



# The use of information and communication technology to characterize municipalities: who they are and what they need to develop e-government and smart city initiatives

Erico Przeybilovicz1 Maria Alexandra Cunha<sup>1</sup> Fernando de Souza Meirelles<sup>1</sup>

This study investigates the infrastructure characteristics and use of information and communication technologies of Brazilian municipalities reflecting on the possibility of developing e-government and smart cities actions. A quantitative study of cluster analysis, using data from the research "Munic 2014", identified four clusters: the Technologyless, the Concerned-on citizen, the Concerned-on legislation, and the ICT Supported, that suggest different courses of action in ICT. Each group of municipalities presents different needs for the development of e-government and smart cities actions that indicate the need for specific actions for each of the four clusters.

**Keywords:** smart city; municipality; ICT; e-government.

# O uso da tecnologia da informação e comunicação para caracterizar os municípios: quem são e o que precisam para desenvolver ações de governo eletrônico e smart city

Este estudo explora as características de infraestrutura e uso das tecnologias da informação e comunicação dos municípios brasileiros, refletindo sobre a possibilidade de desenvolverem ações de governo eletrônico e smart cities. Um estudo quantitativo de análise de agrupamentos foi realizado sobre dados da Munic 2014 e identificou quatro clusters: o Sem-tecnologia, o Atento ao cidadão, o Atento à legislação e o Provido de TIC, que sugerem diferentes vias de ação em TIC. Cada grupo de municípios apresenta diferentes necessidades para o desenvolvimento de ações de governo eletrônico e smart cities, que requerem ações específicas para cada um dos quatro clusters.

Palavras-chave: smart city; município; TIC; governo eletrônico.

# El uso de la tecnología de la información y comunicación para caracterizar a los municipios: quienes son y lo que necesitan para desarrollar acciones de gobierno electrónico y smart city

Este estudio investiga las características de infraestructura y uso de las tecnologías de la información y comunicación de los municipios brasileños, reflexionando sobre la posibilidad de desarrollo de acciones de gobierno electrónico y de smart cities. Un estudio cuantitativo de análisis de agrupamientos realizado sobre datos de la investigación Munic-2014 identificó cuatro clusters: el Sin-tecnología, el Atento al Ciudadano, el Atento a la legislación y el Provisto de TIC, que sugieren diferentes vías de acción en TIC. Cada grupo de municipios presenta diferentes necesidades para el desarrollo de acciones de gobierno electrónico y smart cities que indican la necesidad de acciones específicas para cada uno de los cuatro clusters.

Palabras clave: smart city; municipio; TIC; gobierno electrónico.

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# 1. INTRODUCTION

This work aims to understand the characteristics of municipalities in terms of ICT infrastructure and use, in order to develop actions of e-government and smart cities. Over time, countries have been improving in indicators related to e-government (United Nations, 2016) and cities across the planet are implementing actions to become smarter, creating strong urban solutions based on technology. The aim is to improve the lives of people living in cities, the quality of resource management and engage citizens.

Although 'smart city' is a theme studied in areas of knowledge such as urban planning and technology management in government, currently there does not seem to be consensus on the definition of the term (Bolívar, 2016). The term 'smart' is associated with the development of solutions to urban problems using technology. The theme of e-government is older and, perhaps because of this, more widespread and studied. It is linked to the modernization of public administration through the use of information and communication technology (ICT), to improve the efficiency of the operational and administrative processes of the governments (Diniz et al., 2009). It is also associated to the use of the internet in the public sector to provide online services and to expand democratic practices (Cunha and Miranda, 2013). Both e-government and smart cities' initiatives rely on technology infrastructure, hardware, software, networks, the internet, services and applications, and the use that local governments make of it. In Brazil, e-government projects have been in place since the 2000s. More recently, Brazil has seen several smart cities initiatives: the Frente Nacional de Prefeitos (National Front of Mayors) houses the Rede de Cidades Inteligentes e Humanas (Smart and Human Cities Network); the program Minha Cidade Inteligente (My Smart City) of the Ministry of Science, Technology, Innovation and Communications; the Brazilian Congress is working to form the Joint Parliamentary Committee in support of intelligent and human cities; Curitiba, Vitória and Rio de Janeiro are some examples of cities with smart initiatives; multilateral agencies and development banks are implementing funding lines for this area and, technology providers on a global scale are keenly interested in the subject. In the municipal elections of October 2016, smart city and e-government where topics expressed in the plans of several candidates. However, despite the efforts, ICT management in Brazilian cities is deficient, the Brazilian context shows low use of technology in governmental processes, there is poor infrastructure of ICT, and great challenges to be overcome in when it comes to ICT governance and management (CGI, 2016a).

The premise guiding this work is that the availability of infrastructure in municipalities is diverse, with consequences for the use that municipal governments make of technological resources. These differences in availability and use of technology, set different challenges and paths when deploying e-government or smart city projects. Thus, the research question that guides this study is: how does the infrastructure and use of ICT characterize groups of municipalities? When identifying these groups, it is possible to recommend policies on management that take into consideration their differences and are more likely to improve the use of ICT infrastructure and offer better investment opportunities. To answer the research question, techniques on descriptive statistical and clusters were used, based on data provided by the Brazilian Institute of Geography and Statistics (IBGE) in the Basic Information Research of Municipalities — Munic 2014 (IBGE, 2016) — on ICT use and infrastructure availability.

This study brings contributions to the practice and field of studies on the use of ICT in governments. In relation to government practice, public managers and experts in multilateral agencies who lead and design programs to encourage the use of ICT can benefit from understanding the differences between municipalities. Programs and lines of support and/or financing should consider these differences in infrastructure investment planning. From the scientific point of view, Gregor (2006) describes the works in information systems that elaborate taxonomies or typologies as a theory to "analyze". The typology of municipalities offered in this study reveals characteristics of the computerization of local governments in Brazil and allows subsequent studies to deepen the understanding of the phenomenon, with the creation of indicators, tests or an explanation of the Brazilian practice.

