government usually refers to local, regional, and central governments (World Bank Group).

(Continues)

TABLE 8 (Continued)

Dimension	Building blocks (BB)	Definition
economic	BB5 – Index of economic freedom (IEF) – *ln_IEF*	Economic freedom is the fundamental right of every human being to control his/her 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 index of economic freedom measures economic freedom based on 12 quantitative and qualitative factors, grouped into four broad categories, or dimensions, 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 productive internal 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 a rapid and free flow of information (The Global Competitiveness Report).
Economic	BB8 – Human development report (HDI) – *ln_IDH*	The human development index 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).

TABLE 9 Descriptive statistics of building blocks

Building Blocks	Group	Mean	Minimum	Maximum	Standard deviation
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*	DE	109.6565	90.66246	163.9305	16.07739
	EE	–	–	–	–
BB3 - Higher Education – *ln_HigherEdu*	DE	5.301208	4.37	6.27	0.4264256
	EE	4.256566	3.35	5.04	0.3470972
BB4 – Government expenditure on education, total (% of GDP) – *ln_EduExpend*	DE	5.485551	3.3	8.55955	1.100235
	EE	–	–	–	–
BB5 – Index of Economic Freedom (IEF) – *ln_IEF*	DE	71.54348	62.1	82.6	4.315792
	EE	59.95404	44.1	71.7	6.234451
BB6 - Foreign Direct Investment (FDI) – *ln_FDI*	DE	27650.67	50	379894	53414.36
	EE	18582.87	14	135610	27496.88
BB7 – Infrastructure Index – *ln_Infra*	DE	5.345507	3.64	6.65	0.70985
	EE	3.833838	2.43	5.31	0.5918743
BB8 – Human Development Report (HDI) – *ln_IDH*	DE	0.8806184	0.804	0.949	0.0336865
	EE	0.7476212	0.556	0.855	0.060245

Note: DE, Developed countries; EE, Developing and emerging countries.

TABLE 10 Endogeneity test

	Explanatory variables	Instrumental variables	*p*-value (C estatistic)
Developed countries	ln_R&D	ln_R&D(t-1); ln_Patent; ln_Article	0.6058
	ln_SecEdu	ln_FemaleEnr; ln_MaleEnr	0.7192
	ln_HigherEdu	ln_HigherEdu(t-1)	0.1008
	ln_EducExpend	ln_Paten; ln_Article	0.7351
	ln_IEF	ln_IEF(t-1)	0.3361
	ln_FDI	ln_FDI(t-1)	0.1856
	ln_IDH	ln_IDH(t-1)	0.4268
Emerging countries	ln_R&D	ln_R&D(t-1); ln_Article	0.1068
	ln_HigherEdu	ln_HigherEdu(t-1)	0.2875
	ln_IEF	ln_IEF(t-1)	0.6796
	ln_FDI	ln_FDI(t-1)	0
	ln_IDH	ln_IDH(t-1)	0.8989

TABLE 11 Models estimated by feasible generalized least squares: Developed countries

Building Blocks (ln)	Dimension	Model 1	Model 2	Model 3	Model 4
R&D	Innovation	0.0094***	–	–	–
R&D$_{(t-1)}$		–	0.0111***	0.0124***	0.0116***
SecEdu	Human capital	0.0183***	0.0134***	0.0177***	–
SecEdu$_{(t-1)}$		–	–	–	0.0081
HigherEdu		0.0287***	0.0171**	0.0164*	0.0144
EducExpend		0.0281***	0.0271***	–	–
EducExpend$_{(t-1)}$		–	–	0.0277***	0.0271***
IEF	Economic	−0.0159	−0.0002	−0.0033	−0.0014
FDI		0.0004*	0.0003*	0.0005**	0.0005*
FDI$_{(t-1)}$		–	–	–	–
Infra		0.0295***	0.0300***	–	–
Infra$_{(t-1)}$		–	–	0.0179**	0.0202***
IDH		0.1029***	0.1219***	0.1142***	0.1385***
Constant		−0.6090***	−0.6086***	−0.6011***	−0.5550***
BIC	–	−1066.612	−950.882	−955.8988	−955.8624
AIC		−1096.606	−979.8164	−984.8332	−984.7968
VIF		2.64	2.65	2.68	2.68

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

(Dang, 2011; Kwok & Tadesse, 2006). Moreover, some models included lagged values of other variables, following the theoretical adequacy of the model (Moralles & do Nascimento Rebelatto, 2016).

