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RESEARCH ARTICLE

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# Using a digital divide index among enterprises in the context of public policies in Brazil

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## Abstract

The aim of the present paper is to discuss the relevance of an index that is capable of measuring the digital divide among small and medium enterprises (SMEs) and to discuss its importance in the context of public policy design. It is contended that the digital divide mainly affects microenterprises and SMEs, and that this phenomenon is related to the low productivity and high mortality rates of these organisations. The methodology for creating the index is replicated here in order to discuss the quality criteria necessary for this index within the scope of its utility for public managers.

**KEYWORDS**

digital divide, ICT indicators, public policies, SMEs

## 1 | INTRODUCTION

Information and communication technologies (ICTs) are widely used by enterprises to generate, store and transmit data and information. ICT enables innovation in processes, products and services, and can break the cycle of diminishing returns and establish a virtuous cycle of growth and productivity (Biagi, 2013).

Given the potential of ICT to enable innovation, and in accordance with Fong (2009) and Stiakakis, Kariotellis, and Vlachopoulou (2009), this paper argues that differences in the effective use of ICT and adoption by enterprises can increase the gap between their levels of development and productivity, and especially between larger and smaller companies. To refer to this phenomenon of differences in ICT use, this article adopts the concept of the ‘digital divide’ in its two forms, the “first-order” and “second-order” digital divides (Dewan & Riggins, 2005), which will be detailed in the following sections.

In order to discuss the importance of public policy in fostering the use of ICT in a business environment with the aim of bridging the digital divide between enterprises we pose the following research question: *How can an index of ICT use, based on a regular survey, be used to better inform public policies?*

In the business context, ICT has traditionally been studied by means of theories about the adoption and dissemination of innovation; this has produced relevant theoretical and practical contributions, such as the study by Alismaili, Li, Shen, and He (2016) on the adoption of cloud computing by small and medium enterprises (SMEs). However, in the present article, the focus is not on the phenomenon of adoption and dissemination but on the digital divide, a problem that affects the economic order. For instance, according to Fong (2009), developing countries were the last to enter the digital revolution; one of the main factors influencing the economic gap between developing and developed countries is their success in exploiting this technological potential.

By changing the focus of discussion from adoption to the digital divide, we hope to help bring together two relevant fields of study: ICT in organisations and public policy (PP).

  

## 2 | THE DIGITAL DIVIDE AMONG ENTERPRISES

In the 1980s and 1990s, there was an intense debate in the academic literature on the topic of ICT and its impact on the productivity of enterprises; in particular, the question of whether ICT actually affects productivity was a discussion that became known as the ‘productivity paradox’ (Brynjolfsson & Yang, 1996). The present paper is based on the conclusions already reached in the literature, namely that ICT can directly or indirectly affect productivity, although its benefits may be concentrated among certain companies or take longer to be perceived, as explained by Brynjolfsson, Rock, and Syverson (2018). In industries producing ICT goods and services, such as the software industry, this impact is a direct one; when ICT is used as an input for other businesses, its impact is indirect (Gordon, 2012) and is dependent on effective use. This effective use can be understood as the appropriate application of ICT within the companies' processes to obtain improvements in business integration, decision making, strategic planning, and business benefits such as better productivity and increased quality, among others (Zwicker, Souza, & Vidal, 2006).

While ICT can impact productivity and enable innovation in companies that can acquire and properly use it, companies that do not have access to ICTs or are not able to employ them appropriately in their processes and business will be at a disadvantage. According to Wielicki and Arendt (2010), SMEs appear to be the most disadvantaged group, since they are not able to exploit the use of ICTs in the same way as large companies. This happens because they lack the proper knowledge, skilled management, and skilled labour to properly use ICTs and integrate them in the business processes and not from a lack of access to ICT. As a consequence, these authors find that there are broadening discrepancies between SMEs and large companies in terms of the utilisation of ICT and e-business. In the same vein, Stiakakis et al. (2009) and Arendt (2008) show that the diffusion of ICT among companies is one of the main factors driving economic growth. For these authors, the fact that small and medium-sized companies cannot take advantage of the benefits of ICTs and e-business makes them more vulnerable to changes in financial and competitive market conditions. These discrepancies among companies can be conceptualized as a type of disparity of ICT access and use, better known as the digital divide.

The Organization for Economic Cooperation and Development (OECD) defines the digital divide as the gaps between individuals, households, businesses and geographical areas with regard to both the opportunity to access ICTs as well as the ability to use the Internet to carry out a wide variety of online activities (OECD, 2001). In addition to the OECD, several other international organisations are concerned with the issue of the digital divide, such as the Digital Opportunity Task Force, which includes the world's eight richest nations (the G8).[1]

More recently, the concept has evolved to reflect a more complex phenomenon than a simple and static division between the ‘haves’ and ‘have nots’ (Van Dijk, 2006). For Van Dijk (2006), material access (i.e. physical and financial access to computers and networks) is only the first barrier in overcoming the digital divide. This is followed by skill access, which involves operational, informational and strategic skills, and then by usage access, the actual and purposeful use of computers.