# 2. E-GOVERNMENT, SMART CITIES AND ICT INFRASTRUCTURE IN BRAZILIAN MUNICIPALITIES

The literature on e-government and smart cities places particular emphasis on ICT infrastructure in local governments. The first studies carried out in Europe and the USA in the field were followed by research in developing countries. Based on the concept of e-government and smart cities, this section shows ICT infrastructure as a necessary, albeit insufficient, condition for the materialization of potential e-government gains. Brazil already has robust data that allows to reflect on this issue.

E-government, can be understood as the use of ICT by governments in its relationship with citizens and in the processes of public administration (Grönlund, 2010). This term emerged in the late 1990s, closely associated with state reform movements and new public management. At the outset, the term was more related to the provision of electronic services and administrative efficiency, but more recently, and even in non-academic publications, it incorporated the support of digital means into democratic practice (United Nations, 2016:143). Numerous work has been devoted to conceptualizing e-government and mapping this field from different perspectives, such as the provision of e-services to citizens (Rampelotto, Löbler and Visenti, 2015; Damian and Merlo, 2013), the use of ICT for internal processes of the public administration (Tripadalli, Fernandes and Machado, 2011), transparency, governance and democracy (Pinho, 2008; Bernardes, Santos and Rover, 2015) and stages of e-government development in Brazil (Sano, 2012). There is a recommendation to study the factors that promote or hinder the adoption of modern ICT tools by municipalities (Sano, 2012). In Brazil, there is extensive research on the use of ICT by governments. The IBGE, conducts the studies Estadic and Munic, gathering census-type data from states and municipalities. The Brazilian Internet Steering Committee, publishes the research ICT Households (CGI, 2016b), which includes information about the use of e-government by the population, and the ICT Electronic Government (CGI, 2016a), which studies in depth aspects of ICT infrastructure, use and supply of services and participation mechanisms.

The development of ICT infrastructure has a positive effect on the development and growth of e-government, especially the internet. E-government actions make use of the infrastructure and the collection of government information to provide transparency and e-services. When ICT infrastructure is deficient, e-government development is inhibited and it limits the proportion of citizens that can be served (Singh, Das and Joseph, 2007; Siau and Long, 2009; Srivastava and Teo, 2010; Zhao, Collier and Deng, 2014). Governments have considered ICT as an important tool to meet goals such as improving the quality of public services, lower costs and increase transparency. Developing

countries also see ICT as indispensable, but not sufficient, tools for economic and social development and reduction of corruption. Mexico's experience makes clear that the introduction of ICT is a component of government reform, but other changes are needed, both in the organizational aspect of government and in legal and cultural issues (Gil-Garcia, Arellano-Gault and Luna-Reyes, 2010). ICT infrastructure is especially relevant to the advancement of e-government in local governments. Among state institutions, local governments are the closest to citizens. Municipalities, counties and districts are responsible for providing local public services, according to the laws of each country (Rahman, 2010). The study of e-government in local governments began in the United States and Europe (Almazan and Castañeda, 2010), but there are already studies from around the world, especially in developing countries. In the United States, Kaylor, Deshazo and Van Eck (2002) analyzed the municipalities and the use of ICT for the development of public services on the internet, proposing means to measure the implementation of e-government among different American cities. Leenes and Svensson (2002) identified differences in the development of e-government between the national and municipal level in the Netherlands and found that while the national government was successful, municipalities were slow and inefficient with few resources to deploy e-government. Moon (2002) identified similar results in adopting e-government in US local governments, and suggested that there are barriers toward municipal e-government progress such as lack of financial, technical, personnel, and legal capacity. In Africa it has been observed that the lack of ICT infrastructure severely restricts the use of the internet and the adoption of e-government, not only in local governments but across the whole country (Ngulube, 2007). Based on the actions of e-government in Nigeria, it is suggested to strengthen the ICT infrastructure to improve the supply of e-services and to be able to undertake new projects (Asogwa, 2013). A comparative review of studies of e-government strategies carried out in local governments in six countries (Bangladesh, India, South Korea, Pakistan, Singapore and Sri Lanka) led to the conclusion that increasing e-government depends on institutional development, information infrastructure, legal and regulatory adequacy, and that central government has an important role to play in supporting its implementation (Rahman, 2010).

The studies seem to agree that in order to reach the maximum capacities that ICT can offer to e-government practice, it is necessary to take into account the legal and socioeconomic context, the local pragmatic demands, to include the participants in the local management process and to reinforce the institutional capacities (Lalovic, Djukanović and Zivkovic, 2004). Having a nationally agreed plan, integration between government departments and initiatives planned to implement ICT infrastructure policies are important, as are local and international partnerships to finance the progress of e-government initiatives in developing countries (Thompson and Brown, 2007). ICT investment alone may not lead to increased use and diffusion of e-government. Educating and training citizens is also necessary (Zhao, Collier and Deng, 2014). However, the development of ICT infrastructure as well as the intensive provision of e-services by local government could engage active citizen groups in decision-making processes and support the development and proper implementation of e-democracy in the locality (Turner, 2005).

