Identification of research trends in emerging technologies implementation on public services using text mining analysis

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Abstract

Purpose – This study aims to conduct performance and clustering analyses with the help of Digital Government Reference Library (DGRL) v16.6 database examining the role of emerging technologies (ETs) in public services delivery.

Design/methodology/approach – VOSviewer and SciMAT techniques were used for clustering and mapping the use of ETs in the public services delivery. Collecting documents from the DGRL v16.6 database, the paper uses text mining analysis for identifying key terms and trends in e-Government research regarding ETs and public services.

Findings – The analysis indicates that all ETs are strongly linked to each other, except for blockchain technologies (due to its disruptive nature), which indicate that ETs can be, therefore, seen as accumulative knowledge. In addition, on the whole, findings identify four stages in the evolution of ETs and their application to public services: the "electronic administration" stage, the "technological baseline" stage, the "managerial" stage and the "disruptive technological" stage.

Practical implications – The output of the present research will help to orient policymakers in the implementation and use of ETs, evaluating the influence of these technologies on public services.

Social implications – The research helps researchers to track research trends and uncover new paths on ETs and its implementation in public services.

Originality/value – Recent research has focused on the need of implementing ETs for improving public services, which could help cities to improve the citizens' quality of life in urban areas. This paper contributes to expanding the knowledge about ETs and its implementation in public services, identifying trends and networks in the research about these issues.

Keywords Emerging technologies, Public services, Text mining, Clustering analysis, Science mapping

Paper type Literature review

1. Introduction

The term emerging technologies (ETs) has been frequently used by IT professionals and academics. However, there is no general agreement regarding its definition and multiple definitions of ETs can be found in prior research (Small *et al.*, 2014; Halaweh, 2013; Alexander *et al.*, 2012), mainly based on their different key attributes. In our research, we adopt the definition of ETs pointed out by Rotolo *et al.* (2015), who carried out a systematic literature review and defined the ETs such "*as a radically novel and relatively fast-growing technology*

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characterised by a certain degree of coherence persisting over time and with the potential to exert a considerable impact on the socio-economic domain(s) which is observed in terms of the composition of actors, institutions and patterns of interactions among those, along with the associated knowledge production processes. Its most prominent impact, however, lies in the future and so in the emergence phase is still somewhat uncertain and ambiguous" (p. 1833).

ETs offer the opportunity to transform the way governments engage with citizens, make policy decisions and redefine public services (Engin and Treleaven, 2019). Indeed, the implementation of ETs in existing administrative processes and public services has traditionally had a substantial impact (Jin and Lee, 2013). Focused on the public services field, the ETs implementation could be well researched from a public value perspective as it focuses at the same time on the internal efficiency of public administration on the one side and on the service quality and broader societal effects on the other side (van Noordt and Misuraca, 2020).

Nonetheless, although ETs are expected to bring benefits for improving public services and social life (Olofsson and Mali, 2019), they also have main challenges in their implementation. This way, ETs can have negative impact by hiding corruption behaviours (Adam and Fazekas, 2020) or even damaging the ecological environment (Dusik *et al.*, 2018). The impact of the implementation of ETs could be, therefore, positive or negative, with much depending on how they are used (Dusik *et al.*, 2018; Adam and Fazekas, 2020) or even how society's ethical norms are changed with their implementation (Kastenhofer, 2011; Olofsson and Mali, 2019).

In addition, despite increased attention on ETs, politicians, policymakers and public sector officials have a limited understanding of both the impact of ETs on public services (Lindgren *et al.*, 2019), and the competences and capabilities needed to consider implementing ETs in public services (Dawes and Nelson, 1995; Harrison *et al.*, 2019). The lack of this understanding could make ETs be used for different purposes than those directly to improve public services (Valle-Cruz, 2019) or even not to result in effective implementation (van Noordt and Misuraca, 2020).

This limited understanding and the uncertainability of how to implement ETs to enhance social development suggests not only the need for further research but also for efforts to improve their knowledge and ability to use them in the creation of public value successfully. In addition, research on the implementation of ETs in public services is not only fragmented and scattered, but also, we lack an overall view of how this research has been approached in previous literature.

Under this framework, literature reviews are important as research tools, especially in emerging areas (Mertens, 2019), in which scientific documents published represent added-value information, providing a new reference point to both evaluate ongoing actions in public services and conduct novel research into public services (Sicilia *et al.*, 2019). As noted recently by OCDE (2019), as the implementation of ETs is still at an early stage, a permanent mapping exercise will be helpful to better evaluate the public sector adoption trends, identify replicable good practices, create synergies and foster experience sharing among a wider range of countries, especially in their implementation for creating innovative services (OCDE, 2019).

In this context, performance analysis allows researchers to measure, quantitatively and qualitatively, the contribution of ETs in public services, understanding the dynamics over different years in the evolution of the ETs in public services research and mapping the science landscape, which has become a focus area for research (Archambeault *et al.*, 2015). Also, clustering scientific publications is an important technique in bibliometric analysis (van Eck and Waltman, 2017) that enables the researcher both to map and assess the existing intellectual territory.

Nonetheless, up to now, there are no studies in the information science research field which use performance analysis, science mapping and clustering analysis in order to deal directly with the research on ETs implementation in public services and, especially, on keywords shared by documents, mapping the literature directly from the interaction of key terms. These tools could allow us to examine the evolution of the ETs implementation in public services topic and a longitudinal study based on an inclusion index could be used to detect

conceptual nexuses between research themes in different periods (Cobo *et al.*, 2011a, b; van Eck and Waltman, 2017).

Therefore, the aim of the study is to conduct performance and clustering analyses with help of the Digital Government Reference Library (DGRL) v16.6 database examining the role of ETs in the public services delivery. This analysis will help researchers to identify trends of research hotspots in this topic, clustering and mapping keywords and the most relevant topics on this issue. The findings of the present research will help to orient policymakers in the implementation and use of ETs for evaluating the influence of these technologies on public services.

To achieve this aim, we reviewed the scientific production from 2000 to 2020 in the DGRL v16.6 database about ETs implementation in public services and applied the SciMAT and VOSviewer techniques for performance and clustering analyses. Section 2 presents the utility of clustering analysis, science mapping and longitudinal studies. In Section 3, methodology presents the research design adopted for analysing the evolution and relevance of the ETs implementation in public services' research field. Then, we analyse the results and main findings of the research in Section 4. Finally, the discussion and conclusion of Section 5 bring the paper to an end. In this last section, research gaps and future lines of study are identified.

2. Utility of clustering analysis, science mapping and longitudinal studies

A literature review is an essential feature of any academic project because it creates a solid foundation for advancing knowledge and facilitates theory development in such areas where research is needed (Senyo *et al.*, 2019; Manfredi Latilla *et al.*, 2018; Alcaide Muñoz and Rodríguez Bolívar, 2015). Hence, in academic literature, we can find bibliometric studies that try to identify the historical roots of a determined field of study (Sidorova *et al.*, 2008), to identify prospects for future research and to decide the right direction in which to focus future studies and academic projects.

