
Electronic government maturity index: proposal to evaluate the maturity of local government portals

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Abstract: This paper proposes an evaluative index for local government portals, called the electronic government maturity index (e-GMI), as a measure of the electronic government maturity. In a congruence of the maturity models by Lee and Kwak (2012), United Nations (2014) and Lechakoski (2015), the e-GMI is composed of five maturity stages, structured in nine analysis dimensions. Each dimension has checkpoints in the portal, called analysis attributes, which measures the development stage of the portal through fuzzy logic. For empirical validation, the e-GMI was applied to the portals of the Brazilian capitals' city halls and resulted in classifications of Stages 2 and 3 of maturity. The validation in these case studies confirms that the model composed by e-GMI is a robust, deep and objective electronic government maturity model, and an important instrument to evaluate local governments' portals.

Keywords: electronic government maturity index; e-GMI; maturity models; e-government.

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1 Introduction

Electronic government (e-government) connects government to its stakeholders (citizens, businesses, its employees and other instances of government) using information and communication technologies (ICTs). This interaction is through government portals on the World Wide Web (WWW) or via applications for mobile phones and tablets. The concept of e-government treated in this article considers the three main pillars:

- 1 the use of technological tools to make digital and integrated services
- 2 to promote access to government information through public transparency and open data
- 3 to expand the mechanisms of social participation by communication tools (Batista, 2018; Bezerra, 2008; Cepik and Canabarro, 2014; Dziekaniak, 2012; Garcia, 2006; González de Gómez, 2002; Kawashita, et al., n.a.; de Laia, 2009; Lee and Kwak, 2012; Máchová, 2015; Marcondes and Jardim, 2003; De Pinho and Sacramento, 2009; Ribeiro, 2011; Ribeiro et al., 2011; Snellen, 2007).

For evaluation of the development of e-government, the literature proposes several maturity models. Called 'e-government maturity models', they allow observation of their performance from pre-identified stages that evolve over time. Reaching maturity means being at a level of continuous development, optimisation and improvement in order to achieve excellence in assets and organisational objectives; in stages from publishing information to supporting online transactions and electronic participation (e-participation). Based on the 'capability maturity model' (CMM) and on information systems that consider vertical and horizontal structure of the organisation, these models portray the reality of the process, and serve as a guide to improve the quality of the portals, pointing out the required steps to reach optimisation and continuous improvement (Batista, 2018; DeBri and Bannister, 2015; Fath-allah et al., 2014; Fernandes, 2007; Kawashita et al., n.a.; Lechakoski and Tsunoda, 2015; SEI, 2006; Snellen, 2007; Windley, 2002).

The literature has a range of e-government maturity models, and this study analysed 33 maturity models, among the most cited in the literature: ANAO (1999), Baum and Di Maio (2000), Hiller and Bélanger (2001), Deloitte (2001, with Maranny, 2011), Layne and Lee (2001), Wescott (2001), Howard (2001), Akutsu (2002), Netchaeva (2002), United Kingdom (2002), Windley (2002), Moon (2002), European United (2002, 2007, with Anes, 2009; Capgemini, 2007), Accenture (2003, with Lechakoski, 2015; Shahkooh et al., 2008), Reddick (2004), West (2004), Siau and Long (2005), Torres (2006), Esteves and Sousa (2006), Andersen and Henriksen (2006), Cisco (2008), Almazan and Gil-Garcia (2008), Shahkooh et al. (2008), Kim and Grant (2010), Chen et al. (2011), Dias (2011), Lee and Kwak (2012), United Nations (2014), Dias and Costa (2013), Khan (2015) and Lechakoski (2015).

Of these, only 15 models (Table 1) have in their structure the concept of the three pillars: information, service and participation. With different characteristics, these models allow analysis of the e-government at different levels: national, state and local.

In general, the models follow an increasing order of technological development to implementation of e-government: interaction with the citizen, safe transaction of services, vertical and horizontal integration, interoperability, and in most cases, offering e-participation tools in the last stage.

In this way, after the first stage, while the bureaucratisation of internal processes is dissolved with the insertion of ICT and made more flexible for open and participative management, new tools are incorporated into e-government. These are signs of improvement in the framework of its maturity, to meet user expectations in the form of secure and sophisticated digital services. Highlights are the models of Hiller and Bélanger (2001), Moon (2002), Siau and Long (2005) and Shahkooh et al. (2008). The model of Hiller and Bélanger (2001) was one of the first, in this selection, to contemplate the political perspective.

The most advanced levels of maturity happen gradually (Rover et al., n.d.), because the e-governments require resources for vertical and horizontal integration, observed only at more advanced stages and mature (Fath-allah et al., 2014). The models by Wescott (2001) and Almazan and Gil-Garcia (2008) differ from the others because they present six stages of development of e-government, basically subdividing the initial phase, called 'information', in two levels. On the other hand, there are models, such as Torres (2006) and Dias and Costa (2013), that propose the separate evaluation between the three pillars, which are presented in parallel and without technological interdependence.

Table 1 Maturity models with three pillars in its structure

<i>Author</i>	<i>Model</i>	<i>Description</i>
Hiller and Bélanger (2001)	'Privacy strategies for electronic government'	Five-stage model based on the technological perspective of service availability and e-participation, but not in real time.
Wescott (2001)	'E-government in the Asia-Pacific region'	Maturity model developed in the Asian region, which presents six stages of development of e-government, including digital democracy.
Akutsu (2002)	'Adaptation of the ANAO model'	Five-stage model that is an adaptation of the model proposed by ANAO-OGO. This new model includes citizen participation in government decisions and the formulation of public policies.
Netchaeva (2002)	'E-government and e-democracy a comparison of opportunities in the North and South'	Five-stage model of e-government development, with the characteristic of social participation, through opinion polls.
Moon (2002)	'The evolution of e-government among municipalities: rhetoric or reality?'	Five-stage model developed to assess the current state of municipal e-government initiatives in the USA, resulting in a database of 2000 municipal e-gov. surveys.
West (2004)	'E-government and the transformation of service delivery and citizen attitudes'	Four-stage model based on identifying the promotion of service provision, the capacity for democratic response and public awareness.
Siau and Long (2005)	'Synthesizing e-government stage models – a meta-synthesis based on a meta-ethnography approach'	Five-stage maturity model: internet presence, interaction, transaction, transformation and e-democracy.
Torres (2006)	'Research and study project to evaluate municipal portals and create IPGEM – São Paulo (index for the development of local e-government – TECGOV)'	Five-stage model designed to evaluate municipal electronic services in the state of São Paulo/Brazil. It evaluates aspects of e-gov. interaction and proposes an evaluation of digital democracy unrelated to the development stages of the model.
Esteves and Sousa (2006)	'Municipal e-services development model'	Five-stage model developed to evaluate the digital services in Portuguese local government.
Almazan and Gil-Garcia (2008)	'E-government portals in Mexico'	Six-stage maturity model was used in Mexico in a systematic analysis of 32 state websites to identify their weaknesses.
Shahkooh et al. (2008)	'A proposed model for e-government maturity'	Five-stage model based on models in the literature, which considers the complexity of IT for the delivery of digital services and e-participation.
Lee and Kwak (2012)	'Open government maturity model'	Five-stage maturity model, based on concepts of open government, use of social media and Internet 2.0 tools.
Dias and Costa (2013)	'Multidimensional maturity model'	Maturity model categorised into three independent dimensions: government information, electronic service delivery and participation in public decisions, each one with four stages of development.
United Nations (2014)	'E-government survey 2014: e-government for the future we want'	Four-stage maturity model discusses the development of e-gov. from the perspective of citizen focus, open government and electronic participation using Web 2.0 tools.
Lechakoski (2015)	'Proposal for a maturity model for e-government sites'	Four-stage model developed from the adaptation of other models, and includes four dimensions: services, accessibility, usability and social network. It was applied to state government portals in Brazil.