According to this view, Dewan and Riggins (2005) proposed a conceptual model to analyse the digital divide using two categories: first-order and second-order digital divides. For authors, the first-order digital divide is related to barriers to access to ICT, and the second-order divide is related to differences in the use of ICT among those who already have access to technology. The authors argue that these technologies have become increasingly available and affordable, and most participants in any social system now have access to them. From the viewpoint of enterprises, ICT use can provide leverage, making the second-order divide even more significant in this scenario. The conceptual model of Dewan and Riggins (2005) allows us to study the digital divide from three different perspectives: a) individual; b) organisational; and c) global. From an organisational perspective, which is the focus of the present study, Dewan and Riggins (2005) suggest research questions that are related to the use of ICT by some companies to gain advantages over their competitors and redefine market rules, while other companies lack the same success and are placed at a strategic disadvantage. According to these authors, the lack of ICT investment and adoption by companies becomes a social issue when it creates a significant problem of a competitive disadvantage, especially for smaller enterprises, companies in rural areas, and those companies whose owners are not aware of the importance of ICT.

As discussed above, in terms of organisations, the digital divide phenomenon affects SMEs in particular, and of these smaller companies, microenterprises are the most affected. The fact that SMEs are not able to enjoy the benefits of ICT in the same way as large enterprises makes them more vulnerable to changes in financial and competitive market conditions (Arendt, 2008; Wielicki & Arendt, 2010). Several studies have demonstrated the relevance of ICT use to SME management. Terziovski (2010), for instance, has shown that the absence of information systems that can enable enterprises to monitor their performance is one of the main reasons for SME mortality, followed by informal strategic planning.

In academic literature on digital divide, two recent studies (Bach, Zoroja, & Vukšić, 2013; Srinuan & Bohlin, 2011) have shown that this theme is widely debated in the extant literature. However, a greater emphasis is given to the divides between countries and between individuals, and there is a lack of discussion about what occurs among enterprises.

### 2.1 | The Digital Divide Among Enterprises in Brazil

Specifically in the context of Brazilian companies, the digital divide among SMEs is related more to the use of ICT rather than access, and this characterises a second-order divide. The 2014 edition of the ‘ICT Enterprises’ survey, conducted annually by the Brazilian Internet Steering

[1]See: https://www.mofa.go.jp/policy/economy/it/df0104.html

Committee (CGI.br), showed that although most enterprises had computer and Internet access (96%), only 62% had a presence on the Internet via their own websites, and only 29% reported using an enterprise resource planning (ERP) system to integrate data into a single system (CGI, 2015). Another aspect of this survey that appears to be important is the quality of access; while 55% of larger enterprises had connection speeds of more than 10 Mbps, this proportion fell to 34% among SMEs "CGI.br, 2015".

### 2.2 | The scenario of informality in Brazil

A general law covering micro and small businesses in Brazil was introduced in December 2006. Since then, many previously informal businesses have become formalised, with the aim of being able to issue invoices and pay simplified taxes. The number of formal businesses has increased very rapidly, reaching 7 million in 2017; however, the number of self-employed people totalling 22.8 million, according to the last National Sample Household Survey (PNAD) survey conducted by the IBGE in 2017, and more than 15 million business have not yet become formalised (IBGE, 2017; Nogueira, 2016).

Despite its representativeness and importance in the national economy, no research has been undertaken in Brazil that has monitored the use of ICT in the informal sector. However, the Regional Centre for Studies of the Development of the Information Society (Cetic.br)[2] maps the use of ICT in microenterprises (companies with fewer than 10 employees) that already have formal registration. In 2010, for example, the use of ICT was mapped in 1,500 microenterprises, which were divided between those with between one and four employees (77%) and between five and nine employees (23%). It was verified that 70% of these already had access to the Internet, a figure that rose to 81% for microenterprises that had between five and nine employees. Despite access to computers and the Internet, only 35% received sales orders via the Internet. This figure is very similar to that for small enterprises (as measured in the TIC Enterprises Survey), which reached 36% (CGI, 2011). However, research into ICT in microenterprises is not conducted with the same frequency as that into other enterprises, as it was previously annual and is now biennial. The difference between the use of ICT by large corporations and other businesses (medium, small and micro) is quite similar, as we can observe from the last ICT Microenterprises survey.

## 3 | PUBLIC POLICY IN BRAZIL - FOSTERING ICT ACCESS AND USAGE

In the following subsections, PP in Brazil in relation to ICT in SMEs is exemplified, specifically with regard to training, Internet access and local industrial arrangements. The following examples are given to support our argument for the utility of an ICT usage indicator that can serve both PP design and impact assessment, as discussed in Section 4.