5 | RESULTS AND DISCUSSION

5.1 | Linear analyses

Tables 11 and 12 present the FGLS estimation results for DEs and EEs, respectively. We also used the Bayesian Information Criteria (BIC) and the Akaike Information Criterion (AIC) to compare the goodness-of-fit of each model. The results show that according to the information criterion analysis, model 1 presents the best goodness-of-fit results for DE (BIC = −1066.612; AIC = - 1096.606 and EE (BIC = 722.3849; AIC = - 744.5783).

Our econometric results suggest that BBs have a different impact on AC depending on the development stage. This is an important finding because policymakers must consider different strategies to improve the AC level. Also, our findings show that authorities in developing economies must follow specific strategies to achieve economic development.

R&D has a positive and statistically significant impact on both developed and emergent economies. Moreover, the 1-year time lag for R&D also reveals a positive and statistically significant effect for both country groups. The positive impact of the innovation dimension on AC was expected and explored by several authors (Aldieri et al., 2018; Foster-McGregor et al., 2017; Khordagui e Saleh, 2016). We contribute to this literature showing that the impact of R&D on AC is higher in developed countries than in emergent economies. For example, according to

TABLE 12 Models estimated by Feasible Generalized Least Squares: Emerging countries

Building Blocks (ln)	Dimension	Model 1	Model 2	Model 3	Model 4
R&D	Innovation	0.0089***	–	–	–
R&D$_{(t-1)}$		–	0.0103***	0.0074***	0.0094***
SecEdu	Human capital	–	–	–	–
SecEdu$_{(t-1)}$		–	–	–	–
HigherEdu		−0.0024	−0.0285	−0.0022	0.0257
EducExpend		–	–	–	–
EducExpend$_{(t-1)}$		–	–	–	–
IEF	Economic	−0.0316	−0.0127	−0.0338	−0.0347
FDI		0.0136***	0.0154***	–	–
FDI$_{(t-1)}$		–	–	0.0129***	0.0126***
Infra		0.0404***	0.0505***	0.0414***	–
Infra$_{(t-1)}$		–	–	–	0.0209*
IDH		0.1349***	0.1780***	0.1369***	0.1313***
Constant		−722.3849	−0.0781	−0.0254	−0.0224
BIC	–	−722.3849	−733.8202	−722.5892	−719.0044
AIC		−744.5783	−756.0136	−744.7826	−741.1978
VIF		1.57	1.57	1.58	1.58

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

Model 1, R&D increases AC by 0.0094% for developed countries and 0.0089% emergent countries. There are some explanations for the slightly better elasticity of developed countries. First, emergent economies fail to take advantage of R&D (Khordagui e Saleh, 2016; Silajdzic e Mehic, 2015). Second, there are several drivers of R&D according to the location, which can provide a distinct impact on developed and emergent economies (Von Zedtwitz and Gassmann, 2002). Third, asset augmentation investments are historically concentrated in developed and developing countries that receive more investments in asset exploitation (Chiarini et al., 2020). Fourth, emerging market multinationals promote R&D internationalization in order to expand international markets and product diversification influences R&D performance (Jiménez-Barrionuevo et al., 2011; Lichtenthaler, 2016; Murovec & Prodan, 2009; Shenbarow, 2014; Tang et al., 2019). For this reason, policymakers in emergent economies must develop strategies to improve the use of foreign investment, such as human capital and knowledge spillover in national companies (Aldieri et, al., 2018; Huebler et, al., 2016; Miguelez & Moreno, 2015).

The studies undertake by Cohen and Levinthal (1989, 1990) consider R&D to be a dual function within the firm-level innovation process, as they are necessary for the generation of new knowledge and contribution to the AC. Research shows that companies that conduct their own R&D are better able to use information that is available externally. Therefore, companies invest in R&D not only to develop new processes and product innovation but perhaps mainly, to develop and maintain their broader competitive capabilities and to assimilate and explore available external information (Cohen & Levinthal, 1989). The recognition of this dual role suggests that ease of learning will also affect the organization's incentives to conduct R&D.