The term 'smart city' is newer than e-government. It is linked to planning policies and ideals originating in the United States, in particular, and to the concept of smart growth developed under the new urbanism in the 1980s and that later was adopted in Europe (Hollands, 2008). The adjective

'smart' mainly involves the relationship between urban space and technology, and includes issues such as the ability to generate innovation, the transition to forms of e-governance, social learning, and the possibility of providing ICT infrastructures (Castells and Hall, 1994; Hollands, 2008). Smart city derives from the overlap and combination of these two strands, the new urbanism and the wave of ICT development (Hollands, 2008; McFarlane, 2011). Although the term smart city is used among information technology professionals and also in academic circles, a clear and consistent understanding of the concept has not yet been consolidated (Chourabi et al., 2012, Bolivar, 2016). There are a range of definitions that seem to focus on three different types of ideal definition: smart cities, understood as cities using smart technologies (technology focus), smart cities as cities with smart people (focus on people) and smart cities understood as cities with intelligent collaboration (focus on governance) (Meijer and Bolivar, 2016). In the definitions, in general, governments play a fundamental role in the promotion and development of smart cities, using ICT in interactive, participatory and informationbased creation of urban environments (Batagan, 2011; Batty et al., 2012). The need for ICT in order to be 'smarter' lies in how governments act and not only in how smart cities generate capital and wealth (Hollands, 2008). Governments can use the ability of internet-based technologies to better understand society, improve citizen participation in decision-making processes, increase efficiency of public services, and improve transparency and accountability (Bolivar, 2016).

Smart cities' projects are characterized as conscious efforts to use ICT with the goal of transforming life and work in a region in a meaningful and fundamental rather than incremental way (Komninos and Sefertzi, 2009). As in e-government, ICT is not the only project tool but without it, it is not possible to build a smart city (Malek, 2009; Cunha et al., 2016). For Nam and Pardo (2011), there are three fundamental components of a smart city: technology (including hardware and software infrastructure), people, and institutions. The ICT infrastructure (hardware, software, networks, internet, data etc.) of the city is important because citizens need access to technology to take advantage of the innovations and services available. On the other hand, businesses and government need technology to deliver services. Thus, a part of the studies on smart cities initiatives address issues of technological infrastructure and enabling technologies, aiming to understand the tensions between technological accessibility and systems infrastructure and availability (Giffinger and Gudrun, 2010). It is necessary to take into account the potential for integration between ICT infrastructures and their operational processes (European Commission, 2012), as well as the possibility of citizens' participation in city governance by electronic means. Therefore, technological changes occur rapidly and are a challenge for local government planning and the development of urban communities (Anttiroiko, 2012).

The understanding of e-government and smart cities in the Brazilian context involves understanding the use of ICT in the municipalities. In Brazil, internet access serves 51% of households (CGI, 2016b), equivalent to 34.1 million households. Considering only urban households, this number increases to 56%, while in rural areas it is 22%. According to the *Fundação Getulio Vargas* (Meirelles, 2016), there are four devices (computers, tablets or smart phones) for every five inhabitants. The e-government indicators show that, in City Halls, access to computers and the internet is universalized (CGI, 2016a). But having universal access to resources does not make municipalities equal in the use and application of ICT. The challenges include communication infrastructure, systems, provision of citizen services, transparency and participation mechanisms (CGI, 2016a), and there are different

institutional conditions and technical capacities (Przeybilovicz, Silva and Cunha, 2015). Regarding the management of IT resources, less than half the city halls (41%) have an IT department and 23% of municipalities that claim to, do not have any effective employees, only provisional contracts (CGI, 2016a). If all municipalities have computers and internet access, the question arises as to who is buying and managing these resources, and who is responsible for making decisions about architecture, systems, and relationships with suppliers. The research ICT Electronic Government (CGI, 2016a) shows the fragile ICT structures in municipalities, which may play a fundamental role in guaranteeing citizens' interests and demands in relation to internet access, for example (Gonçalves, 2011). Other research corroborates the little concern of cities with ICT, although almost all of them are fixed on the proposal for the construction of information systems (Jambeiro, Sobreira and Rabeiro, 2011).

The literature shows that ICT infrastructure is a basic condition for the development of e-government and smart city actions. In this study, we seek to understand the ICT characteristics of the municipalities, since different infrastructure configurations suggest different paths of action.

# 3. METHODOLOGY

This is a quantitative research that uses descriptive and clustering techniques. Using SPSS® software, descriptive statistics were used to organize, summarize and describe the data. The data were then subjected to interdependent multivariate clustering techniques, which allow pattern recognition. According to this technique, the resulting clusters should then exhibit high internal homogeneity (within) and high external heterogeneity (between clusters) (Hair et al., 1998). In this study, this means that the municipalities included in a cluster must have similar infrastructure characteristics and IT use, and that each cluster of municipalities is heterogeneous in comparison to the others.

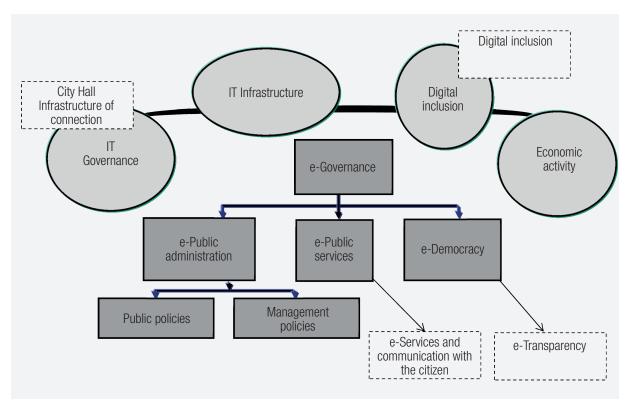
The population is formed by 5,570 Brazilian municipalities. The data were collected from the Munic database, created by IBGE, in 2014. Munic is issued periodically, the first time in 1999 and the last in 2015 in all municipalities, forming a census. The publication is organized in chapters, in which relevant aspects of the management and structure of the municipalities are highlighted. This article used the part of Munic 2014 that presented the responses of the municipalities about ICT. The Munic research from 2014 was used instead of the one from 2015 because the latter did not collect data on ICT. The part of the publication analyzed included 85 questions about the forms of remote service, ICT, digital inclusion and access to public information. The websites of the United Nations Development Program (UNDP), which includes the Human Development Index (HDI-M), were also consulted; research by Pibmun 2012 provided estimates of the Gross Domestic Product per capita per municipality, and the Brazilian Public Sector Accounting and Fiscal Information System (Siconfi) database of the National Treasury Secretariat provided information on the annual balance sheet of 2014, declared by the municipalities' legal representatives.

