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Public Services Provided with ICT in the Smart City Environment: The Case of Spanish Cities

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Abstract: Social, technological and economic changes, citizen demand of services modernization, new ICT developments related to the Internet of Things and an economic situation that urges more efficient public administrations, have allowed the adoption of ICT by municipalities in order to provide public services. All the foregoing constitutes a boost of the smart city concept, which is considered in the scientific literature mainly from a technical point of view, overlooking deeper analysis on the specific services being provided by means of smart technologies. The current research identifies services provided using smart technologies at 26 Spanish smart cities and the degree of smart development of those cities based on which services provide. The results highlight that the services most widely implemented are those that allow direct reductions in local administration expenditure. On the other hand, the remaining services enjoy greater perspectives of future development. Additionally, three groups of smart city development have been identified, which allows benchmarking analysis and enhances the exchange of information between the cities.

Keywords: Smart city, public services, technology for smart cities, benchmarking of cities, ICT
Categories: C.2.m, H.3.5, H.4.3

1 Introduction

Advancements in innovative information technology (IT) solutions have enabled not only the private sector, but also public institutions to radically improve the way they perform their operational activities [Stragier, Verdegem, & Verleye, 10]. This has allowed local governments to transform the way services are offered to citizens [Gupta et al., 08; Kamal et al., 10].

Cities have taken advantage of Information and Communication Technology (ICT) to enhance its competitiveness and improve citizen quality of life during the last 20 years. This phenomenon is associated to the smart city [Caragliu et al., 11]. Within the last several years, the smart city concept has gained a lot of attention and momentum in the European Union, with various projects being set up in nearly every European city [Schuurman et al., 12].

Additionally, citizens are demanding greater efficiency, sustainable development, quality of life and improvements in resource management. In order to address these questions, local authorities are considering the implementation of management models which, jointly with energy efficiency, new infrastructures and environmental protection, mainly focus on ICT. A city that implements all these policies is considered a smart city [Rosario et al., 13].

A significant amount of publications try to conceptualize and define the elements and application domains that constitute smart cities, mostly from a technological approach [Nam & Pardo, 11; Schuurman et al., 12]. However, little research has been carried out in order to analyze ICT innovation on public services provided within the framework of smart cities. Furthermore, there is a lack of research on services currently being implemented under the umbrella of the smart city concept. Besides, the literature that analyzes this environment usually focuses on individual case studies [Nam & Pardo, 11; Schuurman et al., 12]. Therefore, a deeper research based on comparative analysis of different cities using objective criteria is needed.

In this context, this paper pursues to fill those gaps by analyzing key public services provided using innovative ICT in the Spanish smart cities environment. As the smart city concept is generally used from a holistic perspective, we also aim to identify different levels of smart cities depending on the services provided.

This analysis will allow local governments to know what other cities are doing stablishing comparatives with their municipality and learning best practices from pioneers. Moreover, IT professionals will be able to understand which public services are more developed and identify which might bring opportunities when implemented.

The rest of the paper is structured as follows: section 2 describes the context of smart cities and the public services they provide from a theoretical perspective. In section 3 we explain the methodology used for the research. Section 4 is dedicated to the results of the public services provided in the main 26 Spanish cities that count with innovative and smart cities' technology. In section 5 we discuss the results and section 6 includes the conclusions. Finally, on section 7 we report limitations and propose lines for future work.

2 Smart cities environment

The Smart cities have aroused in a context characterized by the convergence of a need for change in municipalities and the availability of technology.

2.1 Challenges for municipalities

We look upon the Public Sector as the set of activities of any given nature practiced by public entities, where local government appears as the link between the public sector and the citizens [Martins Marques de Lima Rua, 12]. As a result of its proximity to people, local governments are subject to a significant pressure to deliver greater and more efficient public services [Cabrero Mendoza, 97; Paulin, 13]. Local governments are responsible of identifying community needs and respond to them with the most adequate services and management models [Iglesias et al., 13; Martín Vallespín & Gianfelici, 11].

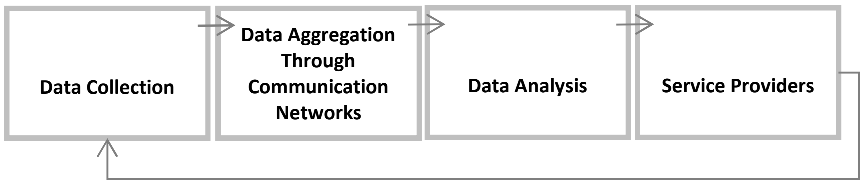
In a phase of economic crisis and budget cutbacks in many Western countries, innovation and change in the public sector look particularly significant [Pollitt, 10]. It is necessary to improve the efficiency of existent services and to create new ones adapted to the current situation [Fernández & Nebot, 13].

ICT applications can offer solutions when responding to those political, managerial, democratic or material challenges [Pattaro & Tripi, 13; Sabucedo & Anido-Rifón, 10]. Technology can bring about transformational change in public service provision, administration and engagement with the general public [OECD, 05]. In order to achieve this goal, municipalities must assimilate a variety of technologies that integrate a special microenvironment that is described next.

2.2 Technology for the smart city

Digital devices connected through the Internet are producing big amounts of data that can be turned into knowledge using computational power, a concept known as Big Data. All this knowledge can improve efficiency, productivity and quality as well as reduce costs and cut waste [Bătăgan, 11]. An important aspect within these innovative applications of ICT is the collection of all sorts of data and information by sensors and sensor networks [Schuurman et al., 12].