Source: Prepared by the authors

Table 2 Potentialities and challenges of models studied

	<i>Lee and Kwak (2012)</i>	<i>United Nations (2014)</i>	<i>Lechakowski (2015)</i>
Potentialities	<ul style="list-style-type: none"> This model focuses on open government and public transparency, an evolutionary approach to citizen participation in developmental stages (concept of e-participation and e-collaboration), use of Web 2.0 tools in less advanced stages, enhancement of collective knowledge and open collaboration among government, citizens and the private sector. The model proposes, from the earliest stages, an evolutive way to gather spontaneous citizen collaboration through the transparency and openness of public management. 	<ul style="list-style-type: none"> This model has financial and non-financial digital services analysed within the same evolutionary stage, that is, the digital services are public services offered digitally, with or without financial ties to management. In addition, e-participation is structured as electronic information sharing, electronic consultation and electronic decision making, expanding in the direction of the concept of electronic democracy. 	<ul style="list-style-type: none"> This model highlights the importance of usability and accessibility, with emphasis on the relationship between citizens (C2C) in the participatory process and the use of social networks to complement the communication between the state and citizens, which shows more adaptation to the citizen's daily life.
Challenges	<ul style="list-style-type: none"> This model is rigid regarding the evolution of citizen participation and it shows the theoretical model without metrics. It does not analyse e-government from the perspective of information, digital service and e-participation; and, it does not address the C2C communication. In addition, it associates the concept of e-voting with e-participation, directing its use more as a 'poll' and less as decision-making. 	<ul style="list-style-type: none"> This model does not deal with C2C communication and considers citizen interaction and the use of Web 2.0 only in the last step. Also, although considered necessary, it does not include a more careful assessment of accessibility in stages. 	<ul style="list-style-type: none"> This model is rigid because each stage goes through the fulfilment of the functionalities of the previous stage. As well, it does not consider the transition stages of online services and does not mention the importance of open government and public transparency. The structure of the e-participation is focused on social networks and little on government portals

Source: Prepared by the authors

In contrast, models such as Tecgov, Lee and Kwak, Lechakoski and Tsunoda, and Netchaeva, are open to social participation even in initial stages whose level of development of digital services is not yet considered integrated.

Even though they were built without specific evaluation mechanisms, these models serve as a basis for designing e-governments' development stages and identifying their level of maturity. However, for a more robust assessment, it is necessary to have a set of indicators that allow objectively observing the maturity of e-governments.

Although there are several models that incorporate the concept of the three pillars of e-government (information, services and participation), and some directed to the local e-government, many models do not detail the variety of indicators at each stage of development. They attribute little relevance to issues such as usability, digital accessibility or use of tools already incorporated into everyday life.

Also, they do not consider a strong variation in the structural model and they do not allow for identification of different levels of development within the same maturity stage. On the other hand, many models too slowly progress the weighing, calibration and empirical validation of the stages and they are sometimes generic in pointing out the improvements needed to reach optimisation and as well as how they rank a portal's specific stage of development. Rampelotto et al. (2015) propose an assessment previously formulated in exploratory interviews and questionnaires, but in their work, the authors do not contemplate the multi-dimensional concept of e-government.

Battle-Montserrat et al. (2011) argue that few models consider the evolutionary stages of public administration, and important aspects such as proactivity, simplification of digital services, integration and interoperability, and an interaction with the citizens mediated by Web 2.0 – tools that citizens use in their daily lives. Of the 15 models, Table 2 highlights that the use Web 2.0 tools, including digital media, as a participatory channel, and other important factors local government.

After a thorough analysis of these models, these three models stood out: Lee and Kwak (2012), United Nations (2014) and Lechakoski (2015). Table 2 shows their potentialities, and although these models articulate many important characteristics in isolation, each of them demonstrates challenges.

Thus, this article aims to propose a maturity model built from the three models above, composed of a robust and objective methodology that can explore the variety of indicators to assess e-government maturity in local governments.

2 Methodology: proposal to evaluate the maturity of local government portals

From the models studied in this article, three of them were highlighted for their characteristics: United Nations (2014), Lechakoski (2015) and Lee and Kwak (2012). The characteristics described in Table 2 were considered relevant to incorporate into a maturity model.

In this way, these three models were grouped for the construction of a single maturity model that combines all potentialities, in a concept called a metamodels, where a new model is derived from existing ones (Kawashita et al., n.a.). The congruence of the three models thus translated into a single maturity model composed of five stages of development, which are described in Table 3.

Table 3 Congruence of models of Lee and Kwak (2012), United Nations (2014) and Lechakoski (2015)

<i>Maturity level 1</i>	
United Nations (2014)	Emerging: Availability of basic government information, policies, laws and departmental structure. The information is static, but you can access them through links.
Lechakoski (2015)	Stage 1: static (one-way) Accessibility: Minimal accessibility with audio or has video resources without audio and non-textual content with text alternative. Identifies errors in the interaction with the user. Usability: The portal is consistent with the purpose of the agency and presents its purpose, information and services. It has standardised pages (branding), a logical navigation structure and accessible content, and avoids too much information on the homepage. Social network: Government insertion in social networks through profile or page as a form of communication with the user.
Lee and Kwak (2012)	Initial conditions: Static interaction with the citizen. It is a phase with little online governance capacity, without any government-citizen interactivity and little level of transparency.
<i>Maturity level 2</i>	
United Nations (2014)	Enhanced: A simple one-way or two-way state-citizen interaction stage, with downloads and non-electronic submission of forms for government services and applications. The site has versions in other languages.
Lechakoski (2015)	Stage 2: dynamic (bidirectional) Accessibility: Presents audio with pre-recorded subtitles, and pre-recorded self-describing videos. Allows you to select another language on the site. Form headers and labels describe their purpose. Usability: The portal is compatible with all major browsers. It features branding elements always located at the same place and search engines on every page. Texts are formatted to facilitate reading, page exploration and content understanding (left alignment and divided into topics or paragraphs). Social network: Active participation in social networks, including checking with citizens about their satisfaction regarding the site(s) and suggestion for online services.
Lee and Kwak (2012)	Data transparency: First step for open government, with publication of relevant government data. Presence of mechanisms for public feedback on the usefulness and quality of information. Use of e-mail to receive comments from the public.
<i>Maturity level 3</i>	
United Nations (2014)	Transaction: Complete two-way communication with citizens, including sending and receiving contributions on government policies, programs, regulations, etc. The portal may process non-financial transactions such as online tax files or to request certificates, licenses and permits; or financial operations in secure environments, with data security and privacy information and some forms of electronic authentication in citizen identification.
Lechakoski (2015)	Stage 3: transactional Accessibility: Live audio subtitles are synchronised, and texts can be scaled to size. Keyboard operations have visible focus. Usability: Page highlights more used sections or services, and forms show fields with the desired format and number of characters. Presence of tutorial and site map. Social network: Social networks disseminate information, experiences and improvements already implemented and future government actions. Stimulates and uses keywords (via taxonomy or ontology with '#') to extract shared contact among citizens on social networks to map and process needs.

Note: *Breakdown of Maturity level 4 to emphasise e-government's ubiquity.

Source: Based on Lee and Kwak (2012), Lechakoski (2015) and United Nations (2014)

Table 3 Congruence of models of Lee and Kwak (2012), United Nations (2014) and Lechakoski (2015) (continued)

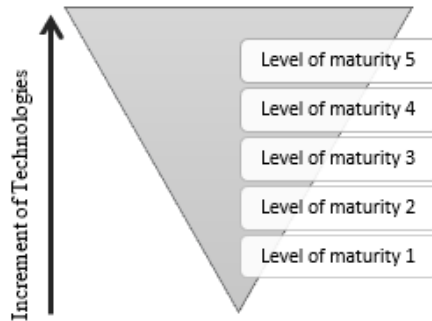
<i>Maturity level 3</i>	
Lee and Kwak (2012)	Open participation: Increasing and valuing open data transparency and availability. Informally uses tools to promote culture and practice aimed at citizen participation via the internet. Popular participation is accepted and used in political decisions via e-vote, e-petition, Web 2.0 tools, blogs, microblogs, social bookmarking/tagging, social networks, etc. While at Level 2, information is opened to the public, in Level 3 the government 'opens up' to public ideas but requires effective government responsiveness.
<i>Maturity level 4</i>	
United Nations (2014)	Connected: E-services and e-solutions continually span departments and ministries; and information, data, and knowledge are transferred to government agencies through integrated apps.
Lechakoski (2015)	Stage 4: Integrated Accessibility: Presence of sign language (pre-recorded) in videos and audios. Contextual help item is available for the accessed content. Usability: Opening links without automatically opening new windows and there are no auto-installable plugins to perform tasks. The error messages are explanatory and succinct. Social network: Provides a content sharing environment that makes it possible to post suggestions, complaints and solutions for best practices on e-government platforms.
Lee and Kwak (2012)	Open collaboration: A more complex process of public engagement, with open collaboration between government agencies; the public and the private sector through data sharing and contributions from the population. Public consultations are organised, and their data used to promote new knowledge and improve decision-making
<i>Maturity level 5</i>	
United Nations (2014)	Omnipresence*: It integrates all possible services available online, with payments made on the portal itself and automatically sends the information to all departments involved with the service. Approach focused on the citizen, with e-services classified by segmented groups and personalised in a single portal. Government creates an environment that enables citizens to be more involved with government activities and to have a voice in decision making, through Web 2.0 and other tools for interacting with citizens.
Lechakoski (2015)	Stage 5: omnipresence* Accessibility: Allows all operations to be operable with keyboard functionality. Usability: Portal structure is defined by the tasks performed by the citizen and not by the organisational structure. Allows customised pages with services and information of greatest interest to the citizen. Social network: From the collaborative culture, the citizen makes use of the keywords to classify the contents and gather data in order to share the knowledge produced.
Lee and Kwak (2012)	Ubiquitous engagement: Open data, applications and processes are interoperable between government agencies in a horizontal and vertical integration. It values transparency and public engagement, participation and collaboration through virtual interaction mechanisms, expanding the reach and depth of technological resources and the power of social media. The public has universal access to government data, information and services, which are easily accessed by mobile and tablet devices.