The technology variables were regrouped in four dimensions: City Hall infrastructure of connection, digital inclusion, e-services and communication with the citizen, and e-transparency, as proposed by Przeybilovicz, Silva and Cunha (2015) and based on the proposal by Cunha and Miranda (2013) (figure 1).

Because the study uses a secondary database, not all proposed dimensions can be fully described. Figure 1 shows (in rectangles) the dimensions that are most common to aspects of governance

or e-government and those that have been observed. The application of ICT can be done in the areas of management policies or public policies, e-services and extension of democratic practice. In this study, the secondary data from Munic allowed observing aspects of e-services that foresee the improvement of service provision to the citizen, through digital means and transparency, made possible by the use of ICT. As other aspects have been valued in government ICT projects, the circles in Figure 1 represent these other dimensions. It was possible to examine data on ICT governance (infrastructure of connection) and digital inclusion. Digital inclusion encompasses government efforts to use the internet, the access to means of communication, to a computer, and even citizens skills in using it.

FIGURE 1 REFERENCE MODEL ON USING ICT BY BRAZILIAN PUBLIC ADMINISTRATION



Source: Adapted from Cunha and Miranda (2013).

From the visual inspection and descriptive analysis of the data extracted from Munic, the municipalities of Brejo de Areia (MA) and Hulha Negra (RS) were excluded as they did not answer any of the questions. In addition, 733 municipalities that did not answer any questions about e-services and communication were excluded. The final sample is made up of 4,835 municipalities. As for the variables, the study excluded those not related to the use of ICT — the variables named as "others" and the qualitative ones. The study also excluded the variables about owning computers in operation and internet access, which reach 100% and 99.8% of positive responses, respectively. At the end, 39

variables were used, among the 85 available from Munic. It was found that municipalities considered important in the national context were excluded from the sample because they did not respond to some of the 39 questions. The data for these municipalities was completed by the researchers and validated by three specialists in the area. The variables HDI-M (UNDP), GDP per capita (IBGE) and municipality revenue per capita (STN) were included in the analysis. For this last variable, for the municipalities that did not present information, the average revenue found for municipalities with the same population size, according to IBGE classification, was considered.

The final model consists of 4,835 municipalities with 39 variables, presented in box 1, which make up the four dimensions analyzed, and the socioeconomic information of the municipalities used for characterization. All technological variables have dichotomous answers 0 (no) and 1 (yes), except for the variable computers connected in network, 0 (no), 1 (some of computers) and 2 (all computers).

#### **BOX 1 DIMENSIONS AND VARIABLES ANALYZED**

| Dimensions                                    | Variables  | Description   |
|---|--|---|
| City Hall infrastructure of connection        | Computers connected in network  Intranet  Municipal government has a functioning website   | The variables represent the infrastructure of connection and ICT  |
| E-services and communication with the citizen | Available remote services  Communication through internet  Available services of news and information about the municipality  Access to documents and forms  Procurement processes and bids  Ombudsman and citizen service  Electronic bid  Consultation of processes  Prior consultation and provisional licenses  Official diary, municipal legislation and public finances  Open and competitive hiring process  Online enrollment in the schools of the public education system  Issuing of debt clearance certificate  Appointment scheduling in the public health system | The variables include the form of service, whether remote or electronic, and the public services available to the population online |

Continue

| Dimensions        | Variables   | Description   |  |  |  |
|-------------------|---|---|--|--|--|
|                   | Government develops policies/plan/program on digital inclusion                |   |  |  |  |
| Digital inclusion | Public and free of charge internet access in access centers                   | The variables illustrate the                                    |  |  |  |
|                   | Information on services available in computerized kiosks/information desks    |   |  |  |  |
|                   | Connections between partners and underprivileged communities (ICT purchasing) | digital inclusion initiatives developed by the local government |  |  |  |
|                   | Creation of computing centers (Telecentros)                                   |   |  |  |  |
|                   | Computer in schools of the public education system                            |   |  |  |  |
|                   | Government provides Wi-Fi connection and access                               |   |  |  |  |
|                   | Specific legislation/procedures/provisions on access to information           |   |  |  |  |
|                   | Available channels to request/access public information                       |   |  |  |  |
|                   | Received requests – municipal government (2013)                               |   |  |  |  |
|                   | Available real time information on the budget and financial execution         |   |  |  |  |
|                   | Register of the competences   |   |  |  |  |
|                   | Organizational structure  |   |  |  |  |
|                   | Address and telephone numbers of agencies                                     | The variables present the initiatives of local                  |  |  |  |
| E-Transparency    | Public service hours  | government to offer access                                      |  |  |  |
|                   | Record, payments and transfer of financial resources                          | to public information using electronic means                    |  |  |  |
|                   | Record of expenditures  |   |  |  |  |
|                   | Information on procurement processes  |   |  |  |  |
|                   | General data allowing monitoring programs                                     |   |  |  |  |
|                   | Answers for community's frequent asked questions                              |   |  |  |  |
|                   | Data published in open/editable format  |   |  |  |  |
|                   | Data updating   |   |  |  |  |
|                   | Population in the municipality (2014)   |   |  |  |  |
| Socioeconomic     | GDP per capita in the municipality (2012)                                     | The variables illustrate the                                    |  |  |  |
| information       | HDI-M (2010)  | socioeconomic conditions in the municipalities                  |  |  |  |
|                   | Current revenues per capita (2014)  |   |  |  |  |