The least developed countries are exposed to international competition, but in general they do not have a consolidated technological capacity. Thus, they run the risk of seeing the gap widened between them and the developed countries. However, the increasing importance of regional markets, the improvement of communication technologies, the flexibility to physically move equipment and people, as well as the qualification of the workforce and cost pressure, among others, have led multinationals to increasingly invest in R&D outside their countries of origin. Our analysis of the human capital dimension shows that the secondary education and the higher education index are important variables to increase AC in DEs. However, the higher education index did not show statistical significance, either the expected sign to emergent economies. The higher education index measures the quality of education assessed by business leaders, which reveals that companies invest directly in AC when they send their staff for training at advanced levels. It occurs because AC in an organization depends on the professionals who developed an interface with the external environment or subunits within the organization (Schmidt, 2005). This finding corroborates with previous studies, which states that knowledge improvements facilitate the capacity to absorb new technologies (Huebler et, al., 2016). In contrast, in emergent economies, the higher education index did not show statistical significance. This finding was unexpected due to the recurrent positive impact of human capital on AC. One possible explanation is that developing countries have difficulties with quality control. The focus of policies to encourage scientific publication leads researchers to look for more generic and less specialized journals, which reduces the visibility of what is produced in the country.

Within the aforementioned context, China stands out, because all higher education has grown considerably, and other countries are not able to follow. According to Said (2015), the BRICS countries and also Egypt need to increase the number of people looking for exact courses, such as engineering. Worldwide, according to his research, the average is that between 20% and 30% of university students are from technological fields, which, in developing countries, becomes a "weakness."

The Science and Engineering Indicators (2018) report highlights that Americans remain the leader in many aspects of scientific production, but have been losing ground in global competition, especially for developing countries. Brazil appears in 12th place among the countries with the largest number of published papers, with 53 thousand articles in 2016 - China, in the same year, had 426 thousand publications. Brazil had a significant increase in the number of articles published, but it is far behind the EEs that are among the top 10, and investments in science and technology have been falling severely in recent years.

Thus, scientific and technological development depends on continued, permanent investment, as China does in some sectors. Countries that are betting on continued and permanent investment, with a consolidated policy, are making progress. Brazil initiated such a process in recent years. However, unfortunately, Brazil, like other developing countries, is now seeing a deconstruction of this aspect.

We also analyzed government spending on education. As expected, education spending has a positive and significant impact on AC in developed countries. However, we did not analyze this variable in emergent economies due to the lack of data. Our findings corroborate with previous studies (Jiménez-Barrionuevo et al., 2011; Leiponen, 2005; Lichtenthaler, 2016; Murovec & Prodan, 2009; Schmidt, 2005; Shenbarow, 2014). As the literature points out, the abilities of companies to recognize and assimilate new knowledge are largely due to the individual capacities of their workers. This relationship is explained because qualified workers have higher abilities to assimilate and use new knowledge. Since the firm's AC is directly influenced by its employees, their level of formal education, professional experience, and training have a positive influence on companies' AC (Schmidt, 2005).

The results presented by Leiponen (2005) affirm that qualified personnel is fundamental for innovation to be successful. For the organization to benefit from product and process innovation, it must have sufficient internal competence. With low levels of internal knowledge, an organization will not be able to internalize and effectively use the knowledge created or accessed. Another interesting finding is that the EFI does not impact AC for both developed and emergent economies. According to the literature, economically free societies allow labor, capital, and goods to move freely, making business according to the market rules. This free environment promotes new technologies and facilitates the innovation process (Huebler et al., 2016). However, our findings suggest that the EFI does not impact AC on a country level. For example, countries like Argentina, Brazil, and Poland have low EFI, although they have presented high AC. In this way, we can argue that the lack of statistical significance can result from problems in the indicator itself since it needs several pillars for measurement. This unexpected result must be better explored by future studies.