### 3.1 | Public policy related to training in ICT

La Rovere (1998) found that SMEs can be considered to be digitally excluded, as they lack access to information about the benefits and availability of ICT. According to Wielicki and Cavalcanti (2006), this phenomenon is associated more with educational issues, training and the ICT knowledge and skills of employees than with an actual lack of access or financial resources.

Regarding the training of enterprises, their employees, and entrepreneurs, Siqueira and Souza (2016) and Sousa (2010) have identified the following initiatives that stand out within the context of SMEs:

- Secretary of Science and Technology for Social Inclusion (SECIS) – Supports the popularisation of science and the diffusion of technology;
- Ministry of Development, Industry, and Foreign Trade – Provides information and business telecenters (TIN) with the aim of teaching digital literacy to entrepreneurs;
- The Brazilian Service of Support for Micro and Small Enterprises (SEBRAE) – Launched a program entitled Promote Technology and Information Use in Micro and Small Enterprises (Proimpe).

### 3.2 | Public policies related to internet access

Although ICT access seems to be widespread among SMEs (CGI, 2015) and is considered a less relevant factor in explaining the digital divide (Wielicki & Cavalcanti, 2006), even small differences in access to ICT result in differences in the intensity of ICT use. Hence, Souza, Siqueira,

[2]Cetic.br is a department of the Brazilian Network Information Centre (NIC.br), and is responsible for publishing periodic specialised surveys and reports on the use of ICTs and the Internet by several segments of society. More information is available at www.cetic.br.

and Reinhard (2017) have shown that ensuring access to ICT remains important. According to these authors, access to technology, the Internet, and ICT skills and attitudes are factors that are correlated with a more intense use of ICT among SMEs.

In addition, the projected growth in data traffic over the next few years and the requirements for quality in service provision can justify encouraging the adoption of more robust technologies for internet access (Gomes, Araújo, & Cordeiro, 2014). Two national policies in Brazil stand out in terms of facilitating ICT access by Brazilian enterprises. The first is a special credit line which was funded by the Brazilian National Development Bank (BNDES) within the scope of the Special Agency for Industrial Financing (FINAME) program and enables the acquisition of ICT by interested enterprises.

The second policy is called the National Broadband Plan (PNBL), which was created by the Ministry of Communication with the goal of expanding broadband access not only among end users and individuals but also among organisations.[3] In the context of PNBL, broadband can be seen as a basic condition for the economic inclusion of individuals and enterprises (Gomes et al., 2014).

### 3.3 | Industrial policies within the context of local industrial clusters and innovation

According to Castells (2000), the new global economic reality of network formation is a trend that will persist in future. The author affirms that cooperation between members of a network tends to form structures that facilitate learning processes suited to new digital technologies. Similarly, Lastres and Albagli (1999) find that ICT enables interconnections between agents within a chain which fosters ongoing learning as a community rather than solely among individual enterprises. These authors also indicate that ongoing learning by networks is a key to the productive and innovative development of enterprises. According to Castells (2000) and Lastres and Albagli (1999), the influence of the external environment is very important for ICT adoption. They suggest that participation in local industrial clusters called 'local industrial arrangements' (LIAs) in Brazil can help stimulate the adoption of ICT among SMEs. Galdámez, Carpinetti, and Gerolamo (2009) offer the conceptualisation of LIAs as "systems that can be used to promote cooperation among enterprises, ongoing innovation, and sustainable development of small and medium enterprises (SMEs)" (p.3).

In 2003, following the implementation of the Industrial, Technological and Foreign Trade Policy (PITCE), SMEs were given priority in PPs funding firms within specific LIAs (Safarti, 2013). Government agencies such as the BNDES, the Brazilian Trade and Investment Promotion Agency (Apex), the Ministry of Science and Technology, and the Funding Agency for Studies and Research (Finep) support SMEs based on these LIAs. According to Safarti (2013), there were 957 LIAs in 2005, of which 267 were considered a priority.

## 4 | PUBLIC POLICY AND INDICATORS

In this section, the concept of PP cycles is reviewed in order to examine how an index for measuring the digital divide can be useful.

### 4.1 | Public Policy Cycle

According to Souza (2006) and Frey (2000), PPs are ways for public administrations to encourage social development. According to Souza (2006), studies that focus on the evaluation of PPs are referred to as managerialist. As an extension to the view that the sole purpose of a PP is social development, Penteado and Fortunato (2015) argue that PP is not a simple intervention based technical instrument, since it is subject to the influence of several factors in its formation, execution and evaluation. Souza (2006) points out that PPs are related to government programs and to what governments choose to do or not to do in their various areas of action or influence. In spite of a series of criticisms of its distance from the complexity of practice, PP cycle theory is very useful as a theoretical model and as an analytical tool for understanding the interactions between intentions and actions (Pinto, 2015; Secchi, 2010). Frey (2000) defines the PP cycle in five stages as follows: perception and definition of problems; definition of the agenda; elaboration of programs and alternatives; implementation; and evaluation. The cycle continues by repeating these five stages until the termination of the policy. The present article argues that the ICT use index could be useful in two of these steps: identifying a problem and evaluating the results. This is in accordance with the view of May and Wildavsky (1979), for whom the identification of a problem is, in practice, closely related to the last step (evaluation), meaning that the boundary between these phases is not clear.