This analysis is especially relevant in multidisciplinary fields of knowledge in which you can find great heterogeneity in the literature, making it necessary to lay a solid foundation for future research – this is the case in e-Government and information science fields – (Joseph, 2013; Alcaide Muñoz and Rodríguez Bolívar, 2015; Paiva Dias, 2019). Also, according to Cocosila *et al.* (2011), a historical assessment can help expand existing knowledge by analysing and examining change and continuity over time.

In parallel, we also find scientometric studies about e-Government (Rodríguez Bolívar *et al.*, 2016; Alcaide Muñoz *et al.*, 2014) seeking to assist researchers in the development and direction of future analysis, by identifying trends in research topics and the methodology applied. Both bibliometric and scientometric studies allow identifying research gaps and possibilities for improvement in the field of knowledge. Furthermore, these contributions not only serve as a synopsis of existing research but also as an identifier of emerging trends, gaps and areas for future study (Alcaide Muñoz and Rodríguez Bolívar, 2015; Rodríguez Bolívar *et al.*, 2016).

The academic literature has also analysed systematic reviews about open government (OG) (Tai, 2021), due to the fast and impressive technological developments over the past decade in governments with the implementation of OG initiatives. Therefore, it needs to take stock and consider how such contextual changes have impacted the way scholar and practitioners think about OG. This study adopts the principles of Preferred Reporting Items for PRISMA systematic review and meta-analysis and allows to contribute to a more integrated and comprehensive body of OG knowledge.

Overall, this bibliometrics, scientometric and systematic literature reviews have sought to carry out performance analysis and science mapping to capture the relevant terms, topics and methodologies extracted from literature and put emphasis on the findings and insights

obtained. It, therefore, deals directly with a set of terms shared by documents, mapping the literature directly from the interaction of key terms and showing the evolution of the field of knowledge (Alcaide Muñoz *et al.*, 2017; Rodríguez Bolívar *et al.*, 2018). If we focus our attention on the science mapping approach, it displays the structural and dynamic aspect of scientific research, as well as how disciplines, topics filed are related to one another (Cobo *et al.*, 2011b), which allow scholars to analyse the evolution of the field of knowledge or research topics (Cobo *et al.*, 2011a).

Applied to the e-Government field of knowledge, Alcaide Muñoz *et al.* (2017) found symptoms of a research field in constant evolution that had not reached a stage of maturity. Similarly, Rodríguez Bolívar *et al.* (2018) identified an increase in e-Participation research, and the evolution of this field of knowledge to a more techno-social system seeking to engage the citizenry in public sector management. Both papers identified the research topics that were going to pull from the field of knowledge and that would show the greatest developments in the coming years.

In the field of public services, we can find bibliometric studies about public services management (Juliani and Oliveira, 2016) and Government to Business E-services (Panayiotou and Stavrou, 2021). Juliani and Oliveira (2016) analysed major publications involving public services management in the decade 2004–2014, so as to identify scientific gaps to promote and guide new studies about it. To achieve this aim, they carried out an advanced search from Scopus and Web of Science databases, and their findings pointed out both the New Public Management model as the main object of research on this topic, and the scientific gaps involve in the public services motivation. On the other hand, in recent research, Panayiotou and Stavrou (2021) undertook a systematic literature review with 331 publications, which allowed identifying the main research topics in this field and determining future research studies. Even considering the above, up to now, there is no bibliometric, scientometric or systematic literature review in the academic literature on the implementation of ETs in the provision of public services. Thus, this field of knowledge is untapped. It is especially relevant nowadays in which different ETs are becoming relevant in their application to public services, for example, big data, artificial intelligence (AI) or blockchain technologies. Furthermore, we think that it is important to carry out a longitudinal study that allows to show the evolution of the use and implementation of ETs in public services. These studies allow analysing the evolution of a research field along consecutive time periods and showing conceptual evolution that describes how this field of knowledge is conceptually, intellectually and socially structured. According to Small *et al.* (2014), this longitudinal study can aid us tracking how these relationships change as new discoveries are made and perhaps lead to a more informed. In addition, the public managers and politicians could know the research topics that have been further analysed with successful results, which allow them to have a clear idea of the projects to undertake and to invest resources (Lee, 2008).

3. Data collection and methods

3.1 Sample selection

To achieve the purpose of this study, this paper explores and maps relevant research concerning the implementation of ETs for public services in Information Science and, particularly, in e-Government research. In this regard, the early stages of this empirical study were conducted according to the PRISMA statement (Liberati *et al.*, 2009; Moher *et al.*, 2009): selection of database, search strategy and inclusion/exclusion criteria of studies. These initial phases allow us to create a database with the necessary resources to carry out the VOS viewer and science mapping methodologies.

In this sense, based on Webster and Watson's (2002) strategy for conducting literature reviews in Information Systems research, this paper searched for just peer-reviewed articles and conference papers, particularly those indexed by DGRL v16.6 (Scholl, 2021). This database collects peer-reviewed work in the study domains of digital government, digital governance and digital democracy and has been used in extant prior literature studies in e-Government like that analysing citizen diversity in e-Government research (Andersson *et al.*, 2021; Alcaide Muñoz *et al.*, 2017), the relational trust in e-Participation (Demirdoven *et al.*, 2020), the determinants of adoption and use of Information and Communication Technologies for emergency management (Yuan *et al.*, 2021) or the past and future trends in e-Government research (Scholl, 2020).

Covering the period from 1981, DGRL v16.6 contains references to 14,940 peer-reviewed academic papers from core e-Government journals and conferences, as well as relevant publications from other journals in the IS field, in the study domains of digital government, digital governance and digital democracy. This paper uses this database for the search of all documents in all-years period to capture in what ways is the link ETs and public services within the context of e-Government issues.