**Source:** Elaborated by the authors.

# 4. DATA ANALYSIS AND RESULTS

In the descriptive analysis it is possible to observe that more advanced services are not available on the internet, 90.5% of the municipalities do not offer consultation/obtaining of licenses, 98.3% do not have online school enrollment, and 98.9% do not have online doctor appointment scheduling. The city councils' websites have predominantly informative characteristics (91.6%). Municipalities developed digital inclusion initiatives (87.3%) such as public access to the internet (59.4%), creation of computing centers (*telecentros*) (51.9%) and installation of computers in the public school system (66.2%). Regarding transparency, 78.5% still do not have specific legislation to comply with the Brazilian access to information law (LAI).

Cluster analysis was performed with the technology variables presented in box 1. For the generation of the clusters, different methods were tried using SPSS\* v.21.0. First, "two-step" analysis was performed and four groups were indicated. Secondly, the analysis was performed with Ward method and Euclidean distance. The dendrogram indicated the existence of three clusters. Finally, the K-means clustering was used. Previous studies (Przeybilovicz, Cunha and Quandt, 2014; Przeybilovicz, Silva and Cunha, 2015), suggested the formation of six clusters. Analyzes were performed for three, four, five and six clusters. The analysis of four clusters was chosen because the resulting clusters presented a greater possibility of explanation by the researchers. The averages of socioeconomic variables were added for a better description (table 1).

TABLE 1 RESULT OF CLUSTER ANALYSIS K-MEANS

| Final center of the clusters                  |   |                                 |         |        |        |        |
|---|---|---------------------------------|---------|--------|--------|--------|
| Dimensions                                    | Variables   | Range                           | Cluster |        |        |        |
|   |   |                                 | 1       | 2      | 3      | 4      |
| City Hall<br>infrastructure<br>of connection  | Computers connected in network                                    | 0 - None<br>1 - Some<br>2 - All | 1.4859  | 1.6240 | 1.5813 | 1.7296 |
|   | Intranet  | 0 (No)<br>1 (Yes)               | 0.2697  | 0.3952 | 0.3155 | .4986  |
|   | Municipal government has a functioning website                    | 0 - 1                           | 1.0000  | 1.0000 | 1.0000 | 1.0000 |
|   | Available remote services   | 0 - 1                           | .9664   | .9898  | .9896  | .9964  |
| E-services and communication with the citizen | Communication through internet                                    | 0 - 1                           | .8128   | .9230  | .9143  | .9613  |
|   | Available services of news and information about the municipality | 0 - 1                           | .9267   | .9015  | .8631  | .9613  |

Continue

| Final center of the clusters |   |       |         |       |       |       |  |
|------------------------------|---|-------|---------|-------|-------|-------|--|
| Dimensions                   | Variables   | Range | Cluster |       |       |       |  |
| Dimonono                     | Turius 100  | nungo | 1       | 2     | 3     | 4     |  |
|                              | Access to documents and forms   | 0 - 1 | .1054   | .6048 | .5797 | .8257 |  |
|                              | Procurement processes and bids  | 0 - 1 | .0848   | .7826 | .8135 | .8709 |  |
|                              | Ombudsman and citizen service   | 0 - 1 | .1306   | .5323 | .3939 | .8042 |  |
|                              | Electronic bid  | 0 - 1 | .0138   | .2673 | .1946 | .3824 |  |
|                              | Consultation of processes   | 0 - 1 | .0390   | .2072 | .1890 | .4785 |  |
|                              | Prior consultation and provisional licenses                                   | 0 - 1 | .0099   | .0702 | .0496 | .2296 |  |
|                              | Official diary, municipal legislation and public finances                     | 0 - 1 | .1673   | .6263 | .6869 | .8142 |  |
|                              | Open and competitive hiring process   | 0 - 1 | .0718   | .7067 | .6485 | .8379 |  |
|                              | Online enrollment in the schools of the public education system               | 0 - 1 | .0053   | .0091 | .0096 | .0387 |  |
|                              | Issuing of debt clearance certificate   | 0 - 1 | .0183   | .1416 | .1105 | .3565 |  |
|                              | Appointment scheduling in the public health system                            | 0 - 1 | .0015   | .0057 | .0088 | .0237 |  |
|                              | Government develops policies/plan/program on digital inclusion                | 0 - 1 | .8113   | .9173 | .8118 | .9570 |  |
|                              | Public and free of charge internet access in access centers                   | 0 - 1 | .4752   | .6625 | .4868 | .7597 |  |
|                              | Information on services available in computerized kiosks/information desks    | 0 - 1 | .0168   | .0328 | .0192 | .0897 |  |
| Digital<br>inclusion         | Connections between partners and underprivileged communities (ICT purchasing) | 0 - 1 | .0688   | .1042 | .0633 | .1987 |  |
|                              | Creation of computing centers ( <i>Telecentros</i> )                          | 0 - 1 | .4385   | .6127 | .3843 | .6571 |  |
|                              | Computer in schools of the public education system                            | 0 - 1 | .5264   | .7169 | .5757 | .8307 |  |
|                              | Government provides Wi-Fi connection and access                               | 0 - 1 | .2460   | .2786 | .1986 | .3659 |  |
| e-Transparency               | Specific legislation/procedures/provisions on access to information           | 0 - 1 | .0894   | .1789 | .1978 | .3702 |  |
|                              | Available channels to request/access public information                       | 0 - 1 | .7838   | .8913 | .9127 | .9720 |  |