### 4.2 | The evaluation step and indicators

An evaluation system related to the modernisation of public management requires a culture of evaluation during all stages of the PP cycle. This system first gained strength in the United States and European countries, and has been developing in Brazil since 1980 (Faria, 2005; Jannuzzi, 2002).

[3]Ministry of Communications. *Um plano nacional para banda larga: O Brasil em alta velocidade* (A national broadband plan: Brazil at high speed). Available at:<http://www.governoeletronico.gov.br/anexos/plano-nacional-de-banda-larga/download>. Accessed on: Jan 10, 2014.

The evaluation stage is located at the end of the cycle, in the post-implementation phase, but can also be understood as a monitoring activity that permeates all stages of the cycle, from the definition of the problem to the implementation of the process and the final steps. In fact, although there are a number of existing typologies for assessment, Cotta (2001) explains that these typologies generally fall into one of three categories: (i) time-related (before, during or after); (ii) related to the evaluator's position (internal, external, semi-independent); and (iii) related to the object (context, input, processes and results).

Giacomini (2010) points out that the monitoring and evaluation of PPs are increasingly important for the modernisation of public management, and in the same vein, Diamond (2007) states that the production and dissemination of this information is essential for public management and that a culture of evaluation must be present in the practice of public managers. Thus, indicators are essential in informing policymaking, as they provide elements that can guide policymakers' decisions at each step of the policy cycle (Jannuzzi, 2002). Effective public policies require the good use of indicators and sound statistics throughout the different steps of the policymaking process (Scott, 2005). Indicators are also essential for measuring the effectiveness and impact of policies (Othman, 2005).

The development of an indicator as a way to measure a given context can result in political learning, given that the presentation of data and information relevant to that context can generate political insight (Howlett, Ramesh, & Perl, 2009; Johnsen, 2005). Measuring the characteristics of a given social reality enables the formulation of policies that can act as solutions to the possible flaws and/or weaknesses of that reality. Indicators must be capable of presenting relevant information and evidence about the aspects of, or changes that occur in, social reality (Jannuzzi, 2002), thereby serving as an operational instrument for monitoring that reality and formulating and reformulating PPs. Jannuzzi (2002) established that indicators should meet the following criteria: relevance to the discussion of political agendas; validity in terms of representing reality; an absence of problems related to validity or statistical significance; a basis in reliable data; the use of well-defined samples; freedom from systematic data collection errors; presentation of a wide range of coverage, sensitivity to implemented PPs; and being intelligible, updatable, and easily disaggregated according to geographic, demographic and economic variables.

The following sections present three different types of measurement of ICT use by organisations: indicators from the plan of action of the Information Society in Latin America and the Caribbean (eLAC) of the Economic Commission for Latin America and the Caribbean (ECLAC); the Networked Readiness Index (NRI) of the World Economic Forum; and the Digital Divide Index, the construction and composition of which is described in the present article. These indicators are presented as the basis of a discussion about how the Digital Divide Index can be used within the scope of policymaking in Brazil.

## 4.3 | Indicators to track eLAC goals

eLAC is an action plan for the information society that was developed by the ECLAC. This plan of action is composed of several goals. With regard to SMEs, there is a specific objective of increasing access to and use of ICT. In 2010, the eLAC goal tracking report utilised the following indicators for the inclusion of SMEs: access to computers; access to the Internet; having portals on the Internet; use of the Internet to distribute products, search for government information and services, provide client services, provide financial services, and send emails; and use of an ERP and customer relationship management (CRM) systems (ECLAC, 2010).

Data from the 2009 survey indicated that nearly 100% of SMEs had access to computers and the Internet, and used the Internet for communication via email. However, when compared with large enterprises, they had low levels of provision of client services and use of ERPs and CRMs. These data pointed to the presence of a digital divide, which according to ECLAC must be fought against, since in addition to being insufficient, ICT use is unequal between the different sectors of the economy and the different sizes of enterprise (ECLAC, 2010, p.70).

However, these indicators were not aggregated into a single measure that could serve as an index, and this hinders comparison among enterprises.