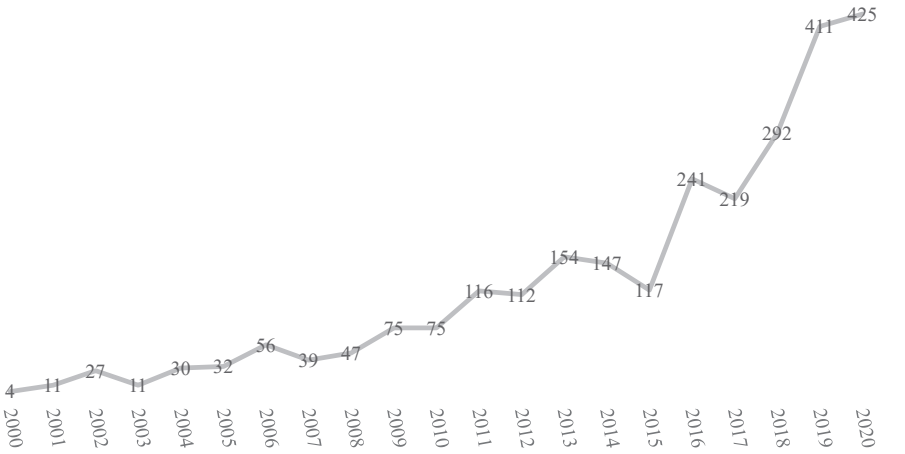
Then, keywords search were configured considering the previously mentioned definition of ETs in this research. Sandner *et al.* (2020) highlighted the novel growth potential of blockchain, IoT and AI technologies. In addition, there are previous studies (Atlam and Wills, 2019; Belotti *et al.*, 2019; Engin and Treleaven, 2019; Harrison *et al.*, 2019) that have addressed the socioeconomic impact that the use of these technologies could have on the public sector, and the ability to interact with different actors, making clear the existence of some uncertainty about the impact and future consequences that they could have. Similarly, prior research (Yuan and Gascó-Hernandez, 2021; Gao *et al.*, 2021; Dris *et al.*, 2019) showed the great transformative potential of OG/data and social media have for the public sector and how its use could affect democracy, governance, transparency and citizenship. Finally, cloud computing is fast creating a revolution in the way information technology is used and procured by organizations and by citizens, supposing a new model of computation which have organizational implications for public sector organizations (Liang *et al.*, 2019). Therefore, considering the previously exposed, we selected the following search query for the topic-search of the related texts and then employed a search within the terms list of the DGRL v16.6 database:

("Artificial Intelligence" OR "Big Data" OR "Blockchain" OR "Distributed Ledger Technology" OR "Cloud Computing" OR "Edge Computing" OR "Data Analytics" OR "Data Mining" OR "Internet of Things" OR "IoT" OR "Machine Learning" OR "Open Data" OR "Open Government" OR "Chatbots" OR "Semantic Web" OR "Sensors" OR "Social Media" OR "Robotics" OR "Virtual Reality") AND ("public services" OR "e-services" OR "electronic services" OR "online services" OR "government services").

In the case of science mapping, we carried out a pre-processing process to detect duplicate and misspelled items, time slicing, data and network reduction. Similarly, in this initial purification of the database, we focused on detecting those studies that focused their analysis of ETs implementation in public services, removing those studies that will not focus on this research topic. Therefore, this initial pre-analysis provides a total of 2,641 documents covering the period 2000–2020 (Figure 1). As can be seen, there has been a progressive increase in articles published on ETs in the implementation of public services since 2009, turning this into a major increase since 2016.

3.2 Methodology of research

Clustering techniques have been developed mainly in fields such as statistics, computer science and network science (van Eck and Waltman, 2017). In this research, Visualization of



Source(s): Own elaboration

Figure 1.
Time sequence for articles on ETs implementation in public services (2000–2020)

Similarities viewer (VOSviewer) and SciMAT are used as techniques for clustering and mapping bibliometric networks.

VOSviewer (https://www.vosviewer.com) is a free software recently used in different fields of knowledge like medicine (Huang *et al.*, 2020; Xie *et al.*, 2020; Yu *et al.*, 2020; Meng *et al.*, 2020), political marketing (Perannagari and Chakrabarti, 2020), management (Mas-Tur *et al.*, 2020), sustainability (Mishra *et al.*, 2020; Chen *et al.*, 2021) or education (Hudha *et al.*, 2020), for constructing, analysing and visualizing bibliometric networks supporting distance-based maps (van Eck and Waltman, 2017). In this research, VOSviewer was used to analyse the keywords – based on the degree of centrality – and visualized the abstract and keyword networks in the research performed about the implementation of ETs in public services, obtaining the temporal distribution of research topics based on these attributes, gaining an insight into the research evolutions and trends in this topic.

To achieve this goal, for each publication included in the DGRL v16.6 database, the terms included in the search query previously mentioned occurring in the abstract and the keywords of the publication were identified. Concretely, on one hand, the keyword co-occurrences were analysed to map the research output and hotspots, which can provide insight into new research frontiers. In this analysis, the minimum number of occurrences of a keyword in titles and abstracts was set at ten. Of all publications in the DGRL database, 903 terms that seemed most relevant were algorithmically selected. Then we screened these terms to find those directly linked with the aim of this paper and involved in the search query of this research (ETs and public services). This process made to select 73 terms, which are shown in the term map visualization provided in Figure 2.

On another hand, this research also examines the topic of the implementation of ETs in public services, looking for the key terms selected in the search query in the abstracts of the documents included in the DGLR v16.6 database. Of all terms that were found in at least 30 publications, the 1,554 terms that seemed most relevant were algorithmically selected. Similar to the process made for the keyword selections previously mentioned, we screened these terms to find those directly linked with the aim of this paper and involved in the search query of this research (ETs and public services). This process made to select 46 terms, which are shown in the term map visualization provided in Figure 2.

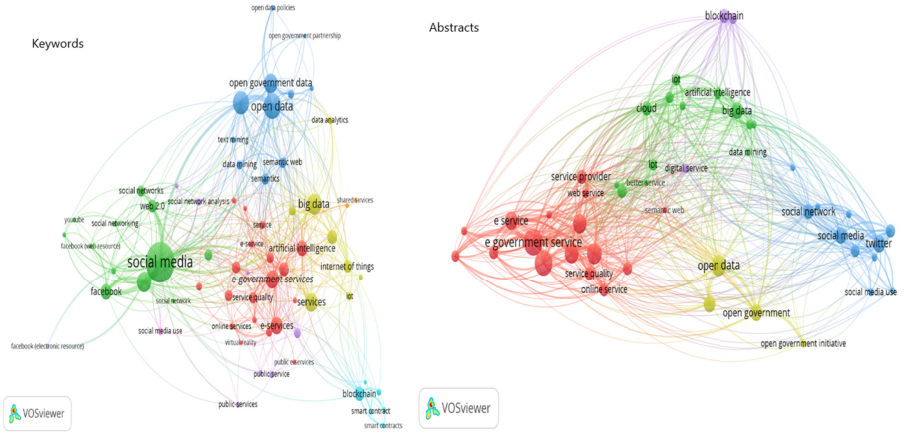


Figure 2.
Network visualization of keywords and abstracts

Source(s): Own elaboration

As for performance analysis and science mapping, this paper uses the open-source software SciMAT (http://sci2s.ugr.es/scimat), created for analysing a research field, detecting its conceptual subdomains and performing longitudinal studies tracking the evolution of the ETs implementation in public services across different periods (Cobo *et al.*, 2011a). SciMAT is based on a co-word analysis (Callon *et al.*, 1983) and incorporates algorithms and measures for science mapping workflow (Cobo *et al.*, 2011b, 2012).