The relationship between FDI and AC has been analyzed in the literature. Our findings corroborate with several previous studies arguing in favor of foreign investments to improve the local AC (Abor et al., 2008; Alfaro et al., 2004; Anyanwu, 2006; Ayanwale, 2007; Bevan & Estrin, 2004; Bevan et al., 2004; Dikova & Van Witteloostuijn, 2007; Dupasquier & Osakwe, 2003; Estrin & Uvalic, 2016; Girma, 2005; Inekwe, 2013; Kalotay, 2010; M. Kim, 2015; Li-Ming et al., 2016; Owusu-Nantwi & Erickson, 2019; Padilla-Perez & Nogueira, 2016; Shuxian e Qian, 2009; Ubeda & Pérez, 2017; Ying-Chun & Holtbrügge & Kreppel, 2012). Moreover, our findings advance the current literature showing that the impact of FDI is higher in emergent economies than in developed countries. It occurs because the literature demonstrates that FDI is essential for the introduction of advanced technology, and it is significant for the development of emerging countries in the short term (Li-Ming et al., 2016; Ying-Chun et al., 2009). Some developing countries with robust infrastructure, highly trained workforce, reasonable protection of intellectual property—especially in Asia and the Pacific—have attracted FDI in R&D. These countries benefit from opportunities arising from the growing demand of multinationals for inexpensive talent and developing markets. Its policies focus on measures to maximize the indirect effects of FDI technologies and improve absorption capacity by encouraging local firms to engage in R&D.

As expected, the infrastructure index has a positive and significant impact on the AC for developed (0.029%) and emergent (0.040%) economies. Note that infrastructure double impacts AC in emergent economies than developed regions. It occurs because 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. The elasticity of the infrastructure index is higher in emergent regions because these countries can take advantage of improving their infrastructure to increase the local AC.

The human development index (HDI) can be considered a proxy for the quality of life (education, health, and income) of people living in developed and emergent economies. The HDI has a positive impact on AC in both country groups. One important finding is the better HDI elasticity in emergent countries, which shows that a better quality of life in developing regions provides a better AC. The channels linking HDI and AC can be explained by better current and future education (Elmawazini, 2014), better health conditions, which provides a long-life expectancy and better income due to a more sophisticated environment. Also, this relationship could be explained by the developed capabilities required to improve AC (Ferraz et al., 2020; Sen, 2001).

It is worth noting that FDI has increased significantly for developing countries over the past two decades. In this way, it is highlighted the importance of investigating not only the factors that impact the inflow of FDI in a given economy but what are the effects of this capital on the

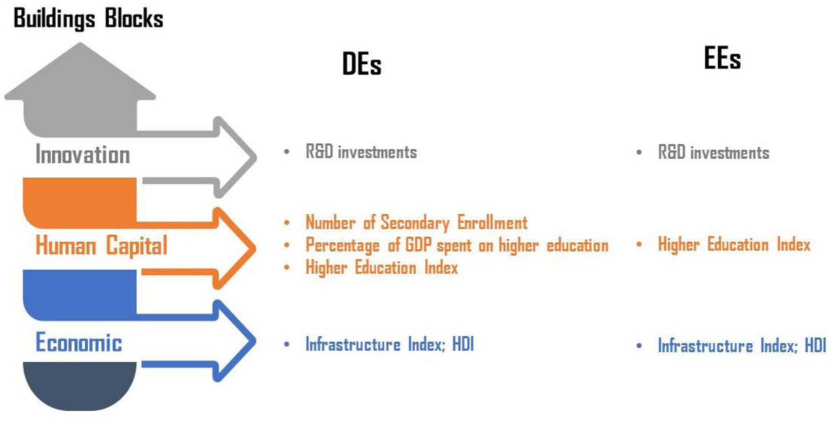

FIGURE 3 Building blocks for developed and emergent countries [Colour figure can be viewed at wileyonlinelibrary.com]

economic growth of the receiving nation, since these impacts may be conditioned by the AC of this receiving market (Abor et al., 2008; Anyanwu, 2006; Dupasquier & Osakwe, 2003; Inekwe, 2013). Our analysis proves that BBs in developed and emergent regions are not the same. This finding answers our first hypothesis (H_1). For both groups, the R&D Investment, FDI, country infrastructure index, and HDI variables can be considered BBS for AC. However, for DEs, BBs also consider 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 dimension. It is noteworthy that the EFI variable was not detected as an AC BB in any of the groups.