## 4.4 | Network Readiness Index (NRI)

The Network Readiness Index (NRI) was defined by the World Economic Forum (WEF) to evaluate a country's level of readiness to obtain and participate in the benefits of ICT (World Economic Forum, 2016). This index consists of measures related to the environment (infrastructure), readiness (culture, adherence, and processes) and use of ICT by society, government and enterprises of a particular nation. According to the Global Information Technology Report (GITR), the higher the NRI, the better the country's conditions for development, innovation, competitiveness and productivity. In the 2009 and 2014 reports, for example, the correlation between NRI and per capita GDP was very high (0.71) in high-income southeast Asian countries (Singapore and Japan), European countries (Finland, Sweden, Norway, the Netherlands, Switzerland, the United Kingdom and Luxembourg) and the United States (World Economic Forum, 2016).

A sub-index of the NRI specifically captures the dimension of ICT usage among enterprises using the following indicators, all of which are measured at the country level: ICT adoption; capacity to innovate; number of patent applications; Internet use for B2B; Internet use for B2C; and staff training for ICT.

When this sub-index related to ICT in enterprises is exclusively analysed, Brazil ranks fifth in relation to other Latin American countries and appears below South Africa and China in relation to the BRICS countries, as shown in Table 1.

In comparison with the other four BRICS countries (Russia, India, China and South Africa), Brazil ranked third, as shown in Table 2.

In general terms, Brazil fell from 33 to 59 in the rankings between 2012 and 2016, as shown in Table 3.

Two observations can be made here about the usage of the sub-index created by the NRI regarding sample size and representativeness. In terms of size, and with the exception of patent applications, the indicators were measured by the Executive Opinion Survey, which is conducted annually by the World Economic Forum in several countries. The survey is used to calculate a country's competitiveness. In the case of Brazil, 143 executives were interviewed.

With regard to the representativeness of the enterprises interviewed, although it was not possible to establish how many SMEs were included in the 2014 publication, an approximation based on the 2011 survey suggests that 22% of those interviewed had up to 100 employees, 14% had up to 500 employees, and the others had more than 500. This leads to the hypothesis that the ICT use index is mostly based on the responses of large enterprises, and this may have elevated the value of the index and given Brazil a higher ranking. Thus, this index may not adequately reflect the reality of SMEs in Brazil.

## 4.5 | Digital Divide Index

Siqueira, Souza, and Chagas (2014) proposed a Digital Divide Index to measure the intensity of ICT use by SMEs, based on the argument that use, rather than access, is the most important aspect when studying the digital divide among enterprises in Brazil. This measure is based on the model proposed by Zwicker et al. (2006), in which ICT use in organisations is composed of the following dimensions: (i) ICT use for the enterprise's internal (vertical and horizontal) and external integration; (ii) ICT use to support decision making; and (iii) ICT use to generate knowledge and innovation.

The aim of the present study was therefore to analyse the validity of the Digital Divide Index proposed by Siqueira et al. (2014) in the context of PP, using the criteria listed by Jannuzzi (2002). This article integrates several other studies of the digital divide in which the authors use the data from the 2013 edition of the survey to (a) demonstrate how the index was created (Siqueira et al., 2014); (b) explore sectoral differences (Siqueira,

**TABLE 1** NRI sub-index: Ranking in Latin America

| | 2016 | | 2015 | | 2014 | |
|---|---|---|---|---|---|---|
| Country | NRI | Rank | NRI | Rank | NRI | Rank |
| Costa Rica | 3.97 | 38 | 4.01 | 39 | 4.01 | 38 |
| Guatemala | 3.91 | 45 | 3.93 | 44 | 3.90 | 42 |
| Honduras | 3.90 | 46 | 3.78 | 56 | 3.42 | 91 |
| Chile | 3.89 | 47 | 3.91 | 47 | 3.89 | 45 |
| Brazil | 3.70 | 59 | 3.83 | 52 | 3.92 | 41 |
| Mexico | 3.62 | 66 | 3.56 | 72 | 3.59 | 70 |
| El Salvador | 3.52 | 78 | 3.73 | 59 | 3.47 | 80 |
| Colombia | 3.50 | 82 | 3.51 | 81 | 3.47 | 79 |
| Ecuador | 3.49 | 83 | N/A | N/A | 3.59 | 71 |
| Dominican Republic | 3.45 | 88 | 3.53 | 77 | 3.60 | 67 |
| Uruguay | 3.45 | 90 | 3.44 | 89 | 3.43 | 86 |
| Peru | 3.43 | 91 | 3.43 | 90 | 3.43 | 89 |
| Argentina | 3.36 | 103 | 3.33 | 101 | 3.33 | 99 |
| Paraguay | 3.08 | 121 | 3.17 | 111 | 3.27 | 105 |
| Nicaragua | 3.00 | 130 | 3.11 | 119 | 3.20 | 113 |
| Venezuela | 3.00 | 131 | 3.00 | 128 | 3.15 | 119 |
| Bolivia | 2.96 | 132 | 3.07 | 123 | 3.16 | 118 |
| Haiti | 2.84 | 134 | 2.82 | 134 | 2.77 | 140 |
| Puerto Rico | | | 4.38 | 29 | 5.05 | 19 |