Note: *Breakdown of Maturity level 4 to emphasise e-government's ubiquity.

Source: Based on Lee and Kwak (2012), Lechakoski (2015) and United Nations (2014)

The format was based on the proposal by Lechakoski (2015), whose maturity model is formed by an inverted pyramid, as new technologies and tools are inserted, the more developed and robust the portal becomes, indicating higher levels of e-government maturity (Figure 1).

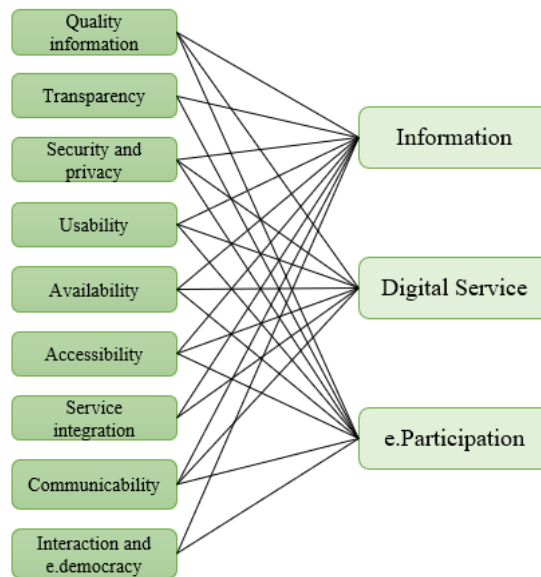
Figure 1 Pyramid of the proposed model of maturity



Source: Adapted from Lechakoski (2015)

However, in order to obtain a more robust and detailed evaluation, the main congruent characteristics of the models were extracted, which, united with the concept of the three pillars, allowed the design of nine evaluation perspectives, called ‘analysis dimensions’: (D1) quality information, (D2) transparency, (D3) security and privacy, (D4) usability, (D5) availability, (D6) accessibility, (D7) service integration (D8) communicability and (D9) interaction and electronic democracy (e-democracy).

Figure 2 Relationship between analysis dimension and three pillars of e-government (see online version for colours)



Source: Prepared by authors

Table 4 Analysis dimensions for e-government maturity

<i>Dimension</i>	<i>Description</i>	<i>Justification</i>
D1	Quality information Considers whether information is comprehensible to the citizen, with a logical, current organisation focused on the production of knowledge.	The information needs to be clear, in a format geared to its target audience, and presents a level of accuracy (updated by the person responsible for it).
D2	Transparency Considers whether information is published to foster accountability and directed towards open government (open data).	Publication of government data enables citizens to track the planning and execution of government actions. The open format enables any machine to read and encode data.
D3	Security and privacy Considers the reliability promoted by the site through a privacy policy and security information.	The visibility of the site's security and privacy conditions gives users confidence in government-citizen interaction.
D4	Usability Considers the ease of the use of the portal, structure of presentation, content layout and navigability based on heuristic assessments.	Used for interface evaluation, indicates whether the interaction is efficient or not, that is, a poor operationalisation of usability can make it difficult or even impossible to perform an operation on a portal.
D5	Availability Considers whether the site is available 24/7 (24 hours a day and 7 days a week), even when the public agency is not open.	A portal that provides 24/7 access provides greater convenience and comfort to the user, as they do not have to wait for the agency's opening hours to perform operations.
D6	Accessibility Considers tools for serving hearing, visual, intellectual, and physical disorders through architectural barrier suppression tools. It gives access to people with special needs and promotes easy access to information and communication to other users.	Accessibility is key to including all citizens, regardless of their limitations in the digital environment.
D7	Service integration Considers the procedures for performing a fully online public service without having to trigger the physical agency to complete the transaction. The site may feature non-financial transactions (accessing online tax files or required certificates, licenses and permits) or financial transactions, performed in fully secure environments.	On the web, citizens expect agility, convenience and efficiency in online services. The integration of services via interoperability is essential for this to happen.
D8	Communicability Considers the means and channels of communication with the citizen.	It is essential that the government provides channels of communication so that citizens can make their complaints, leave suggestions and request information that they do not find on the website.
D9	Interaction and e-democracy Considers the instruments of participatory and collaborative interaction.	Opening the government to the citizens to be a part of the decision-making process is a public administration choice, however it strengthens democracy, encourages citizens to engage in public affairs, and promotes their empowerment.

Source: Prepared by authors based on the literature searched (Arouck, 2001; Bach and Scapin, 2005; Brasil, 2007, 2014; Corrêa, 2012; Costa, 2007; Costa et al., 2013; Funai and Rezende, 2011; Lima, 2018; Nielsen and Landauer, 1993; OECD, 2004; De Pinho and Sacramento, 2009; Rothberg, 2010; Santos, 2014; United Nations, 2014; Viana, 2012)

Table 5 Analysis attributes

	<i>Attributes of analysis</i>	<i>Maturity stage</i>	<i>Rating/scale</i>
D1	1.1	Website consistent with the purpose of the agency	Two-dimensional
	1.2	Clear information in understandable language and without grammar and spelling errors	Likert
	1.3	Relevant government information on policies, programs and laws	Likert
	1.4	Information accessible via links	Two-dimensional
	1.5	Additional information files available for download	Two-dimensional
	1.6	Homepage avoids information overload	Likert
	1.7	Information with logical organisation	Likert
	1.8	Information update (once a week)	Two-dimensional
	1.9	Explanatory notes for technical terms	Two-dimensional
	1.10	Presence of documentation and tutorial (answers to frequently asked questions and mentoring for site use)	Two-dimensional
	1.11	Information categorised to produce knowledge	Likert
	1.12	Information from other spheres of government in a single citizen portal	Likert
D2	2.1	Information as regulated by applicable law	Two-dimensional
	2.2	Identification of who is responsible for the administrative act	Two-dimensional
	2.3	Item to track situation/status of an issue	Two-dimensional
	2.4	Disclosure of government actions that promote control and enforcement	Likert
	2.5	Open documents formats: JSON, XML, CSV, ODS, RDF	Two-dimensional
	2.6	Disclosure of website satisfaction indicators	Two-dimensional
D3	2.7	Dissemination of government information, experiences and actions on social networks	Likert
	2.8	Dissemination of public information/contributions	Likert
	2.9	All information is accessible by mobile device	Likert
	3.1	Privacy policy information	Two-dimensional
	3.2	Page security information	Two-dimensional
D4	3.3	Portal requires identification and password to access citizen area	Two-dimensional
	4.1	Structure with logic in navigation, clear and visible options, simple interface and good aesthetics	Two-dimensional
	4.2	Presence of sitemap or help icon to guide user	Likert
	4.3	Consistency and standardisation in presentation, tasks and formats (visual identity)	Two-dimensional
	4.4	Name of the links have to clear and known terms in the real world	Likert
	4.5	Accessing the homepage from any navigation point	Two-dimensional
	4.6	Allows user to control operations	Two-dimensional
	4.7	Compatible with most used browsers (Internet Explorer, Mozilla Firefox, Google Chrome, Safari)	Two-dimensional
4.8	All-page search tool (semantic search)	Likert	

Source: Prepared by authors based on the literature searched (Arouk, 2001; Brasil, 2007, 2011, 2012; Costa, 2007; Costa et al., 2013; Dzialekaniak, 2012; Freitas et al., 2002; Lechakowski, 2015; Lee and Kwak, 2012; Nielsen and Landauer, 1993; Santos, 2014; Santos et al., 2013; United Nations, 2014; Usability.gov, 2017; Viana, 2012)

Table 5 Analysis attributes (continued)