Thus, for the innovation dimension, R&D Investments are considered as a BB for both groups. For the human capital dimension, the number of secondary enrollment, the higher education index, and the percentage of GDP spent on higher education are reported as BB for DE, and for EE, the higher education index is said as BB. Finally, for the economic dimension, the FDI, the country's infrastructure index, and the HDI are rated as BB for both groups. These results can be demonstrated in Figure 3.

5.2 | Nonlinear analyses

Advancing the analyzing process, we present the threshold regressions, which contribute to showing the nonlinearity of AC in developed and emergent countries. Following the linear estimations and model comparisons from Section 5.1, we used Model 1 through a fixed-effect regression to analyze the threshold effect. Model 1 was chosen because the BIC test reveals a better information criterion comparing to other models.

For developed countries, the estimates indicate a nonlinearity for BB Investments in R&D, and a threshold of 0.45% was found. Thus, developed countries seem to be unable to absorb knowledge to the same degree above this threshold. Regarding emergent economies, 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 the AC of emerging and developing countries, although it does not present a nonlinearity for EE.

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.

However, it is worth mentioning China for emergent economies. 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. Besides, 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 have proved to be an advantage for developing Asian economies, as well as for developed countries. A close partnership has been established between the United States and South Korea in various technology areas and also with India in the development of clean technology.

For DEs, we did not find statistically significant nonlinearity for BBs in the human capital dimension—number of secondary school enrollments, higher education index, and the percentage of GDP spent on higher education. Although these variables did not present nonlinearity, they are pointed out as BBs for the AC. For emergent economies, the variable analyzed for the human capital dimension was the higher education index (threshold = 3.67), which presented statistical significance. According to the literature, companies' abilities to assimilate new knowledge derive mainly from the individual capacities of their workers (Jiménez-Barrionuevo, García-Morales & Molina, 2011; Lichtenthaler, 2016; Murovec & Prodan, 2009; Shenbarow, 2014).

According to the economic dimension, the FDI for DEs presents statistical significance for the regime above the threshold value ($ 39,874,81 - million), in which the impact of the FDI is approximately 0.0005% on AC, with a 1% increase. For emergent economies, the FDI BB showed no nonlinearity. For the BB index of economic freedom (IEF), it showed nonlinearity for the developed country group, with a threshold of 75.3. Thus, the estimates that above the index of 75.3 developed countries have a nonlinear behavior.

The 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 more significant 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 & Oliveira, 2015). Therefore, FDI BB is linear with the AC, especially for emerging and developing countries.

Another BB that stands out is the infrastructure index, which showed significance for both regimes for emergent economies (threshold = 3.92). For DEs, we did not detect nonlinearity. For emergent economies, above the threshold (3.6), the 1% increase has an impact of 0.027% on the AC, and below the threshold, the 1% increase has a 0.032% impact on the 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 and other inefficiencies are issues that create social discontent and barriers to economic 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, the BB of the HDI has presented in both regimens statistical significance for emergent economies. The results indicate that there is a certain point (threshold = 0.58) where the impact on the AC becomes small.

The results found for the thresholds analysis points to the acceptance of H_2: The thresholds of the AC BBs differ for developed and developing economies. For DEs, the innovation dimension stands out, with BB Investments in R&D with nonlinearity. For emergent economies, the economic dimension stands out, with the BBs country infrastructure index and HDI showing nonlinearity. Tables 13 and 14 summarize our econometric findings.

6 | FINAL CONSIDERATIONS

By employing an SLR, this study was able to find and compare the main BBs of AC with both linear and nonlinear econometric techniques. After evaluating the better suited model for developed and EEs, their respective thresholds were estimated with a panel fixed-effects threshold regression approach. This procedure allowed the analyses of all BBs selected in the literature.