Source: WEF Global Information Technology Report 2016

**TABLE 2** NRI sub-index: Ranking in BRICS

| Country | 2016 NRI | 2016 Rank | 2015 NRI | 2015 Rank | 2014 NRI | 2014 Rank |
|---|---|---|---|---|---|---|
| South Africa | 4.20 | 32 | 4.1664 | 34 | 4.15 | 30 |
| China | 3.91 | 44 | 3.93 | 46 | 3.89 | 44 |
| Brazil | 3.70 | 59 | 3.83 | 52 | 3.92 | 41 |
| Russia | 3.61 | 67 | 3.61 | 66 | 3.45 | 84 |
| India | 3.55 | 75 | 3.45 | 88 | 3.78 | 51 |

Source: WEF Global Information Technology Report 2016

**TABLE 3** NRI sub-index: ICT use among organizations – Brazil 2012 to 2016

| 2012 | | 2013 | | 2014 | | 2015 | | 2016 | |
|---|---|---|---|---|---|---|---|---|---|
| Index | Ranking | Index | Ranking | Index | Ranking | Index | Ranking | Index | Ranking |
| 4 | 33 | 3.9 | 34 | 3.9 | 41 | 3.83 | 52 | 3.70 | 59 |

Source: WEF Global Information Technology Report 2016

Souza, & Reinhard, 2015); (c) validate the statistical technique employed in data analysis (Siqueira, Araujo, Souza, & Reinhard, 2015); and (d) find factors that contribute to bridging the divide (Souza et al., 2017).

The next section explains the methodology used to create the index, and is followed by a discussion of its importance.

## 5 | METHODOLOGICAL ASPECTS

The Digital Divide Index was initially proposed and developed by Siqueira et al. (2014) using microdata from the 'ICT Enterprises' national survey conducted in 2011 by CGI.br. For the purposes of this article, the index was replicated using microdata from the survey's 2014 edition that were made available in 2015. This section presents the conceptual model, in addition to the steps taken to replicate the index, which took place in three stages, as described below.

### 5.1 | Data selection

The index was created using a subsample of the microdata obtained in the national CGI.br ICT Enterprises survey, according to rigorous criteria for sampling design and selection. In the present article, the index was replicated using data from the 2014 survey, which included interviews with 7,198 small, medium and large enterprises. To compose the subsample, only SMEs were considered, and the sample of this universe consisted of 5,346 enterprises. We considered SMEs ranging from 10 to 249 employees, following the definition of the European Statistical Office (Commission of the European Communities, Eurostat) and the United Nations (UN), Recommendation No. 2003/361/CE of May 6, 2003 of the Commission of the European Community. It should be noted that Cetic.br adopts the same criterion for size classification in its surveys. Information about turnover is not available from the data. Enterprises that did not respond or that responded 'do not know' to any of the questions representing the variables used to calculate the Digital Divide Index were excluded. The final sample consisted of 3,231 SMEs.

### 5.2 | Statistical method

The measurement model shown in Figure 1 was obtained based on the conceptual model of ICT use and structural equation modelling. This model was replicated using SmartPLS software and a factorial score was obtained for each enterprise for each dimension of ICT use. After calculating the scores for each dimension, a factorial score for the second-order index (ICT use) was also obtained (the weighted sum of the answers in each dimension). Finally, the scores for each sub-dimension and the scores for the ICT use index were transformed into an interval between zero and one.

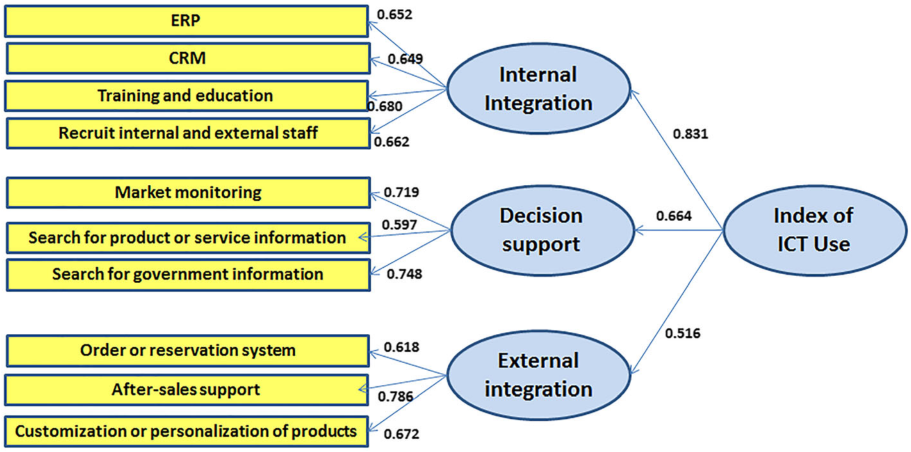


**FIGURE 1** ICT use index, obtained from an analysis of ICT Enterprises survey microdata

### 5.3 | Quality of the model

The indicators used here to assess the PLS model were: composite reliability (CR), which must be greater than 0.70; convergent validity, assessed based on the mean average extracted from the concept (AVE), which must be higher than 0.50; factor loading analysis, which must be significant and/or higher than 0.70; and discriminant validity, which can be assessed using cross-loadings (Hair, Hult, Ringle, & Sarstedt, 2014).