|                 | Final center of t   | he clusters |              |               |          |          |  |
|-----------------|---|-------------|--------------|---------------|----------|----------|--|
| Dimensions      | Variables   | Range       | Cluster      |               |          |          |  |
|                 |   |             | 1            | 2             | 3        | 4        |  |
|                 | Received requests – municipal government (2013)                       | 0 - 1       | .1795        | .3035         | .2282    | .4770    |  |
|                 | Available real time information on the budget and financial execution | 0 - 1       | .6066        | .6784         | .9143    | .9397    |  |
|                 | Register of the competences   | 0 - 1       | .2498        | .2446         | .3042    | .7432    |  |
|                 | Organizational structure  | 0 - 1       | .4775        | .4609         | .5044    | .8788    |  |
|                 | Address and telephone numbers of agencies                             | 0 - 1       | .6211        | .6988         | .7590    | .9591    |  |
|                 | Public service hours  | 0 - 1       | .3293        | .3431         | .3731    | .8164    |  |
|                 | Record, payments and transfer of financial resources                  | 0 - 1       | .3461        | .0566         | .8447    | .8307    |  |
|                 | Record of expenditures  | 0 - 1       | .4332        | .1846         | .9544    | .9283    |  |
|                 | Information on procurement processes                                  | 0 - 1       | .3407        | .4519         | .8038    | .8759    |  |
|                 | General data allowing monitoring programs                             | 0 - 1       | .2857        | .1971         | .3747    | .6600    |  |
|                 | Answers for community's frequent asked questions                      | 0 - 1       | .1268        | .1166         | .1105    | .4204    |  |
|                 | Data published in open/editable format                                | 0 - 1       | .4607        | .5640         | .5669    | .6686    |  |
|                 | Data updating   | 0 - 1       | .7785        | .7497         | .8695    | .8852    |  |
|                 | Number of municipalities per cluster                                  |             | 1,309        | 883           | 1,249    | 1,394    |  |
| Characteristics | Average population (2014)   |             | 17,490       | 28,960        | 22,079   | 83,190   |  |
| of              | Average GDP per capita (2012) US\$                                    |             | 5,464.70     | 7,440.32      | 7,664.41 | 9,371.80 |  |
| municipalities  | Average HDI-M (2010)  |             | 0.634        | 0.668         | 0.670    | 0.698    |  |
|                 | Average revenues per capita (2014) US\$                               |             | 1,065.71     | 1,182.01      | 1,245.94 | 1,193.29 |  |
|                 |   | Key         |              | Worst results |          |          |  |
|                 |   | NEY         | Best results |               |          |          |  |

**Source:** Elaborated by the authors.

The results allow to observe the municipalities in clusters that were denominated: 'Technologyless', the 'Concerned-on citizen', the 'Concerned-on legislation' and the 'ICT supported'. In addition to these, a fifth group was formed with the 735 municipalities excluded from the sample.

# 1) Cluster 1 — 'Technologyless'

This cluster presents an average population of 17,490 inhabitants, an average GDP per capita of US\$ 5,464.70, with an average municipality revenue per capita of US\$ 1,065.71 and the worst average of HDI-M: 0.634. It is the smallest and the poorest cluster. It presents the worst indicators of ICT use and infrastructure: the city has little infrastructure, electronic services and low rates of communication with the population, promotes a small number of actions for digital inclusion and e-transparency. The group consists of 1,309 municipalities and, although the largest number is in the Northeast (514), there are municipalities representing this cluster in all Brazilian regions.

# 2) Cluster 2 — the 'Concerned-on citizen'

The 'Concerned-on citizen' cluster (with 883 municipalities) has an average population of 28,960 inhabitants, with GDP per capita of US\$ 7,440.32, average revenues per capita of the municipalities around US\$ 1,182.01, and average HDI-M 0.668. The emphasis of attention is the citizen, as it uses ICT to promote e-services and communication. It pays some attention to digital inclusion and shows little transparency through electronic means. Most of the municipalities of this group are located in the Southeast region of Brazil (297).

# 3) Cluster 3 — the 'Concerned-on legislation'

It has an average GDP per capita of US\$ 7,664.41 and 22,079 inhabitants; municipal average revenue per capita of US\$ 1,245.94, the best among the four groups, and average HDI-M of 0.670. These municipalities are bigger and richer than the others. As there are better economic conditions, they are in position to improve the City Hall infrastructure of connection, the offer of e-services to the citizens, in communication and in the digital inclusion. The municipalities in this cluster are more concerned with transparency than with citizen service, possibly to comply with legislation. A large number of municipalities in this cluster are also from the Southeast region (408). The group is formed by 1,249 municipalities and is second in socioeconomic indicators.

# 4) Cluster 4 — 'ICT supported'

This cluster represents a group of 1,394 municipalities that presented the best result in relation to socioeconomic indicators, with average GDP per capita of US\$ 9,371.80, municipal revenue per capita of US\$ 1,193.29, lower than cluster 3, and average HDI-M 0.698. It consists of capitals and cities considered important in the Brazilian context, such as São Paulo and Rio de Janeiro. These two municipalities had socioeconomic indicators (GDP, population and revenue) taken from the calculation of the averages in order to avoid distortion. Municipalities of the cluster 'ICT Supported' are large and rich with an average of 83,190 inhabitants, the ICT indicators are the best, from infrastructure to use to benefit the citizens and e-transparency. The group is formed largely by municipalities of the South (471) and the Southeast (415).