Based on Börner *et al.* (2003) and Cobo *et al.* (2011b), the analysis made by the SciMAT software follows sequential steps in its analysis of research data: data retrieval, data pre-processing, network extraction, network normalization, mapping, analysis and visualization. The result of all the processes is visualized into two main science maps which represent both the detected groups of key terms of each period analysed in a two-dimensional space according to the density and centrality measures (strategic map) and the temporal evolution of the research terms across periods (evolution map).

As noted previously, in our study, we used the DGRL v16.6 database (http://faculty.washington.edu/jscholl/dgrl/) to retrieve the data and we carried out an advanced search with the keywords mentioned in the sample selection section. Then, we conducted a pre-processing process – detect duplicate and misspelled items, time slicing, data and network reduction, a network extraction phase – the relationship between documents and references, a co-word analysis (Callon *et al.*, 1983), a normalization process – with the Salton's Cosine (Salton and McGill, 1983) and the Jaccard indexes (Peters and van Raan, 1993), a principal component analysis and clustering algorithms (Chen and Redner, 2010; Coulter *et al.*, 1998), and finally a three-stage process to analyse the research field in a longitudinal framework (Cobo *et al.*, 2011b). In total, in our research, SciMAT grouped the key terms in a final corpus of 31 words related to ETs implementation in public services.

4. Analysis of results

4.1 Networking and clustering analysis

As noted previously, VOSviewer algorithm was used to perform the cluster analysis assigning each term to exactly one cluster (that is most related to the term) by using natural language processing techniques (van Eck and Waltman, 2011) and measuring the strength of the relationship based on a mathematical formulation (van Eck and Waltman, 2010) that uses

the number of the documents in which the terms occur together (van Eck and Waltman, 2010, 2017), avoiding an overlap of clusters. This analysis was performed for both "keywords" and "abstract" analysis.

Regarding the keywords' analysis, we obtain a total of 73 keywords selected which fall into 6 different clusters (Figure 2). When working with keywords, the occurrences attribute indicates the number of documents in which a keyword occurs.

In the visualization results (Figure 2), each keyword is represented by a circle whose diameter and size of the label reflects the number of publications in which the term appears. The distance between two terms offers an approximate indication of the relatedness of the terms (co-occurrence links), which is indicated using curved lines. Colours represent groups of terms that are relatively strongly related to each other (clusters). Finally, in the case of word relations, shared words in the titles, abstracts or full texts of publications serve as an indication of the relatedness of publications (e.g. Boyack and Klavans, 2010; Janssens *et al.*, 2006).

As we can see in Figure 2, six clusters have been found represented with different colours (purple, red, green, blue, yellow and aqua) which identify six key terms (public services -in general-, e-Government services, social media, OG and open data, big data and blockchain, respectively). Not all technologies are linked to general public services (only social media, IoT and blockchain). By contrast, all technologies are linked to e-Government services or e-services, which means that all of them have been used for improving these online services. In addition, Figure 2 shows that all ETs are linked to each other, except for blockchain technologies (only slightly linked to big data, IoT and AI).

The purple cluster is composed of the idea of general public services (online and in-person public services) and, especially, those public services delivered in municipalities. Indeed, the main concept of this cluster is municipal services showing a total link strength score of 22 with 18 links and 42 occurrences. By contrast, the red cluster is focused on e-Government services (total link strength: 96; No. links: 33; No. of occurrences: 144), including the different types of services (information services or emergency services, for example) as well as the service quality aspect. In addition, AI (total link strength: 59; No. links: 24; No. of occurrences: 99) and virtual reality (total link strength: 7; No. links: 7; No. of occurrences: 10) appear in the red cluster closely related to e-Government services.

Papers included in the green cluster are mainly focused on social media tools and its application to public services. The main concepts included in this cluster are social media (total link strength: 421; No. links: 45; No. of occurrences: 693), Twitter (total link strength: 220; No. links: 27; No. of occurrences: 186) and Facebook (total link strength: 136; No. links: 20; No. of occurrences: 99). These tools are linked not only to the public services but also to open data, data mining, data analytics, big data, AI and IoT. In addition, the strongest relations are those shown with OG (link strength: 30), open data (link strength: 10) and big data (link strength: 16) – see thicker curved lines in Figure 2.

Papers included in the blue cluster are those focused on open data (total link strength: 211; No. links: 29; No. of occurrences: 261) and OG (total link strength: 170; No. links: 29; No. of occurrences: 222). In addition, semantic web technology is also included in this blue cluster (total link strength: 59; No. links: 20; No. of occurrences: 45). Regarding OG and open data, these terms have usually been used in an indiscriminate manner (Ruvalcaba-Gomez *et al.*, 2018) although they are different. In any case, these technologies are mainly linked to social media (link strength: 30), big data (link strength: 23), IoT (link strength: 6) and AI (link strength: 1) –Figure 2.

The yellow cluster is mainly driven by big data (total link strength: 130; No. links: 31; No. of occurrences: 178), cloud computing (total link strength: 59; No. links: 28; No. of occurrences: 97) and IoT (total link strength: 84; No. links: 28; No. of occurrences: 95) – also machine learning with less relevance (total link strength: 52; No. links: 26; No. of occurrences: 41). These technologies are linked to the previous ones and with blockchain technologies (aqua

cluster) and are linked to all kinds of public services (not only online services). Finally, papers in the aqua cluster are mainly focused on the concept of the blockchain (total link strength: 61; No. links: 16; No. of occurrences: 88) and its link with big data (link strength: 3), cloud computing (link strength: 1), IoT (link strength: 4), AI (link strength: 4) and all kind of public services (in-person and online public services).

As for the analysis of the abstracts using VOSviewer software, we obtain a total of 46 terms selected which fall into five different clusters – red, green, yellow, blue and purple clusters (Figure 2). In this particular case, text data is obtained from the titles and abstracts of scientific publications.

The red cluster is mainly based on the concept of public services, except for the term "digital service" which is included in the purple cluster with the concept of the blockchain (total link strength: 151; No. links: 19; No. of occurrences: 161). The red cluster is linked to the rest of the clusters analysed. The main concept included in the red cluster is e-government services showing a total link strength score of 448 with 36 links and 554 occurrences, followed by electronic government (total link strength: 201; No. links: 26; No. of occurrences: 480). E-government services are not only the most important concept of the red cluster but also in the rest of the concepts identified in our research.