## 6 | DATA ANALYSIS

As an example, Table 4 contains the first four enterprises in the sample, and gives the factorial scores for each dimension of ICT use in addition to a score for ICT use.

Table 5 presents the values for the mean, standard deviation and interquartile ranges, based on the entire sample of 3,213 enterprises.

In order to analyse the digital divide between SMEs, the enterprises were classified as: a) excluded; b) partially excluded; c) partially included; and d) included, based on the quartiles obtained by analysing the use index score. Thus, enterprises with scores lower than 0.0459 (first quartile) were classified as excluded, and those with scores higher than 0.743 were classified as included.

Lastly, Figure 2 illustrates the phenomenon of the second level of the digital divide, as a concentration of excluded enterprises occurs among smaller enterprises.

In Figure 3, we can see the evolution of the ICT use index over three editions of the ICT Enterprises survey (2011, 2013 and 2014), demonstrating the changes for each size of company and the overall changes. The index showed evolution for all sizes of enterprises, and was also able to show differences between the evolution of companies, for example the fact that enterprises with 100 to 249 employees expanded their ICT use more rapidly than other enterprises between 2011 and 2013.

## 7 | DISCUSSION AND FINAL REMARKS

The main argument presented in this article is the need to consider the differences in ICT use between enterprises as an issue that is related to the digital divide. From this perspective, the digital divide is related to the low productivity rates and high mortality rates of enterprises. Based on this understanding, public policy should be created to bridge this gap. Firstly, we argue that the digital divide index meets the quality

**TABLE 4** Examples of enterprises and index scores

| Enterprise ID | CNAE | Size (emp.) | External Integration | Internal Integration | Decisions | ICT Use |
|---|---|---|---|---|---|---|
| 1 | 1 | 20–49 | 0.000 | 0.253 | 0.744 | 0.393 |
| 2 | 4 | 20–49 | 0.310 | 0.253 | 0.499 | 0.354 |
| 3 | 7 | 20–49 | 0.000 | 0.000 | 0.754 | 0.287 |
| 4 | 8 | 20–49 | 0.000 | 0.000 | 0.754 | 0.287 |

CNAE = National Classification of Economic Activities 2.0, Brazilian Institute of Geography and Statistics (1 = Manufacturing; 4 = Transportation; 7 = Real State; 8 = Arts and Entertainment)

**TABLE 5** Distribution by size

| | N | Mean | Standard Deviation | 1st Quartile | Median | 3rd Quartile |
|---|---|---|---|---|---|---|
| **2014 Index** | 3,231 | 0.591 | 0.199 | 0.459 | 0.592 | 0.743 |

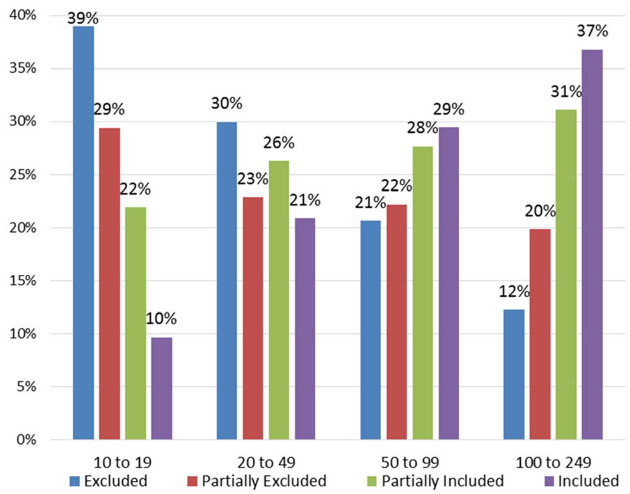


**FIGURE 2** Distribution of the digital divide among enterprises by size (number of employees)

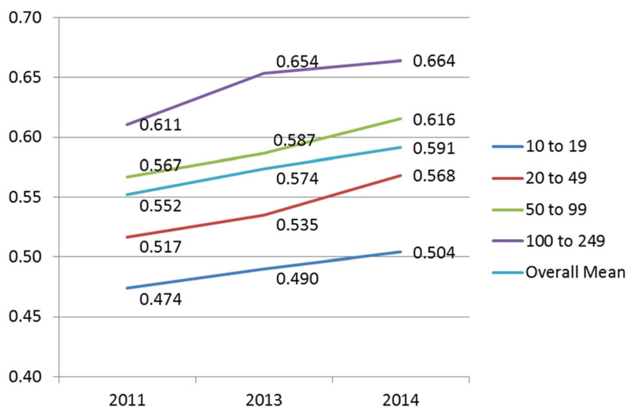


**FIGURE 3** Mean values of the ICT use index by year and size of enterprise (number of employees)

criteria proposed by Jannuzzi (2002), de Martino Jannuzzi (2014), as shown in Table 6; it can therefore be considered relevant to the creation and assessment of public policies that are directed towards the digital inclusion of SMEs, since it both clarifies the phenomenon, as shown in Table 6, and meets these criteria.