Our contribution was to reveal that the BBs are different between developed and emergent economies, which affects policy recommendations. For both groups, the R&D investment, FDI, country infrastructure index, and HDI variables can be considered BB for AC. However, for developed countries, the BBs also consider the number of secondary education enrollments, the higher education index, and the percentage of GDP spent on higher education. It is noteworthy that the EFI cannot be considered as a BB of the AC in any of the groups.

We also contributed to measuring the thresholds for each BB. Our analysis confirms that the thresholds of the AC BBs differ for developed and emergent economies. For developing economies, the innovation dimension stands out, with the BB investments in R&D with nonlinearity. For emergent economies, the economic dimension stands out, with the BBs country infrastructure index and HDI showing nonlinearity. Finally, we argue that the most significant BBs for developed countries are, in fact, not the most important BBs for emergent economies. It occurs because these countries have different socioeconomic conditions.

Our findings reveal that policymakers must develop strategies to increase human capital in areas where foreign companies are located. Besides, the FDI policy strategy must 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.

These results have direct implications for industrial policy to attract FDI, being complemented by programs that encourage the competitiveness of national industries, in order to increase their total productivity. Identifying BBs and thresholds allows policymakers to define goals to

TABLE 13 Developed economies: thresholds of each building block

Absorptive capacity	R&D	SecEdu	HigherEdu	EducExpend	IEF	FDI	Infra	HDI
R&D		0.0102***	0.0090***	0.0066**	0.0096***	0.0087***	0.0070**	0.0079***
SecEdu	0.0123**		0.0133**	0.0187***	0.0143***	0.0143**	0.0122**	0.0207***
HigherEdu	0.0044	0.0098		0.0166	0.0151	0.0212**	0.0148	0.0162
EducExpend	−0.0070*	−0.0103**	−0.0067*		−0.0071*	−0.0070*	−0.0077*	−0.0069*
IEF	−0.0211	−0.0295**	−0.0299**	−0.0352***		−0.0360**	−0.0335**	−0.0302**
FDI	0.0006**	0.0006**	0.0005**	0.0008***	0.0006**		0.0005*	0.0158**
Infra	0.0256***	0.0138**	0.0180***	0.0150**	0.0177***	0.0151**		0.0005*
HDI	−0.0621*	−0.0442	−0.0739*	−0.0516	−0.0650*	−0.0653*	−0.0524	
Constant	−0.1015	0.0797	−0.0338	−0.0785	0.0163	−0.0419	−0.0291	−0.0939
Threshold	−5.40***	4.7424***	1.5994***	1.9081***	4.3215***	10.5935***	1.4061***	−0.102***
<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

All variables measured in ln. Consider: *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$.

TABLE 14 Emergent economies: thresholds of each building block

Absorptive capacity	R&D	HigherEdu	IEF	FDI	Infra	HDI
R&D		−0.0005	−0.0013	−0.0014	−0.0020*	−0.0012
HigherEdu	−0.0057		−0.0098	−0.0054	−0.0033	0.0036
IEF	−0.0001	0.0035		0.0036	0.0108	0.0069
FDI	−0.0013**	−0.0015***	−0.0009*		−0.0008	−0.0012**
Infra	0.0216***	0.0208***	0.0217***	0.0230***		0.0223***
HDI	0.1463***	0.1314***	0.1407***	0.1320***	0.1480***	
Constant	−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***

Alll variables measured in ln. Consider: *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$.

develop policies to attract FDI, to enhance positive productivity spillovers, and to avoid negative competition-related spillovers for the domestic industry. The results support the idea that FDI is a major channel to transfer technology, and that the host countries, depending on their AC, eventually bring in new technologies accompanied by FDI.

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 our sample, which ultimately limited the number of countries analyzed, especially in developing countries. 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.

As we employed the technological frontier distance (technology gap) as a proxy for AC following Girma (2005), another suggestion for a future study would be the calculation of TFP using nonparametric frameworks such as the Malmquist index (Cao et al., 2017; L. H. Chen et al., 2016; Q. Fu & Ji, 2017; Mu et al., 2017).

Finally, future studies may employ meta-analysis to select BBs, a statistical method used in the systematic review to integrate the results of the included studies and increase the statistical power of primary research (Ayati et al., 2021; Ng et al., 2021; Reis et al., 2021; Souza & Ribeiro, 2009).

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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