# 5) Municipalities excluded from the sample

The 735 municipalities excluded from the analysis are small, averaging 14,706 inhabitants, and have worse socioeconomic indicators than those of the municipalities organized in the clusters presented. Average GDP per capita is US\$ 4,557.84, average municipal revenue per capita of US\$ 987.97, HDI-M is 0.597. Of these municipalities, 85.3% say that the website of the municipal government is not in operation. Regarding digital inclusion, 77.2% reported there is some initiative in place, although in a timid manner; 44.9% have computing centers (*telecentros*), 49.7% have computers in the schools of the public education system, 17.9% have access to a Wi-Fi connection. About 95% of them do not have specific legislation complementary to the Brazilian access to information Law.

Brazilian municipalities have different characteristics of ICT use, which leads to the discussion of different problems and possibilities for action.

# 5. DISCUSSION

There are limitations in the use of ICTs by municipalities, but there have been advances in relation to the scenarios of 2009 and 2012 (Sano, 2012; Przeybilovicz, Cunha and Quandt, 2014; Przeybilovicz, Silva e Cunha, 2015). The compulsory electronic interaction required by the federal government in the municipalities, in some programs, universalized the use of computers and the internet, which led to the removal of these variables from the analysis model. There are important differences to be considered in the use of the resources. The limited use of ICT by most municipalities can lead to investments in inefficient e-government initiatives and smart cities. More than a decade ago, in a reflection on e-government research, Grönlund (2005) showed that government's initiative making available computers and internet access did not necessarily improve citizens' services and/or governments capacity to manage resources. In the discussion of the results of this work, different approaches are proposed to foster the use of ICTs for the clusters of 'Technologyless', the 'Concerned-on citizen', the 'Concerned-on legislation' and the 'ICT supported'

An e-government policy with transparency, e-services and participation requires minimal resources of ICT infrastructure, which is not present in the Technologyless cluster. In developing or emerging countries, such as Brazil, the use of ICT is a particularly thorny problem. Poor and small municipalities rely heavily on resources from other levels of government and, on their own, can hardly design public policies that benefit from technology. Taking into account the opportunity for interactive, participatory and ICT-supported creation (Batagan, 2011), the lack of ICT infrastructure, management and skills leaves them unskilled to achieve the status of smart city (Batty et al., 2012). The results of this study, and a comparison with international studies, allow some suggestions of IT governance for the municipalities included in the Technologyless cluster. Several barriers in the developing of e-government initiatives have been reported in the literature, including lack of financial resources, technical resources, qualified staff and size of municipality (Moon, 2002). While it is not fair to blame the federal government for the lack of computerization, the central government has a strategic role to play in some of these issues (Rahman, 2010). On the other hand, instead of depending exclusively on state or federal funding, the municipalities in the Technologyless cluster can form partnerships with other municipalities in the region, consortia or associate with other municipalities and seek financing from international agencies (Thompson and Brown, 2007) extending the availability and use of ICT in e-government or smart cities and encourage digital inclusion. The federal government can provide support to these initiatives by providing loan guarantees and technical support for the development of local projects. With the establishment of a temporary national system, it is possible to support the development of these initiatives, with qualified people in the use of ICTs and in the formulation of public policies for the development of information systems and support for implementation. The municipalities in the Technologyless cluster are the target, as they need more attention of the associations of municipalities and of the state and federal governments, to promote public policies and to implement ICT resources. These actors can provide catalogs of solutions for municipalities, encourage the use of solutions already available in the form of free software, promote

training and support for use, suggest implementation of IT management practices and processes, in short cycles, for quick gains, financial support and investment and a suggestion of legal framework. ICT availability does not guarantee the development of e-government (Gil-Garcia, Arellano-Gault and Luna-Reyes, 2010; Rahman, 2010) and smart cities (Nam and Pardo, 2011), but without it, there is little hope of reaching the benefits offered by e-services (Turner, 2005) and transforming life and work in the region in a meaningful way (Komninos and Sefertzi, 2009). The Technologyless cluster requires the expansion of technology use and institutional capacity building in short cycles and with perceived results by the government and/or the population. Self-learning has a long cycle for these municipalities, the investment risks are high and the lack of local mobilization in this sense needs to be considered. It is important to emphasize that the implementation of IT management actions, both participatory and based on local needs, can mitigate the effects of the creation of technical dependency and central government resources and obtain the commitment of the population.

'The Concerned-on citizen' municipalities "do their homework" meaning that in the competition between resource scarcity and municipal demands, they apply ICT resources to the benefit of the citizen. It is possible to imagine better ICT management than the previous group with institutional capacity and some IT management processes. The population take advantage of the potential benefits of e-government actions, as there is a greater offer of e-services and more digital inclusion initiatives. The municipality needs to move forward in e-transparency, an important dimension for exercising social control over local government actions. Concerned-on citizen municipalities have potential for 'smart' initiatives.

The results also show that it is not enough to have ICT resources and infrastructure to increase the actions of e-government, as it is the case of the 'Concerned-on legislation' cluster. This cluster is composed of municipalities with relatively good socioeconomic conditions, some of which are among the municipalities with higher revenues. Inclusion in the agenda of ICT actions directed to the citizen, especially provision of e-services and digital inclusion are necessary. Brazil has a public transparency policy ruled by federal laws, such as the Access to Information Law (LAI, law n. 12,527) is the most recent, promulgated in November 2011. Federal, state and municipal governments are subject to LAI, which was implemented in stages. It became mandatory for large municipalities when it came into force (May, 2012) and, progressively, the obligation has been extended to all others (2014). The legal obligation can be an explanation for the 'Concerned-on legislation' municipalities to have advanced in e-transparency, not prioritizing the use of ICT in citizen services.