	<i>Attributes of analysis</i>	<i>Maturity stage</i>	<i>Rating/scale</i>	
D4	4.9	Black text, light background, left-aligned and divided into topics (short paragraphs and subtitles)	Likert	
	4.10	Displays current system status (user-accessed path level location)	Two-dimensional	
	4.11	Frequently used pages or sections highlighted	Two-dimensional	
	4.12	Required form fields highlighted with just the desired number of characters	Two-dimensional	
	4.13	Explanatory error messages	Two-dimensional	
	4.14	Consistent browsing and identification (same purpose on one page)	Likert	
	4.15	Allows going back on the navigation bar and eliminates horizontal scrolling	Two-dimensional	
	4.16	Intuitive menus, new information indicators and interactive approach	Likert	
	4.17	Allows customisation of pages with information of most interest to the user and creation of shortcuts	Likert	
	4.18	Portal structure according to tasks	Likert	
	D5	5.1	Page indication inaccessible, incomplete or under construction	Two-dimensional
		5.2	Links work correctly	Two-dimensional
		5.3	Site does not stop (hang) during use	Two-dimensional
	D6	5.4	Readability $24 \times 7 \times 365$	Likert
		6.1	Non-textual content with text alternative (image with textual description)	Two-dimensional
		6.2	Pre-recorded audio or video (without audio) with alternative media for content equivalent information	Two-dimensional
		6.3	Error identification in user interaction	Two-dimensional
		6.4	Focus performs automatic changes without opening new page (no pop-ups or opening links in new window)	Two-dimensional
6.5		Presence of pre-recorded audio subtitles	Two-dimensional	
6.6		Audio description or alternate media pre-recorded for video	Two-dimensional	
6.7		Presence of headers and labels in forms	Two-dimensional	
6.8		Allows you to select another language for the page	Two-dimensional	
6.9		Allows you to change text size and contrast	Two-dimensional	
D7	6.10	Real-time subtitles synchronised with audio or video	Two-dimensional	
	6.11	Visible focus when keyboard operable (highlighted edge)	Two-dimensional	
	6.12	Sign language presence in audio files and videos	Two-dimensional	
	6.13	Context-sensitive help icon	Two-dimensional	
	6.14	Site functionality via user keyboard	Two-dimensional	
	7.1	Portal lists services performed by agency	Two-dimensional	
	7.2	Most wanted services highlighted	Two-dimensional	

Source: Prepared by authors based on the literature searched (Arouk, 2001; Brasil, 2007, 2011, 2012; Costa, 2007; Costa et al., 2013; Dziekaniak, 2012; Freitas et al., 2002; Lechakowski, 2015; Lee and Kwak, 2012; Nielsen and Landauer, 1993; Santos, 2014; Santos et al., 2013; United Nations, 2014; Usability.gov, 2017; Viana, 2012)

Table 5 Analysis attributes (continued)

	<i>Attributes of analysis</i>	<i>Maturity stage</i>	<i>Rating/scale</i>	
D7	7.3	Online services feature virtual operating logic	Likert	
	7.4	User performs operation with agency via sending information	Likert	
	7.5	Services accessed through security standards (only user has access)	Two-dimensional	
	7.6	User performs financial transaction with agency	Two-dimensional	
	7.7	Reports from preselected data	Two-dimensional	
	7.8	Services integrated with other government agencies	Likert	
	7.9	Allows user to change database and the transition is automatic	Two-dimensional	
	7.10	Agency makes all public services available online	Likert	
	7.11	Services database can be searched and categorised by user	Likert	
	7.12	Provides app for tablets and mobile devices	Likert	
	D8	8.1	Telephone, address and opening hours of institutions	Two-dimensional
		8.2	Profile presence in social networks	Two-dimensional
8.3		Linked to social networks (Twitter, Facebook and blogs)	Two-dimensional	
8.4		Citizen help icon via FAQ	Two-dimensional	
8.5		Links to send suggestions, complaints and doubts (ombudsman)	Two-dimensional	
8.6		Email from the institutions involved and responsible for the sector for public contact	Two-dimensional	
8.7		Widespread use of blogs, microblogs, social bookmarking/tagging, social networking	Two-dimensional	
8.8		Contacting government using contact form	Two-dimensional	
D9	8.9	Citizen help icon via online service	Two-dimensional	
	9.1	Participation in discussions on social networks to improve e-government platforms	Likert	
	9.2	Mechanisms of interactivity: audio, video or wikis	Two-dimensional	
	9.3	Real-time communication and interactive collaborative space tool	Likert	
	9.4	Interactive applications on discussion forums or chat	Likert	
	9.5	Presence of e-voting or e-petition tools	Two-dimensional	
	9.6	User collaborates with government via social networks	Likert	
	9.7	User collaborates with government on portal	Likert	
	9.8	Open interaction between government and public	Likert	
	9.9	Presence of public consultations	Likert	
	9.10	User understands the concrete actions of their participation in decision making	Two-dimensional	
9.11	Interactive applications via smartphones or tablets	Likert		

Source: Prepared by authors based on the literature searched (Arouk, 2001; Brasil, 2007, 2011, 2012; Costa, 2007; Costa et al., 2013; Dziekaniak, 2012; Freitas et al., 2002; Lechakowski, 2015; Lee and Kwak, 2012; Nielsen and Landauer, 1993; Santos, 2014; Santos et al., 2013; United Nations, 2014; Usability.gov, 2017; Viana, 2012)

The selection prioritised the main aspects to be analysed in a government portal, according to the congruence models and the studied literature (Arouck, 2001; Bach and Scapin, 2005; Brasil, 2007, 2014; Corrêa, 2012; Costa, 2007; Costa et al., 2013; Funai and Rezende, 2011; Lima, 2018; Nielsen and Landauer, 1993; OECD, 2004; De Pinho and Sacramento, 2009; Rothberg, 2010; Santos, 2014; United Nations, 2014; Viana, 2012), and considered the three pillars of the e-gov.: information, digital services and e-participation (Figure 2). The concept of interoperability was considered transversal to the selected dimensions, but its analysis was concentrated on D7.

The concept of the selected analysis dimensions, presented in Table 4, served as a reference for the construction of the e-gov. evaluation model.

For each one of the dimensions, we have been grouped checkpoints, called ‘analysis attributes’. This concept was extracted from the specifications of the proposed model and concepts of the analysis dimensions, and it allows a robust and objective measurement of portal maturity.

The unit of measurement was individually assigned to each analysis attribute. If in the evaluation, the presence or absence identification of the attribute defined its criterion, the two-dimensional evaluation scale was used: 1 for portal presence and 0 for its absence. If, in the evaluation, an attribute was partially achieved (although not satisfactorily present), the four-point Likert scale was chosen to detail the degree of agreement or disagreement: 0 it does not meet the criteria, 1 it meets partially, 2 it meets satisfactorily, and 3 it meets fully the analysed attribute.

Table 5 presents the 92 analysis attributes distributed by analysis dimension, identified by stage of maturity, and shows which ones configure the proposed evaluation model.

The verification of the level of service for each attribute, nominated by Corrêa (2012) as ‘adherence checking’, guided the evaluation process and resulted in the indication of the maturity level reached. This provided an overview of the analysis of maturity of the portal, according to the pre-established criteria above.

For this, the evaluation of the analysis attributes results from the application of the score, according to the defined evaluation scale, and its sum corresponds to the score from each analysis dimension, according to equation (1):

$$D_x = \sum_{i=1}^N AA_i \quad (1)$$

where

D_x analysis dimension assessed

AA analysis attributes for the evaluated analysis dimension.

The sum for each analysis dimension starts, therefore, with the first analysis attribute ($i = 1$) and ends with the n^{th} (n) attribute of the dimension evaluated. In order to differentiate the degree of importance of the analysis dimensions, a weight was assigned to each one, to give them value according to the current context and from the perspective of a given stakeholder. In this study, these values came from in-depth interviews with experts at strategic levels of central government’s e-government policy, in order to understand the relevance of each dimension from the policy maker’s perspective. The

result was: D1 (value 2.0), D2 (value 1.5), D3 (value 2.0), D4 (value 2), D5 (value 1.0), D6 (value 1.5), D7 (value 2.0), D8 (value 0.5) and D9 (value 1.0).

Therefore, the final grade of the portal corresponded to the average of the sum of the analysis attributes in each analysis dimension, considering its relative value, as shown in equation (2):

$$\frac{\sum(D_x p_x)}{\sum p_x} \quad (2)$$

where

D_x analysis dimension assessed

p_x value assigned to analysis dimension.

Therefore, the maximum grade applied for the first stage of maturity (considering the relative value assigned to the analysis dimensions) was 58.5 points; for the second stage, 111.5; for the third stage, 168.0; for the fourth stage, 213.0; and for the last stage of maturity, it was 258.0 points – which one represents the maximum grade given to each of the 92 analysis attributes of the proposed model.