In terms of public policy, we suggest that the proposed index may be more interesting than the NRI and the eLAC indicators. For the NRI, the use of ICT by organisations is calculated based on a sample with few enterprises, and this index does not control the representativeness of the sample. For the eLAC, ICT use is composed of indicators that are not used to create an aggregate index, creating difficulties in visualising the bigger picture of the digital divide.

The Digital Divide Index is based on indicators with the following dimensions: ICT use to support decision making; internal integration; and external integration, according to the theoretical model of use. Based on these indicators, an overall index for ICT use was calculated that we call the Digital Divide Index. This approach offers at least two benefits. Firstly, it is a principled method that allows the researcher to make explicit the conceptual choices made in terms of measuring ICT use based on models that were previously validated by academia, and consequently to select only those indicators that relate directly to the issue under study. Secondly, it is a multidimensional model and the possibility of disaggregation may lead to greater validity of measurement and transparency of the digital divide phenomenon since it is possible to recombine dimensions and analyse variables in their isolated forms. Bersch and Botero (2014) criticised the use of aggregate indicators since they can be (and often are) composed of many variables and multiple sources arranged in such a way as to sustain a certain concept like

**TABLE 6** Jannuzzi's quality criteria and the digital divide index

| Criteria (Jannuzzi, 2002, 2014) | Digital Divide Index |
|---|---|
| Relevance to the discussion of political agendas | The relevance was initially presented in terms of concerns (national and international) about the topics of the digital divide and economic development. |
| Validity in terms of representing reality (validity problems and statistical significance) | The index was initially constructed based on a sample of 2,000 SMEs, and is being replicated with even larger samples. See Siqueira et al. (2014, 2015a, 2015b, 2016). |
| Data reliability (sampling problems, systematic data gathering errors) | The indicator was constructed using microdata from a survey conducted annually by CGI.br, an organisation that follows a criteria sampling process, with the goal of enabling generalisation. |
| Range of coverage | The data were collected throughout Brazil, in all regions and states, according to sampling criteria, to allow generalisation. |
| Sensitivity to existing policies | The index should to some degree reflect the results of existing policies to incentivise and diffuse innovation and technology among SMEs. |
| Intelligibility (the problem of using very complex indicators, revealing technocratic abuse) | The index proposed here ranges from 0 to 1. The lower the score obtained on the index, the less intense ICT use in a given SME, and therefore, the more excluded the enterprise. |
| Updatability | The data are collected annually, with increasingly broad samples used. |
| Can be disaggregated by geographic, demographic and economic variables | The index proposed here can be disaggregated by business sector, region/municipality, revenue and size. |
| Historicity (problems related to the disposition of a compatible series) | The data collection allows for a study of the evolution of the index, since the information is compatible with data previously collected over the last ten years. The index was constructed using 2011 survey data and was replicated using 2013 and 2014 data. |

corruption, democracy, development or governance. Based on this aspect, the index proposed here is composed of several variables; however, it is formed only from those that directly relate to the concept of ICT use and the digital divide. In addition, all of the information comes from a single piece of research, meaning that there are no combinations of indicators that were collected in different ways. Bersch and Botero (2014) also point out that although an index that uses latent variables appears to correctly test the convergent/divergent validity, it is also important to verify the content validity, in other words, to check whether the latent variable actually measures the issue studied. For these authors, while an increase in the number of sources may reduce standard errors and increase reliability, conceptual precision is sacrificed. Again, we highlight that systematic efforts were made to justify the conceptual definitions for our latent variable, the conceptual model of ICT use (Zwicker et al., 2006), and that the index based on this definition was not built by mixing sources or perceptual indicators. These features can reduce bias and improve content validity according to Bersch and Botero (2014), as we have argued here.

Finally, in this article, we have tried to direct the discussion of the adoption of ICT by SMEs toward the social problem that can be represented by the digital divide, since it increases differences in productivity and enterprise mortality. We identify the issue of adoption as a problem that requires adequate public policy, and discuss the benefit of an index that is capable of both shedding light on the problem as well as evaluating the results. We hope that new debates will arise in the junction of these two fields, namely, ICT adoption by companies and public policies.

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