'Concerned-on citizen' and 'Concerned-on legislation' municipalities are able to offer better electronic services to the citizens. The establishment of a horizontal ICT resource management platform improves the sharing of information to provide public services more efficiently and with transparency. Electronic services and these platforms increase economies of scale and ability to negotiate with suppliers. However, there may be no demand by citizens for these services and there is also no legal framework requiring municipalities to offer them. Thus, the provision of electronic services is different between the two clusters. It is necessary to think of standards for citizen services using electronic means and governance of IT resources, which initially contemplate incentives for adoption, but which progress towards mandatory/regulation and universalization of services, within a feasible period.

The municipalities 'ICT Supported' have the greatest potential to be smart cities. They have the best indicators of resources and use of ICT. The database used does not allow an evaluation of all dimensions of the conceptual model of e-government (Cunha and Miranda, 2013), but the cluster had good results in the four dimensions analyzed. This cluster includes capitals and municipalities considered important in the Brazilian context, which already have smart initiatives. Once the city has a technology infrastructure and citizen services, it can interconnect citizens, urban services and other actors in the city, such as companies, third sector, universities, collectives. Synergies are captured between the public services already provided and also the improvement and/or development of new services for the citizen and for the companies. From the crossing and analysis of the different data of the city, services and citizens, the decision making is facilitated and the management of the city is improved. By providing real-time information to citizens, they can make their personal decisions based on what is going on around them. Examples of such services are transport services, such as bus or transit applications. The municipalities of this cluster have the infrastructure to develop architecture for a robust, standard, open and interoperable technology platform that ensures the municipality does not become hostage to suppliers and ensures the development of an innovative ecosystem in the smart city. These municipalities are minimally qualified to develop new ways of contracting suppliers, such as public-private partnerships (PPPs) and contract management (or other forms of agreements) with the establishment of levels of technological services.

Finally, there are the 735 municipalities that were not included in the clusters, possibly digitally excluded, with the worst socioeconomic indicators and indications of poor infrastructure and use of ICT. They have even greater challenges to develop their e-government and smart city actions. It is important for poorer municipalities, such as the 'Technologyless' and the excluded digital ones to access some kind of aid so that they can enjoy the benefits of continued improvement in public management and in their social indicators.

#### 6. FINAL CONSIDERATIONS

This study was guided by the question of how the infrastructure and the use of ICT characterize groups of municipalities. The results showed that there are four clusters and identified their characteristics, which influence initiatives of e-government and smart cities. The study analyzed the profile of municipalities from four dimensions (Cunha and Miranda, 2013): City Hall infrastructure of connection, e-services and communication with the citizen, digital inclusion and e-transparency.

The study sought to contribute theoretically, describing a typology of municipalities from the characteristics of infrastructure and use of ICT. The results show four types, with different needs. While 'Technologyless' municipalities require basic ICT conditions, 'Concerned-on legislation' municipalities need to improve how ICT can be managed and directed to make life easier for citizens. 'Concernedon citizen' cities need to increase the actions of e-transparency. The 'ICT Supported' municipalities are at a more advanced level and can continue the actions towards the idea of smart cities.

Research in e-government should reflect the practice of IT governance in municipal governments, especially in developing countries (Grönlund, 2005). According to the federal government, ICT

<sup>&</sup>lt;sup>1</sup> Available at: <www.governoeletronico.gov.br/>.

initiatives in governments aim at democratizing access to information and must follow three fundamental guidelines: citizen participation, improved internal management and integration with partners and suppliers. However, generic recommendations do not serve all municipalities. E-government public policies recommending generic principles in Brazil may not have achieved the expected effects, and the same may happen with smart city initiatives. The research of e-government and smart cities in developing countries should consider the steps that must be taken at the municipality level. Challenges are not trivial and actions that consider differences between the cities can leverage results. Municipal governments are responsible for defining public policies according to local priorities. ICT use can change the economic potential of the region and create greater competitiveness, leading to new business opportunities and innovation, influencing the economic potential of a municipality and it's potential to become a smart city. Efforts should be made to use ICT in order to transform life and work in a region in a meaningful way. It is important for poorer municipalities to receive financial aid and/or resources for investment in basic ICT infrastructure from other spheres of government.

Different groups of municipalities were identified, each with specific requirements for the best use of ICT. One of the limitations of this study is that the variables that make up each dimension were extracted from a secondary source, Munic 2014, which does not completely define the use of ICTs in municipalities. When conducting the Munic 2014 research, IBGE made changes on the set of questions asked to the municipalities in comparison to previous research. This made it difficult to analyze in depth the development of the topic through history and diminished the capacity of discrimination among the groups of municipalities. However, Munic is a national study that has been conducted regularly for a number of years and therefore allows for some comparison. There seems to have been an evolution in the use of ICTs by municipalities between 2009 (Sano, 2012) and 2014 (Przeybilovicz, Silva and Cunha, 2015). One suggestion for future studies is to analyze how the use of ICT in the municipalities evolves, using the same database, comparing states, regions and municipalities, and to carry out analyzes within the clusters found in this study. Other studies may seek to analyze more closely the concepts and characteristics of development and deployment of e-government and smart city projects. Looking at the e-government literature can shed light on how the term and smart city initiatives are being appropriated in the Brazilian context. Perspectives from other fields of knowledge, such as political science, public management, urban management and sociology, may complement research on e-government and smart cities.

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# **Erico Przeybilovicz**

PhD Student in Business Administration at the São Paulo School of Business Administration of Fundação Getulio Vargas. E-mail: erico.prz@fgv.br.

#### Maria Alexandra Cunha

PhD in Business Administration and Professor at the São Paulo School of Business Administration of Fundação Getulio Vargas. E-mail: alexandra.cunha@fgv.br

# **Fernando de Souza Meirelles**

PhD in Business Administration and Professor at the São Paulo School of Business Administration of Fundação Getulio Vargas. E-mail: fernando.meirelles@fgv.br.