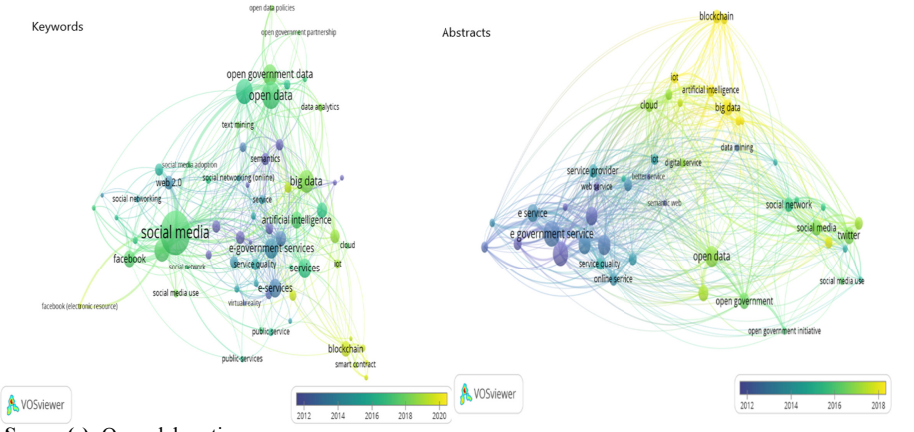
The green cluster includes a group of ETs closely related to each other with similar relevance (big data, IoT, AI and cloud computing). Nonetheless, the main concept in this cluster is big data showing a total link strength score of 231 with 34 links and 226 occurrences, followed by cloud computing (total link strength: 189; No. links: 35; No. of occurrences: 151). In addition, service provision is also included in the green cluster. This cluster shows a high relation with all the rest of the clusters, especially big data with open data (link strength: 17) and cloud computing with e-government service (link strength: 14) that show the thicker curved lines in the map.

The yellow cluster is only composed of open data (total link strength: 228; No. links: 35; No. of occurrences: 375) and OG (total link strength: 170; No. links: 24; No. of occurrences: 226), although these terms are linked to the rest of the clusters, mainly to e-Government services (link strength: 7) and big data (link strength: 17) – see the thicker curved lines joined the terms. In any case, the open data (or OG data) term is predominant regarding the use of OG projects and, therefore, its links are stronger.

Finally, papers included in the blue cluster are those focused on social media and social networks. The main concepts of this cluster are Twitter (total link strength: 229; No. links: 25; No. of occurrences: 241) followed by social media (total link strength: 168; No. links: 31; No. of occurrences: 209). These social media tools are mainly linked to big data (link strength: 12), cloud computing (link strength: 11) and OG (link strength: 8). Only general terms like a social network or social media are linked to the blockchain (purple cluster).

In the overlay visualization (Figure 3), this research shows the average of publications per year for each one of the keywords. This attribute is scored and classified by colours, ranging from blue (lowest score) to green to yellow (highest score) – see the colour bar in the bottom right corner of the visualization. As it can be seen, e-services are the first cluster in the timeline because, previously to the introduction of ETs, these public services were delivered on Internet (web services) and information services were those most uploaded onto the web pages of the public administrations.

From 2015, social media and OG/data technologies became relevant in the delivery of public services. Indeed, social media and OG are closely related to the early literature (Lee and Kwak, 2012; Chun and Luna-Reyes, 2012) and linked mainly to information transparency (Gunawong, 2015). After that, although its origin is prior, big data and IoT got relevance in the public services delivery, mainly based on collecting a great deal of data and data analytics. Finally, blockchain technologies, machine learning and AI are becoming the most relevant in ETs to be implemented for public services.



Source(s): Own elaboration

Figure 3.
Overlay visualization of keywords and abstracts

In the overlay visualization of abstracts visualization (Figure 3), similar to that made previously for keywords, papers regarding the use of OG and social media are the first ones in their application to public services, e-services and attributes of the public services (service quality, service provider . . .). Then, the application of ETs in public services was derived to information services being open data and cloud computing projects as those of most relevance.

In the last years, the use of big data, AI, IoT and blockchain technologies are currently being implemented for improving public services but, the same as noted previously, they are mainly applied to online information disclosures with the aim of improving information transparency and accountability.

Figure 4 shows the density view which indicates the number of items in the neighbourhood of a point (the higher the weights of the neighbouring items, the closer the colour of the point is to yellow). This visualization is particularly useful to get an overview of the general structure of a map and to draw attention to the most important areas on a map.

As can be seen in Figure 4, the main concepts are social media, OG and open data, e-Government services, big data, AI and, finally, blockchain. Therefore, the social media and

Source(s): Own elaboration

Figure 4.
Density visualization of keywords and abstracts

OG technologies are the ETs mostly applied to e-services and those who collect a great number of concepts related to them.

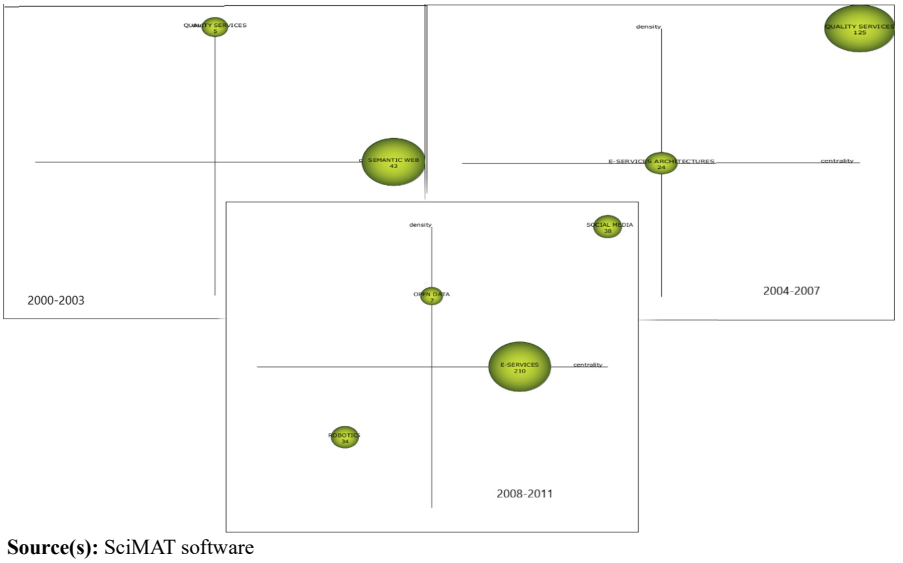
Finally, the density visualization of abstracts (Figure 3) shows that the main concepts are those related to e-Government services. Later, open data and social media were highlighted. The rest seem to have low and similar relevance. Therefore, according to the abstracts analysis, papers put emphasis on the objective of the application of ETs (improving public services), but not on the ETs used, except for open data and social media techniques.

4.2 Science mapping analysis

To carry out a Science Mapping Analysis, we established two steps to analyse a research field in a longitudinal framework. First, we detected the corresponding research themes by applying the simple centres algorithm (Coulter *et al.*, 1998) to a normalized co-word network. The clustering process located keyword networks that are strongly linked to each other and that correspond to centres of interest or to research problems are the subject of significant interest among researchers.

In this phase, the detected themes were visualized by means of a strategic diagram (He, 1999). The strategic diagram shows the detected clusters of each period in a two-dimensional space and categorized them according to density and centrality measures (Callon *et al.*, 1991). Given both measurements, a research field can be visualized as a set of research themes, mapped in a two-dimensional strategic diagram and classified into four groups: motor cluster (upper-right quadrant with high density and strong centrality – called "motor themes"); highly developed and isolate clusters (upper-left quadrant with marginal importance for the field – called "specialized themes"); emerging or declining clusters (lower-left quadrant with low density and low centrality – called "emerging or disappearing themes"); and basics and transversal clusters (lower-right quadrant themes not developed – called "transversal and general themes").