It is important to emphasise that a government portal must meet various requirements to be considered mature, and the programs and the digital services are included according to the needs of the citizens and resources provided by public administration. Based on this, it was realised that there may be a variation within the same maturity stage of an e-government model, and it is possible to find more or less developed applications. This means that two portals may be at the same maturity stage, but they have characteristics that bring one closer to the earlier less developed stage, and the other close to the later more developed one.

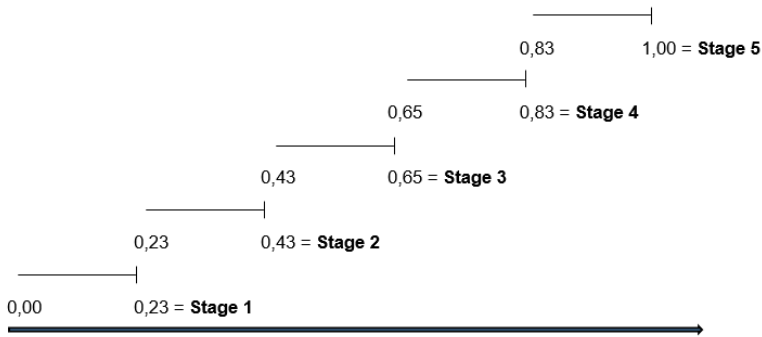
As a result, the real value of the portal's maximum score for each stage of maturity derived percentages relative to the maximum grade that it could reach. Associated with values from 100% to 0%, bands were created between the stages of maturity that followed fuzzy logic of Zadeh et al. (1975):

“Fuzzy sets introduce the idea that elements can belong to a particular set with some degree of relevance, which seeks to assign partially true or false values (fuzzy), usually expressed in the range of zero to one [0,1]. Any real number between these limits represents the degree of relevance or partiality of the proposition” [Corrêa, (2012), p.64]

In this logic, the predicates are fuzzy, that is, they are not exact, like ‘much’, ‘more’ or ‘less’. Therefore, as opposed to binary logic systems – where there are only two values: true (1) and false (0), fuzzy logic admits an infinite range of values between 1 and 0. Therefore, the idea of membership within a given set of values gives the concept of partial truth or degree truth of the proposition (Gomide et al., n.d.).

We relate this concept with the degree of veracity of e-government maturity within a value scale to create the e-government maturity index (e-GMI). This one allowed us to classify a portal into values between 0 and 1 [0, 1], starting from the percentage relative to the maximum grade. The spectrum of this classification is seen within the diagram of Figure 3.

Figure 3 E-GMI spectrum

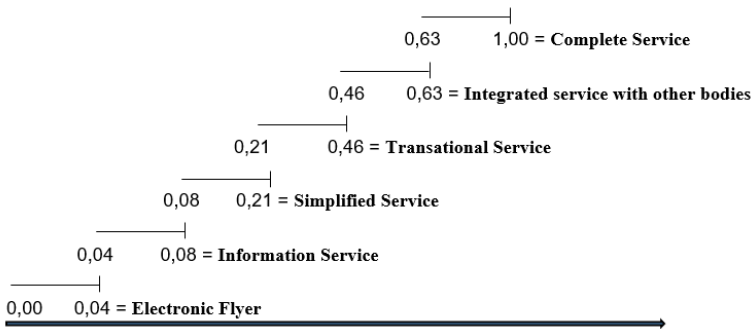


Source: Prepared by the authors

According to this diagram, to reach Stage 2, for example, the portal must reach the sum of points higher than Stage 1; to reach Stage 3, it must reach the sum of points higher than Stage 2, and so on. Therefore, a portal that has e-GMI 0.65 is in Stage 3 of development. On the other hand, a portal that has a maximum e-GMI (1.00) indicates that the portal has a higher level of maturity, meets all selected criteria in this study, and will be ranked in the last stage.

To assess the maturity of the services available, the analysis was based on the classification by Costa (2007), where the author presents a seven-stage classification. However, the author proposes two stages for the transaction phase; the first one is called ‘transactional service’ and the second one ‘transactional service with payment’. We understand that digital services are not restricted to those intended solely for payment of guides or taxes, but include any service that meets the needs of the citizen and provides him facility. Because of this, Stages 4 and 5, proposed by the author, were grouped in a single stage we called ‘transactional service’. This concept is also followed by the United Nations’ (2014) model. Therefore, the six new stages, that similarly followed fuzzy logic, allow comparative analysis of different digital services within the same portal. Figure 4 presents the diagram for digital services.

Figure 4 Digital services maturity spectrum



Source: Prepared by the authors

The proposal of dimensions and attributes’ analysis is a maturity model in process for local e-government that uses the index e-GMI to evaluate the development of a portal and

to indicate its level of maturity. In this model, we can make a comparison of the current state of the portal with the predefined criteria for each maturity stage proposed.

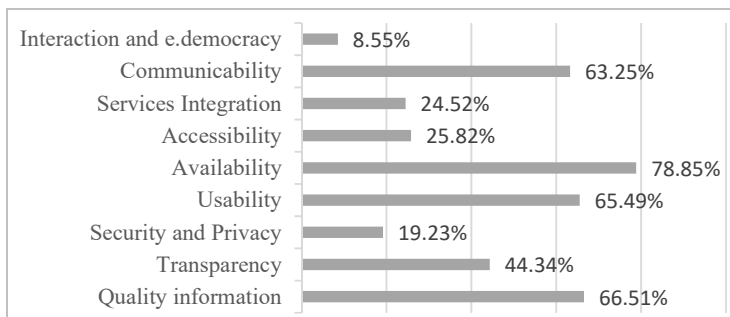
3 Results and discussions: the validation of e-GMI in a case study

The purpose of this model was to undergo the calibration of pilot tests, which allowed the model to be refined and adjusted at the local government level. After that, the model was applied in a case study: the 26 portals of the city halls of the state capitals of Brazil (the level of local government of the executive branch).

The analysis was done in March 2017, following an evaluation standard across all of the portals. In order to access the portals, we used a search engine (<http://www.google.com.br>) with the combination 'city hall × capital of the state'. Each portal was analysed under two themes considered central to a government: health and education; and to triangulate the analysis, included the fiscal issue – the source of financial resources, and therefore, of direct interest of the public administration. In terms of health, we looked at vaccination programs and control of the expanding epidemiological scenario of *Aedes aegypti* (mosquito-borne diseases such as dengue, zika, chikungunya and yellow fever). In the matter of education, we looked at school enrolment for early kindergarten education. And, in the fiscal matter, the municipal income tax and direct payment by the citizen: urban land tax (IPTU). The analysis considered three portal insertion levels, that is, up to three subsequent pages from the home page.

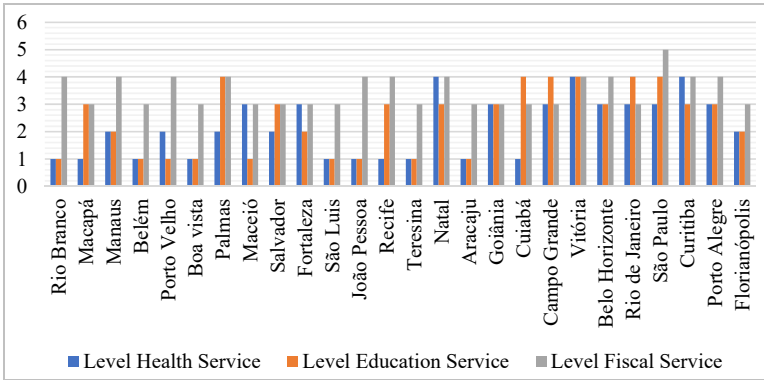
The results show that the portals of Brazilian state capitals present good availability, ease of use, presence of multichannel communication and relevant concern with the quality of information. On average, more than 60% of the portals met the dimensions D1, D4, D5 and D8 satisfactorily. On the other hand, just 44.34% of the portals had good transparency, accountability, and open data initiatives, because most of them only presented legal information. Just 25.82% of the portals were considered accessible, and just over 24% had security and privacy tools. The digital services were considered integrated in 25.82%, and tools for e-participation were used by less than 9% of municipalities. The Florianópolis' portal had its transparency portal unavailable during the evaluation period, which contributed to a lower percentage than expected in the D2 evaluation, but also to a lower final grade for the portal, since it did not fully satisfy the dimensions D2 and D5 (Figure 5).

Figure 5 Compliance with the analysis dimensions in municipal portals



Source: Research data

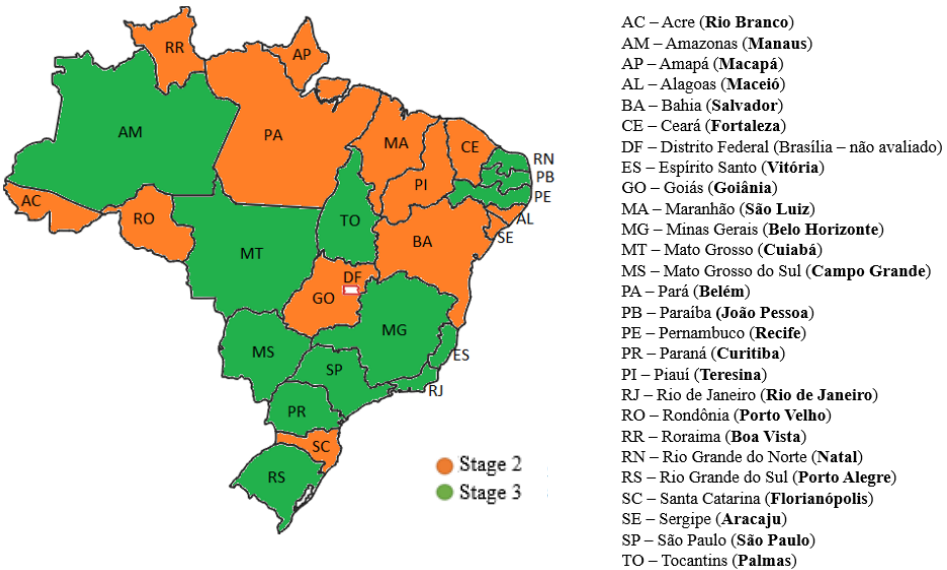
Figure 6 Maturity of digital services in portals of capitals of Brazilian states (see online version for colours)



Source: Research data

In the analysis of digital services, we noticed a greater development in tax services than in education services or health services (Figure 6). For the access to services via tablets and smartphones, few portals presented exclusive apps or websites adapted to them. On the other hand, some portals were proactive in the use of social networks and used a very widespread tool used by citizens in a personal environment to inform them of public actions and policies and to interact with the population. However, most still make poor use of the interaction tool and/or have little preparation of collaborators to interact with the public in this environment. No portal obtained the highest score for the evaluated services.

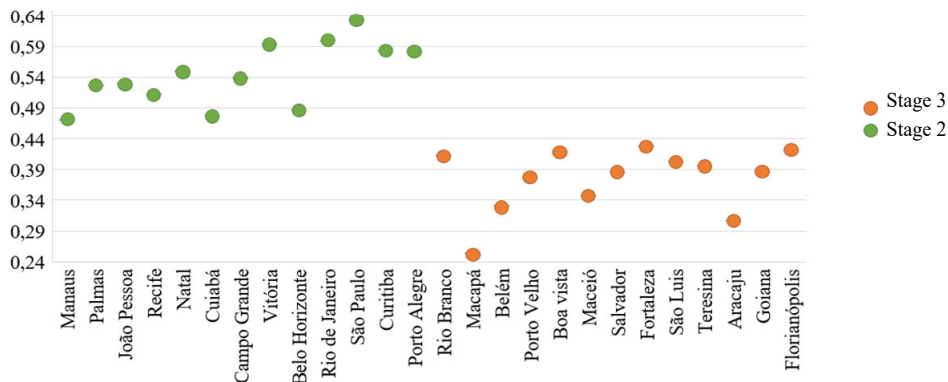
Figure 7 Map of e-government maturity in Brazilian state capitals (see online version for colours)



Source: Research data

In a general overview of portals maturity, Figure 7 shows the stage of e-government maturity in the evaluated portals during the period of analysis from the perspective of e-GMI.

Figure 8 Scattering of maturity stages 2 and 3 (see online version for colours)



Source: Research data

As predicted, within the same maturity stage, the portals showed different levels of development. Under the results found in the application of e-GMI, Figure 8 shows the dispersions found in the maturity stages, where in the same stage, it was possible to find more developed portals than others: Florianópolis and Fortaleza have higher indexes and closer to the maturity Stage 3 than Aracaju and Macapá, for example. Also, São Paulo with e-GMI of 0.63 is closer to Stage 4 maturity than all of the portals evaluated.

The e-GMI evaluation made it possible to observe the significant difference between the cities of São Paulo and Macapá, respectively, the first one and the last one in the maturity ranking, as shown in Table 6.

Table 6 Ranking of the e-government maturity in the capitals of the Brazilian states

City	IMeG	Level of maturity	Ranking
São Paulo	0.63	3	1°
Rio de Janeiro	0.60	3	2°
Vitória	0.59	3	3°
Curitiba	0.58	3	4°
Porto Alegre	0.58	3	5°
Natal	0.55	3	6°
Campo Grande	0.54	3	7°
João Pessoa	0.53	3	8°
Palmas	0.53	3	9°
Recife	0.51	3	10°
Belo Horizonte	0.49	3	11°
Cuiabá	0.48	3	12°

Source: Research data

Table 6 Ranking of the e-government maturity in the capitals of the Brazilian states (continued)

<i>City</i>	<i>IMeG</i>	<i>Level of maturity</i>	<i>Ranking</i>
Manaus	0.47	3	13°
Fortaleza	0.43	2	14°
Florianópolis	0.43	2	15°
Boa vista	0.42	2	16°
Rio Branco	0.41	2	17°
São Luis	0.40	2	18°
Teresina	0.40	2	19°
Goiana	0.39	2	20°
Salvador	0.39	2	21°
Porto Velho	0.38	2	22°
Maceió	0.35	2	23°
Belém	0.33	2	24°
Aracaju	0.33	2	25°
Macapá	0.25	2	26°

Source: Research data

The portals when analysed by the maturity stage do not seem to present such a difference in terms of e-government development, however, under the e-GMI values, the surprising result reinforces the relevance of the distribution of fuzzy logic in the perception of dispersions at each stage of maturity.

4 Final considerations

The model proposed is a congruence of maturity models composed by an index to evaluate local e-government. The e-GMI is a part of a robust, deep and objective maturity model, elaborated in a composite of three maturity models available in the literature: United Nations (2014), Lechakoski (2015) and Lee and Kwak (2012), from which their potentialities were extracted. It was built on nine analysis dimensions that translate the most relevant aspects of a government portal based on the e-government concept of the three pillars. Their respective analysis attributes, all related to the maturity stages of the proposed model, allowed us to evaluate the degree of maturity of government portals through in-depth and objective analysis criteria.

The methodological proposal is distinguished from other models of maturity in the literature by:

- 1 deepening the theoretical root and scope of the model, including issues little debated
- 2 including a broader range of indicators (referred to herein as analysis attributes), providing in-depth and accurate measurement
- 3 assigning different weights to the various dimensions of analysis studied

- 4 allowing, under fuzzy logic, the perception of e-government development dispersions within the same maturity stage, allowing important differences in performance and application of technological resources
- 5 has been validated through empirical testing and exploratory interviews to consider the local reality and its peculiarities.

Their application showed its ability to evaluate local government portals by presenting a ‘picture’ of the local e-government maturity, under the previously defined criteria, in a given problem and at a given time (the data collection period).

Moreover, a model to local governments links e-government’s assessment to realities closer to the citizen, where the implementation of public policy is observed in practice, and where the citizen can participate and see the result of their actions in the daily life of their municipality. On the other hand, e-GMI’s dimensional approach makes it possible to verify in which aspects weaknesses occur that limit the relationship between citizens and government, and that need to be taken into account in the formulation and evaluation of e-government programs.