In the first sub-period 2000–2003 (Figure 5), we can observe that "*quality services*" is an isolated topic that tries to become a motor topic. These articles analyse the quality of public



Source(s): SciMAT software

Figure 5.
Strategic diagrams from 2000 to 2011

services and if they meet the needs of citizens, if they have the quality demanded, and how new technologies can improve that quality and efficiency. Similarly, the "*semantic web*" will go from being a transversal topic to become a driving topic for the research topic under study. This research topic is closely related to e-services, given that the purpose of the semantic web was to use semantic knowledge to find services that can be composed to form an admissible answer through standard ontology languages.

In the second sub-period 2004–2007, we can observe that "*quality services*" have become a motor research topic, related to e-services (Figure 6). These studies analyse the dimensions of website service quality that are most valued by users and thus are able to detect particular problems. Also, we can see that "*e-services architectures*" is a central topic in this period that nourishes the investigations of the semantic web. They analyse the architectural solutions implemented to ensure secure interoperability among information technology systems, as well as the need to have a design of complex information architecture and involve stakeholders having different objectives and various degrees of technological readiness.

In the third sub-period 2008–2011 (Figure 5), we can observe that the "*robotics*" is an emerging research topic. These studies focus on e-services architectures and how new technologies and advances could improve the delivery, efficiency, efficacy and costs of public services. Hence, these studies are closely related to open-source software, with the intention of offering more open, flexible and scalable technological alternatives that improve the provision of public services (Figure 7). Also, the "*social media*" topic is a motor topic in this period. These studies analyse the use of social media in the provision of public services and how the public managers and politicians share their opinions about them and communicate with stakeholders in a virtual space. Similarly, the research topic about social media is related to OG (Figure 7) favour the transparency, participation and collaboration with citizens. On the other hand, the topic "*e-services*" in this sub-period seems to be ceasing to be a motor to become a basic and transversal topic and "*open data*" is an isolated topic. These studies

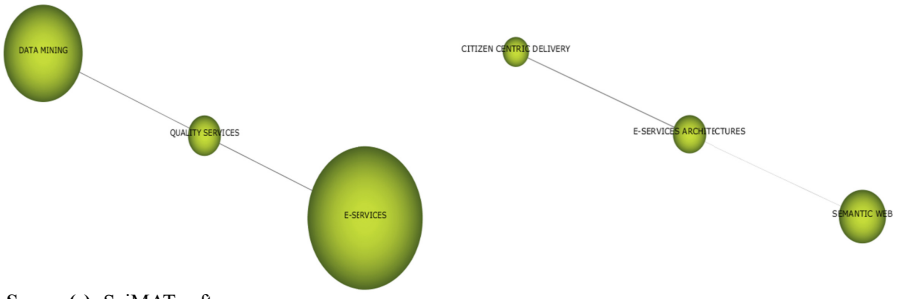


Figure 6.
Keywords connection in sub-period from 2004 to 2007

Source(s): SciMAT software

Figure 7.
Keywords connection in sub-period from 2008 to 2011

Source(s): SciMAT software

examine the presented advantages to promote transparency, innovation and public scrutiny, as well as the challenges to be faced in the future.

In the fourth sub-period 2012–2015 (Figure 8), we can observe that "*open government*" and "*data mining*" are motor research topics in field of knowledge of ETs implementation in public services. As we can see, the "*open government*" articles continue to have a huge connection with the analysis of "*social media*" and "*open data*" (Figure 9). These studies analyse how state and local governments adopted OG initiatives, how these initiatives favour transparency, legitimacy and participation in public decisions and how different social media favour this process of participation and collaboration. Similarly, these articles analysed how public organizations release their data for use by the public to open the government,

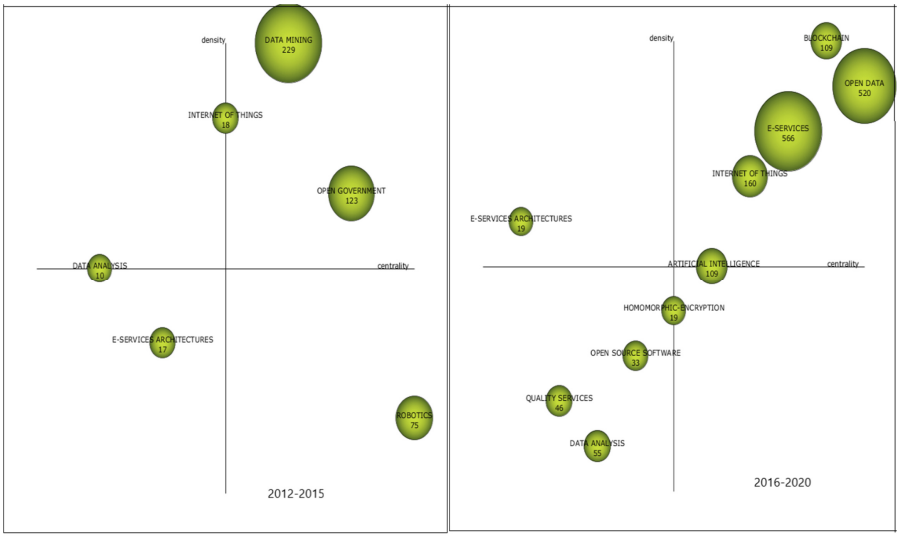


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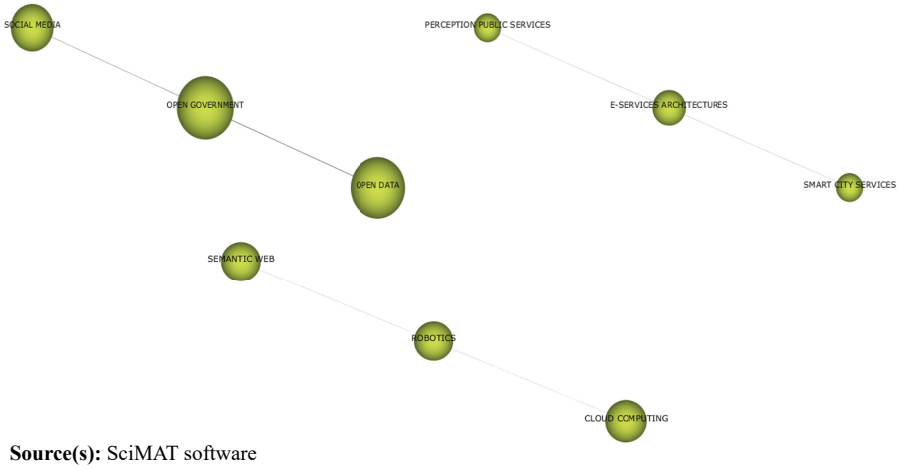
Figure 8.
Strategic diagrams from 2012 to 2020



Source(s): SciMAT software

Figure 9.
Keywords connection in sub-period from 2012 to 2015

highlighting the different strengths and weaknesses, as well as the specific situations in which it could be applicable.