References

- Akutsu, L. (2002) *Sociedade da informação, accountability e democracia delegativa: investigação em portais de governo no Brasil*, Dissertação, Núcleo de Pós-Graduação em Administração, Escola de Administração, Universidade Federal da Bahia.
- Almazan, R.S. and Gil-Garcia, J.R. (2008) ‘E-government portals in Mexico’, in Anttiroiko, A. (Ed.): *Electronic Government: Concepts, Methodologies, Tools, and Applications*, pp.1726–1734, IGI Global, <http://doi:10.4018/978-1-59904-947-2.ch131> (accessed 14 September 2014).
- ANAO (1999) *Electronic Service Delivery, Including Internet Use by Commonwealth Government Agencies*, Canberra [online] <https://doi.org/ISSN 1036-7632> (accessed 4 October 2016).
- Andersen, K.V. and Henriksen, H. (2006) ‘E-government maturity models: extension of the Layne and Lee model’, *Government Information Quarterly*, Vol. 23, No. 2, pp.236–248.
- Anes, A.C. (2009) *Estado de maturidade do e-government Municipal no Distrito de Bragança*, pp.2–116 [online] https://bibliotecadigital.ipb.pt/bitstream/10198/2126/1/Antonio_Anes_MEI_2009.pdf (accessed 7 July 2015).
- Arouck, O. (2001) ‘Avaliação de sistemas de informação: revisão da literatura’, *Transinformação*, Vol. 13, No. 1, pp.2–21.
- Bach, C. and Scapin, D.L. (2005) *Critères Ergonomiques pour les Interactions Homme-Environnements Virtuels: définitions, justifications et exemples*, RR-5531, p.47, INRIA.
- Batista, N.V. (2018) *Política do Governo Eletrônico: a maturidade do e-gov nos municípios brasileiros*, Thesis of doctoral, Lisbon University Institute, Lisbon.
- Batlle-Montserrat, J., Abadal, E. and Blat, J. (2011) ‘Benchmarking Del e-Gobierno Local: Limitaciones de Los Métodos de Evaluación Comparativa’, *El Profesional de la Información*, Vol. 20, No. 3, pp.251–259 [online] <https://doi.org/10.3145/epi.2011.may.02> (accessed 15 July 2016).
- Baum, C. and Di Maio, A. (2000) *Gartner’s Four Phases of E-government Model*, Gartner Group.
- Bezerra, H.D. (2008) ‘Atores políticos, informação e democracia’, *Opinião Pública*, Vol. 14, No. 2, pp.414–431 [online] <https://doi.org/10.1590/S0104-62762008000200006> (accessed 22 June 2015).

- Brasil (2007) *Indicadores e métricas para avaliação de e-Serviços*, Ministério do Planejamento, Orçamento e Gestão, Brasília [online] <http://www.governoeletronico.gov.br/anexos/indicadores-e-metricas-para-avaliacao-dee-servicos> (accessed 6 November 2016).
- Brasil (2011) *Padrões de Interoperabilidade de Governo Eletrônico. Guia de Interoperabilidade Cartilha Técnica*, Ministério do Planejamento Orçamento e Gestão, Brasília.
- Brasil (2012) *Padrões de Interoperabilidade de Governo Eletrônico*, Ministério do Planejamento Orçamento e Gestão, Brasília, gov.br/ePING [online] <http://eping.governoeletronico.gov.br> (accessed 6 November 2016).
- Brasil (2014) *eMag Modelo de Acessibilidade em Governo Eletrônico. Padrões de Interoperabilidade de Governo Eletrônico do Ministério do Planejamento Orçamento e Gestão*, Brasília.
- Capgemini (2007) *The User Challenge Benchmarking the Supply of Online Public Services*, European Commission, Brussels [online] http://ec.europa.eu/information_society/eeurope/i2010/docs/benchmarking/egov_benchmark_2007.pdf (accessed 2 July 2016).
- Cepik, M. and Canabarro, D.R. (2014) *Governança de TI: Transformando a administração pública no Brasil*, University Federal of Rio Grande do Sul (Org.), 1st ed., Coleção CEGOV, Porto Alegre.
- Chen, J. et al. (2011) 'A three-dimensional model for e-government development: with cases in China's regional e-government practice and experience', *Management of e-Commerce and e-Government (ICMeCG)*, Vol. 5, pp.113–120, Hubei, China [online] http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=6092643 (accessed 20 September 2014).
- Cisco, I.B.S.G. (2008) *e-Government Best Practices Learning from Success, Avoiding the Pitfalls* [online] http://siteresources.worldbank.org/EXT/DEVELOPMENT/Resources/20080222_Phil_eGov_workshop.pdf?resourceurlname=20080222_Phil_eGov_workshop.pdf (accessed 22 September 2016).
- Corrêa, A.S. (2012) *Metodologia para aferição do nível de maturidade associado à interoperabilidade técnica nas ações de governo eletrônico*, Pontifícia Universidade Católica, Campinas.
- Costa, E.M. (2007) 'Qualidade de serviço em governo eletrônico', in de Oliveira, F.B. (Org.): *Tecnologia da informação e da comunicação: a busca de uma visão ampla e estruturada*, pp.211–223, Pearson Prentice Hall, Fundação Getúlio Vargas, São Paulo.
- Costa, E.M., Marques, É.V. and Melo, F.V.S. (2013) 'Análise da usabilidade dos portais de comércio eletrônico brasileiros', *Tekhne e Logos*, Vol. 4, No. 3, pp.87–110.
- de Laia, M.M. (2009) *Políticas de governo eletrônico em estados da federação brasileira: uma contribuição para análise segundo a perspectiva institucional*, University Federal of Minas Gerais.
- De Pinho, J.A.G. and Sacramento, A.R.S. (2009) 'Accountability: já podemos traduzi-la para o português?', *Revista de Administração Pública*, Vol. 43, No. 6, pp.1343–1368.
- DeBrí, F. and Bannister, F. (2015) 'E-government stage models: a contextual critique', in *International Conference on System Sciences*, IEEE Computer Society, Hawaii, pp.2222–2231 [online] <https://doi.org/10.1109/HICSS.2015.266> (accessed 10 October 2015).
- Dias, G.P. (2011) 'Q-model: um modelo bidimensional para o e-government', *RISTI Revista Ibérica de Sistemas e Tecnologias de Informação*, Vol. 7, pp.33–46 [online] <http://www.scielo.mec.pt/pdf/rist/n7/n7a04.pdf> (accessed 25 February 2016).
- Dias, G.P. and Costa, M. (2013) 'Significant socio-economic factors for local e-government development in Portugal', *Electronic Government, an International Journal*, Vol. 10, Nos. 3/4, pp.284–309.
- Dziekaniak, G.V. (2012) *Método para inclusão de conhecimento presente em mídias sociais no aprimoramento de plataformas de governo eletrônico*, Thesis of doctoral, University Federal of Santa Catarina, Florianópolis.

- Esteves, J. and Sousa, B. (2006) *Análise do desenvolvimento do governo electrónico municipal em Portugal*, No. 22, Software AG Lisboa [online] http://www.profesores.ie.edu/jmesteves/estudoWebs_municipais_portugal.pdf (accessed 6 February 2016).
- Fath-allah, A. et al. (2014) 'E-government maturity models', *International Journal of Software Engineering & Applications*, Vol. 5, No. 3, pp.71–91 [online] <http://aircse.org/journal/ijseapapers/5314ijsea06.pdf> (accessed 22 November 2016).
- Fernandes, C.C.C. (2007) *Maturidade do governo eletrônico: análise de experiências estaduais* [online] <http://repositorio.enap.gov.br/handle/1/1694> (accessed 25 March 2016).
- Freitas, C., Luzzardi, P., Cava, R., Pimenta, M., Winckler, A. and Nedel, L. (2002) 'Evaluating usability of information visualization techniques', in *Proceeding Advanced Visual Interfaces (AVI2002)*, pp.373–374.
- Funai, M.T. and Rezende, D.A. (2011) 'Governo eletrônico na gestão municipal: avaliação dos serviços eletrônicos da prefeitura de São José dos Pinhais (Paraná)', *Gestão & Regionalidade*, Vol. 27, No. 80, pp.15–29.
- Garcia, R.M. (2006) 'Governo Eletrônico, Informação e competência em Informação', *Inf. & Soc.: Est.*, Vol. 16, No. 2, pp.79–87 [online] <http://www.egov.ufsc.br/portal/sites/default/files/infojur4.pdf> (accessed 25 August 2016).
- Gomide, F.A.C. et al. (n.d.) *Conceitos fundamentais da teoria de conjuntos fuzzy, lógica fuzzy e aplicações* [online] <http://calhau.dca.fee.unicamp.br/pub/docs/gudwin/publications/ifsa95.pdf> (accessed 17 January 2017).
- González de Gómez, M.N. (2002) 'Novos cenários políticos para a informação', *Ci. Inf.*, January/April, Vol. 31, No. 1, pp.27–40 [online] <http://www.scielo.br/pdf/ci/v31n1/a04v31n1.pdf> (accessed 10 September 2015).
- Hiller, J.S. and Bélanger, F. (2001) *Privacy Strategies for Electronic Government*, Vol. 40, Center for Global Electronic Commerce [online] <http://www.businessofgovernment.org/sites/default/files/PrivacyStrategies.pdf> (accessed 10 October 2015).
- Howard, M. (2001) 'E-government across the globe: how will 'e' change government', *Government Finance Review*, Vol. 4, No. 17 [online] <https://www.questia.com/magazine/1G1-78902832/e-Government-across-the-globe-how-will-e-change> (accessed 2 November 2014).
- Kawashita, I.M.S., Baptista, A.A. and Soares, D. (n.a.) *E-government Maturity Models: More of the Same?* [online] https://repositorium.sdum.uminho.pt/bitstream/1822/65105/1/Paper_18_ICEDEG.pdf (accessed 13 July 2020).
- Khan, G.F. (2015) 'Models for social media-based governments', *Asia Pacific Journal of Information Systems*, Vol. 25, No. 1 [online] <https://doi.org/10.14329/apjis.2015.25.2.356> (accessed 19 January 2017).
- Kim, D.Y. and Grant, G. (2010) 'E-government maturity model using the capability maturity model integration', *Journal of Systems and Information Technology*, Vol. 12, No. 3, pp.230–244.
- Layne, K. and Lee, J. (2001) 'Developing a fully functional e-government: a four stage model', *Government Information Quarterly*, Summer, Vol. 18, No. 2, pp.122–136.
- Lechakoski, R.d.M. (2015) *Proposta de um instrumento para classificação de maturidade para sítios de governo eletrônico: um estudo nas prefeituras municipais das capitais do sul do Brasil*, Thesis of Master, University Federal of Paraná, Curitiba.
- Lechakoski, R.d.M. and Tsunoda, D.F. (2015) 'Proposta de um modelo de maturidade para sítios de governo eletrônico', *Novas Práticas em informação e Conhecimento*, Vol. 4, No. 1, pp.43–54 [online] <https://doi.org/10.5380/atoz.v4i1.42319> (accessed 2 October 2016).
- Lee, G. and Kwak, Y.H. (2012) 'An open government maturity model for social media-based public engagement', *Government Information Quarterly*, Vol. 29, No. 4, pp.492–503 [online] <https://doi.org/10.1016/j.giq.2012.06.001> (accessed 29 September 2016).
- Lima, A.C.O. (2018) *Usabilidade e acessibilidade na concepção de novos sistemas inclusivos*, 1st ed., Appris, Curitiba.

- Máchová, R. (2015) *An Analytical Hierarchy Process Model for the Evaluation of the E-government Development*, Vol. 14 [online] <http://eds.b.ebscohost.com/eds/pdfviewer/pdfviewer?vid=20&sid=cd790fa4-25d8-4f14-82ab-62369bd46f7d@sessionmgr104&hid=103> (accessed 13 June 2016).
- Maranny, E. (2011) *Stage Maturity Model of m-Government (SMM m-Gov): Improving e-Government Performance by Utilizing m-Government Features*, Dissertação de mestrado, University of Twente [online] <http://essay.utwente.nl/62691/> (accessed 25 September 2016).
- Marcondes, C.H. and Jardim, J.M. (2003) 'Políticas de Informação Governamental: a construção de Governo Eletrônico na Administração Federal do Brasil', *Revista de Ciência da Informação*, Vol. 4, No. 2, pp.1–14.
- Moon, M.J. (2002) 'The evolution of e-government among municipalities: rhetoric or reality?', *Public Administration Review*, July/August, Vol. 6, No. 4, pp.424–433.
- Netchaeva, I. (2002) 'E-government and e-democracy a comparison of opportunities in the North and South', *International Communication Gazette*, Vol. 64, No. 5, pp.467–477.
- Nielsen, J. and Landauer, T.K. (1993) 'A mathematical model of the finding os usability problems', *Interchi*, Morristown, USA, 24–29 April.
- OECD (2004) *OECD Principles of Corporate Governance* [online] <https://www.oecd.org/corporate/ca/corporategovernanceprinciples/31557724.pdf> (accessed 19 September 2016).
- Rampelotto, A. et al. (2015) 'Avaliação do sítio da Receita Federal do Brasil como medida da efetividade do governo eletrônico para o cidadão', *Revista da Administração Pública*, Vol. 49, No. 4, pp.959–983 [online] <http://www.scielo.br/pdf/rap/v49n4/0034-7612-rap-49-04-00959.pdf> (accessed 14 May 2018).
- Reddick, C.G. (2004) 'A two-stage model of e-government growth: theories and empirical evidence for U.S. cities', *Government Information Quarterly*, Vol. 21, pp.51–64 [online] <http://thirdworld.nl/a-two-stage-model-of-e-government-growth-theories-and-empirical-evidence-for-u-s-cities> (accessed 26 June 2016).
- Ribeiro, C.P.d.P., Peireira, A.D.S., Silva, E.A. and Faroni, W. (2011) 'Difusão da informação na administração pública', *TransInformação*, Vol. 23, No. 2, pp.159–171.
- Ribeiro, M.S.P. (2011) *Governo Eletrônico – aprimoramento da transparência dos serviços da gestão pública através da relação G2C: um estudo de caso na prefeitura municipal de Cachoeirinha/RS*, University of Vale of Rio of the Sinos, São Leopoldo.
- Rothberg, D. (2010) 'Portais eletrônicos de governo e a contribuição da informação e da comunicação para a expansão da cidadania', *Encontro Anual da ANPOCS*, pp.1–32 [online] http://www.anpocs.org.br/portal/seminarios_tematicos/ST02/DRothberg.pdf (accessed 11 July 2015).
- Rover, A.J., Santos, P.M., Ferreira, M.V.A.S., Bernardes, M.B., Pinto, C.A.S., Yamaoka, E.J. and Roczanski, C.R.M. (n.d.) *Avaliação de portais e sítios governamentais* [online] http://www.egov.ufsc.br/portal/sites/default/files/doutorado_artigo_disciplina_egov_v13_paloma_marcus.pdf (accessed 29 November 2016).
- Santos, P.M. (2014) *Framework de apoio à democracia eletrônica em portais de governo com base nas práticas de gestão do conhecimento*, Thesis doctoral, University Federal of Santa Catarina, Florianópolis.
- SEI (2006) *CMMI para Desenvolvimento – Versão 1.2: melhoria de processos visando melhores produtos*, Carnegie Mellon University [online] http://www.sci.cmu.edu/library/assets/whitepapers/cmmi-dev_1-2_portuguese.pdf (accessed 21 September 2016).
- Shahkooh, K.A. et al. (2008) 'A proposed model for e-government maturity', Paper apresentado na *International Conference on Information & Communication Technologies: From Theory to Applications, ICTTA*, pp.7–11 [online] <https://doi.org/10.1109/ICTTA.2008.4529948> (accessed 16 June 2016).
- Siau, K. and Long, Y. (2005) 'Synthesizing e-government stage models – a meta-synthesis based on meta-ethnography approach', *Industrial Management & Data Systems*, Vol. 105, No. 4, pp.443–458.

- Snellen, I. (2007) 'E-government: a challenge for public management', in Ferlie, E., Lynn Jr., L. and Pollitt, C. (Orgs.): *The Oxford Handbook of Public Management*, Oxford University Press, Oxford.
- Torres, N. (2006) *Projeto de pesquisa e estudo para avaliação de sítios de internet (websites) municipais e criação do IPGEM – índice paulista do desenvolvimento de governo eletrônico municipal*, Vol. 53, São Paulo [online] <https://governancaegestao.files.wordpress.com/2008/04/avaliacao-de-sitios-municipais-para-o-estado-de-sao-paulo1.pdf> (accessed 13 November 2016).
- United Kingdom (2002) *Government on the Web II*, HC 764, London [online] <https://www.nao.org.uk/wp-content/uploads/2002/04/0102764.pdf> (accessed 25 November 2016).
- United Nations (2014) *E-government for the Future We Want*, New York [online] https://publicadministration.un.org/egovkb/Portals/egovkb/Documents/un/2014-Survey/E-Gov_Complete_Survey-2014.pdf (accessed 13 June 2015).
- Usability.gov (2017) [online] <http://www.usability.gov> (accessed 1 July 2017).
- Viana, G.B. (2012) *Um framework para adaptação de conteúdo e navegação em portais de Governo Eletrônico*, Tese de doutorado, Universidade Estadual de Campinas, Campinas.
- Wescott, C.G. (2001) *E-government in the Asia-Pacific Region*, Asian Development Bank [online] <https://www.adb.org/sites/default/files/publication/28986/egovment-asia-pacific.pdf> (accessed 22 September 2016).
- West, D.M. (2004) 'E-government and the transformation of public sector service delivery', *Public Administration Review*, Vol. 62, No. 4, pp.15–27 [online] <http://onlinelibrary.wiley.com/doi/10.1111/j.1540-6210.2004.00343.x/epdf> (accessed 13 September 2015).
- Windley, P.J. (2002) *eGovernment Maturity*, Utah.gov [online] <http://www.windley.com/docs/eGovernment%20Maturity.pdf> (accessed 22 September 2016).
- Zadeh, L.A. et al. (1975) *Fuzzy Sets and Their Applications to Cognitive and Decision Process*, Academic Press, New York.