On the other hand, the topic "*Internet of things*" (IOT) is an isolated topic that wants to become an engine of this area of knowledge. Meanwhile, "*e-services architectures*" topic is an emerging topic, which is related to "*perception public services*" and "*smart services*" (Figure 9), i.e. these studies analysed how new, advanced and ETs can be implemented in the delivery of public services, focusing on process architectures and structures. Finally, "*robotics*" is a basic and transversal topic, related to "*sematic web*" and "*cloud computing*".

In the last sub-period 2016–2020 (Figure 8), we can observe that "*open data*" is a motor topic in the analysed field of knowledge. These studies analysed the governmental open data portals around the world and tried to determine the factors, drivers or determinants that explain the different development. Also, "*blockchain*" topic is a motor topic in this sub-period, related to "*smart contracts*" and "*distributed ledge technologies*" (DLT) (Figure 10).

Although there is not a generally accepted and formal definition of blockchain technologies (Rodríguez Bolívar and Scholl, 2019) due to the different perspectives it has (Atlam and Wills, 2019), it is a particular type of data structure used in some distributed ledgers that ensure immutability and integrity of data, recording and maintaining all transactions made in a system across several distributed nodes in a peer-to-peer network (Natarajan *et al.*, 2017; Viriyasitavat and Hoonsopon, 2019). It is considered one particular type or a subset of so-called DLT (Natarajan *et al.*, 2017; Belotti *et al.*, 2019; Panwar and Bhatnagar, 2020), defined as a way of recording and sharing data across multiple ledgers that are collectively maintained and controlled by a distributed network of nodes (Houben and Snyers, 2018).

In our research, results show that, in the sub-period 2016–2020, studies about blockchain are emerging, tried to analyse the characteristics of these technologies, the environment under these characteristics are more appropriate and examined case of studies (especially Smart Contracts cases) implemented in European Union countries. Also, "*Internet of things*" is a motor topic that is closely related to Smart Cities. These studies focused on identifying the factor affecting the actual use of IoT by the potential users and developing a conceptual model, and its application in different domains (mobility, people, economy, government and living).

On the other hand, "*e-services architectures*" topic reduces its importance and becomes an isolated topic, which is related to "*chatbots*" (Figure 10). Meanwhile, "*quality services*" is an

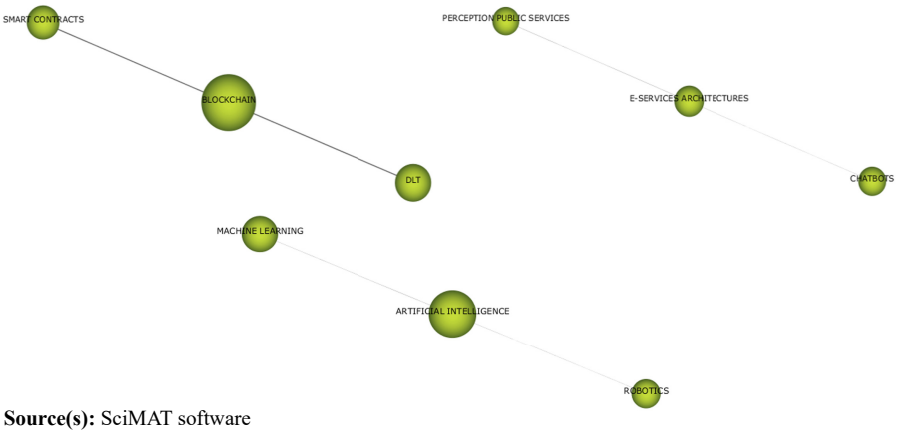


Figure 10.
Keywords connection in sub-period from 2016 to 2020

Source(s): SciMAT software

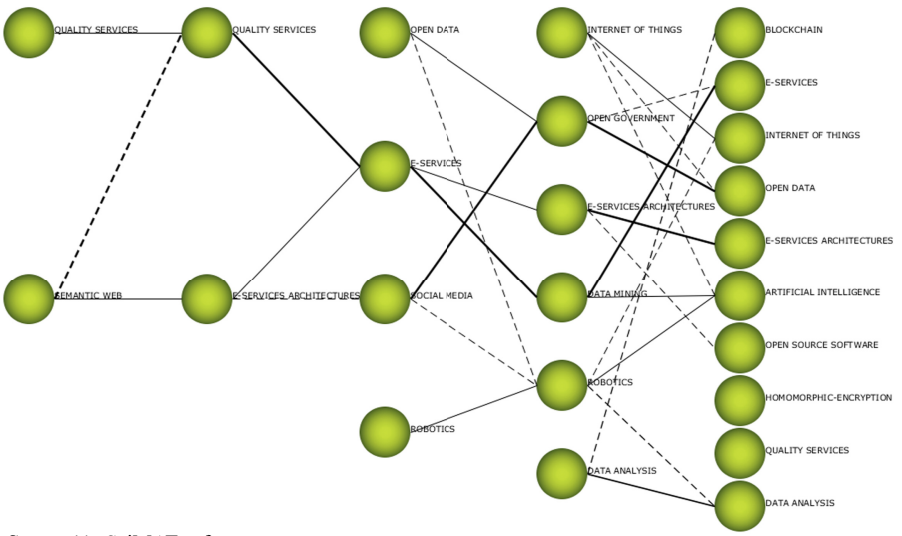
emerging topic, analysing how new and ETs could improve the provide public services, quality, efficiency and citizen-centric. Finally, "*artificial intelligence*" (AI) is a topic transversal that will become a motor topic, which in turn is related to "*machine learning*" and "*robotics*". The rapid advancement of AI technologies has dramatically expanded the technological capacities of the government and the application of AI technologies in government has been accelerating into more substantial areas of the government functions. These articles examine its unique attributes, potentials and applications for government services; investigate the landscape of the current use of AI technologies in government; and discuss key challenges the new technology will pose to the government and how they may be addressed.

Secondly, we carried on longitudinal analysis. In this phase, the evolution of the research themes over a set of periods of time is first detected and then analysed to identify the main general area of evolution in the research field, their origins and their interrelationships. This allows us to discover the conceptual, social or intellectual evolution of the field. SciMAT is able to build an evolution map (Cobo *et al.*, 2011a).

We can observe the evolution of research topics in Figure 11, this evolution reflected in this map confirms what has been glimpsed in the strategic diagrams. Hence, we can observe that initially, the studies on public services were related to the quality of their provision in general terms, beginning to use the term e-services in the 2008–2011 sub-period. Then, in the last two sub-periods, the studies focus more on the structures and architecture of the processes in the provision of these electronic services, especially how new or ETs could favour their distribution, efficiency, effectiveness, costs, satisfaction of citizens and so on.

On the other hand, we can observe that the open data terms appear in the third period, how this topic has a huge relation with OG and a weak connection with robotics. Also, this evolution map shows that social media appears in the 2008–2011 sub-period, which is coherent, given that these technologies and their uses were a boom with the US election campaign. This topic is strongly related to OG, how these tools and channel favour the communication between politicians, public managers and the citizenry.

Finally, in the last sub-period (2016–2020) appears new terms such as blockchain, IoT, AI and homomorphic encryption. This evolution is coherent, given that the number of articles



Source(s): SciMAT software

Figure 11.
Thematic evolution of the research topics (2000–2020)

published on this subject has increased considerably in the last five years (1,588 articles) – Figure 1. In recent years, research has been carried out that has tried to analyse how ETs can improve the implementation of public services, increase their quality, satisfy the demands of citizens, automate their behaviour and so on.

5. Discussion and conclusion

The increasing implementation of ETs has become a central topic of investigation by European sociologists of science (Olofsson and Mali, 2019) due to its positive, but also, negative impacts. Given that, the great importance and challenges that the implementation of ETs can pose for a government and the increase in articles published in the last years, it is vitally important to have a clear idea of the evolution of this topic and the connections that allow improving development and new discoveries in this field of knowledge. Hence, our research utilized computer-aided visualization method to show the dynamic scientific knowledge process for comprehensive analysis. In particular, networks visualization analyses are performed.

Our analysis indicates that all ETs are strongly linked to each other, except for blockchain technologies which are only linked to big data, IoT and AI (Figure 11). On one hand, it means that ETs are always built on previous technologies which are used in different ways for their performance. ETs can be, therefore, seen as accumulative knowledge that each technology contributes to previous technologies. On another hand, it could indicate the disruptive nature of blockchain technologies (together with smart contracts and DLT) which represents new insights from the technical point of view regarding previous ETs. Although recent research has pointed out that ETs and disruptive technologies have been seldom compared and they have been ambidextrously used, differences exist mainly regarding conceptual terminology, theories on which they are supported and approaches aimed (DT focuses on microeconomics, whereas ETs are focused on social aspects) (Li *et al.*, 2018).

As noted by Christensen (1997), a disruptive technology is focused on microeconomics, and it is a new technology having lower cost and performance measured by traditional criteria, but having higher ancillary performance, expanding emerging market niches. Although this definition has been expanded across the years (Utterback and Acee, 2005), the main characteristic of the disruptive technology is its power to change the way we do things (Christensen, 1997), initially in a secondary (niche) market segment and later in the primary segment (Adner and Zemsky, 2005). Hence, our findings support that the number of studies and publications about blockchain technologies has increased in this sense, becoming a motor topic in the last five years (Figure 8).

Also, whereas all ETs are linked to e-Government services or e-services, only those directly addressed to information disclosure are linked to general public services (only social media, IoT and blockchain) (Figure 9). In fact, according to the function performed by each one of the ETs, it will have complete knowledge of the function and utility of each one of the ETs to efficiently implement them in the public services delivery. It also requires adequate training of public officials on this issue.

Similarly, SciMAT analysis highlights the initial concern for improving the quality of public services and how this quality begins to derive into a concern to analyse and understand the structures and process architectures of the provision of public services where the semantic web and open-source software play an important role (Figure 11). Also, it is necessary to understand citizens' perceptions of smartphone-based city management apps and to identify facilitators and barriers that influence app adoption and use.

Another important finding is that AI and virtual reality appear in the red cluster with the key term "*e-Government services*" (Figures 2 and 11) closely related to e-Government services, which indicated that these technologies feed to all ETs for their performance on public

services. Jointly to AI, we find that machine learning and robotics are closely related to e-services (Figure 10). By contrast, social media tools appear as the base on which all ETs support their implementation, showing a substantial increase in the 2008–2011 sub-period, becoming a motor topic in the field of knowledge under study (Figure 5), remaining present as support for OG and open data initiatives (Figures 7 and 9). This technology seems to be the engine for other ETs like open data, big data, AI and IoT for feeding these technologies in their implementation to public services.

The main finding is that blockchain technology seems to be in an early stage of introducing into the field of public services delivery because this term is only linked to general concepts like social media, networking, open data, big data, cloud computing or e-services, but no concrete tools (for example, Twitter, YouTube, etc.) are included into the cluster or linked to it. This can also be seen in the evolutionary map of the SciMAT analysis (Figure 11) and how it relates to terms closely related to this technique (Figure 10). In addition, the studies tend to revolve around analysing the characteristics, strengths and weaknesses of these tools, which are the most appropriate characteristics for the public service in question or the analysis of case studies that analyse services that have implemented these technologies.

Indeed, the overlay visualization (Figure 3) shows how blockchain technology is the most ET in its use by the public sector entities. Public administrations should analyse this technology to use it in the public services delivery, not only focus on information disclosure. Therefore, it is expected a higher development of this stream of research in the close future with particular use of blockchain technologies for the public services delivery.

The overlay and density visualization in the abstracts' analysis put emphasis on the e-Government services as the main concept, being the ETs those technological tools to be implemented for improving these services. In addition, it seems clear that the ETs are mainly addressed to improving information transparency and government accountability. This way, future research should focus their efforts on the application of these ETs to other different areas of public services such as service quality, employing a comprehensive and holistic approach to help achieve service integration of pervasive platforms.

On the whole, findings identify four stages in the evolution of ETs and their application to public services: the "*electronic administration*" stage, the "*technological baseline*" stage, the "*managerial*" stage and the "*disruptive technological*" stage. In the electronic administration stage, public administrations were only focused on uploading the different processes of public services delivery onto their official web pages giving place to research about different models of e-Government interaction and service delivery (Nixon *et al.*, 2010; Mellouli, 2014). In the second stage, social media technologies and OG/open data projects became relevant as technological tools for both expressing citizens their opinion on public services (Dris *et al.*, 2019) and improving information disclosures and transparency in governments (Bertot *et al.*, 2012). So, the main objective in this stage was to put a great deal of information available to the public on social networks and open data platforms. In the managerial stage, different ETs, based on the real-time information gathered on Internet, help the government to create efficient models for data management of public services. In this stage, we can find ETs such as IoT, data mining or Big data, for example. As Al-Sai and Abualigah (2017) indicated, when e-Government utilises big data technologies, the e-Government will be more than just a data. Finally, the disruptive technological stage includes some ETs that are changing the way of interaction between the different actors involved in the public services delivery processes (Engin and Treleaven, 2019). Here we can find, the most representative ETs, blockchain, smart contracts or AI. Future research should test this framework and analyse how each stage has had an impact on both improving quality of public services and meeting citizen satisfaction.

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