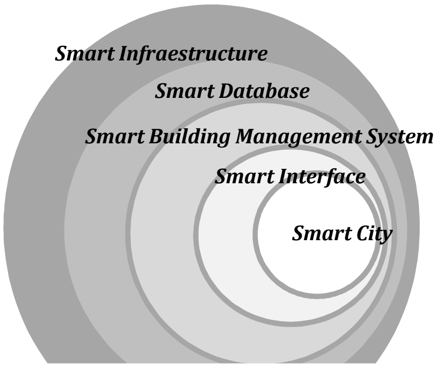
Telefonica proposes a technological model for the smart city (Figure 1) based in the collection of information, its aggregation through communication networks, its storage and analysis, and its utilization by public services providers [Telefonica, 11].



Source: Elaborated by the authors based on a model created by Telefonica [Telefonica, 11]

Figure 1: Technological model for the smart city

Al-Hader, Rodzi, Sharif, & Ahmad, (2009) specify the technological components within the framework of a smart city development pyramid: smart interface (dashboard, common operational platform, integrated web services), smart building management system (building automation control network, local operating network works, HVAC), smart database resources (spatial database, database server, complementary data resources) and smart infrastructure (electrical, water, district cooling, gas, irrigation, fire systems, telecommunications and communications networks, etc.). All components are properly integrated and the systems are combined. On the basis on the pyramid created by Al-Hader et al. (09), we have created a figure of layers, as the smart city is the core where the information is generated, as well as the starting point to reach the other layers (Figure 2).



Source: Adapted by the authors from the Smart city Development Pyramid [Al-Hader et al., 09]

Figure 2: Smart city development layers

The economic crisis has urged local governments to implement innovate and more efficient management models. Besides, explosive broadband and personal devices use has given rise to demands of digital services which also challenges cities [Walravens & Ballon, 13]. The technological context provides local authorities with new opportunities for Big Data, Internet of Things and other cutting edge approaches.

Even though the term smart city is relatively young, it is used all over the world with different nomenclatures, context and meanings [Chourabi et al., 12; Nam & Pardo, 11; Walravens & Ballon, 13]. In our current work, based in a practical approach supported by the existing literature, we have considered a smart city concept that strengthens the importance generated by ICT. The smart city is the urban center made safe, sustainable, and efficient that provides services with the support of integrated materials, sensors, electronics, and networks, which are interfaced with computerized systems, comprised of databases, tracking, and decision-making algorithms. All of this to improve quality of life of citizens [AMETIC, 12; Giffinger & Pichler-Milanović, 07; Hall et al., 00; Kehoe et al., 11; Pattaro & Tripi, 13].

It is now required to go in depth in the analysis of the public services that the smart cities are now providing with innovative ICT.

2.3 Public services in the smart city

Scientific literature provides descriptions of a range of services that can be developed under the approach of the smart city [Aghemo et al., 2013; Kostic & Djokic, 2009; Vicentini et al., 2009]. Additionally, a significant number of studies that describe service provision in a smart city through individual case studies [Bakıcı et al., 12; Baron et al., 12; Lee et al., 13; Pattaro & Tripi, 13]. However, there is a lack of research on the range of services that are currently being implemented within smart cities. Given this situation, it was carried out a review on literature that allowed the identification of specific public services that are being provided under the approach of the smart city technological model. For each service, the need to be covered and the solution selected were considered (Table 1). This compendium of literature regarding public services provided with ICT has not been found on research publications.

Smart municipal solid waste management
Description of services. Cities are currently one of the main sources of waste material [Kan, 09], dealing effectively with all this waste is key for sustainable city design [Zaman & Lehmann, 11].
ICT solution. Schedules and routes for waste collection have to be optimized considering cost, waste weight and volume, distances and traffic [Ogra, 03]. Telematic tools allow gathering information from every waste collection point, which can be used to characterize waste production, collection and disposal [Vicentini et al., 09]. Waste containers can be used to collect data such as weight and volume using sensors placed at different positions in the container [Rovetta et al., 09].
Smart grids and smart metering
Description of services. The term smart grid designates an electrical system that incorporates extensive communication, monitoring capabilities, distributed and autonomous control and management functionalities to the power system; it allows more sustainable means of energy production, distribution and usage [Farhangi, 10]. Smart meters are advanced energy meters that measure energy consumption and provide added information to the utility company compared to conventional devices [Depuru et al., 11]. Information from highly distributed smart metering points is integrated in nearly real time and processed in order to obtain an insight upon which appropriate decisions can be made [Karnouskos et al., 12].
ICT solution. The extensive use of intelligent devices such as smart meters, capable of collecting real-time and accurate information about electricity usage patterns, as well as about the status of distributed energy resources and other components of the grid, is required in order to enable the an efficient energy management [Atzori et al., 10]. Smart meter systems include a smart meter which can communicate and execute control commands remotely or locally, a communication infrastructure and control devices.
Smart buildings
Description of services. Although smart buildings are centred on the use of smart technologies, these buildings are also designed for sustainability and energy efficiency. As stated in the European Commission funded project called “Smart Energy Efficient Middleware for Public Spaces” [Macii, 11], reduction in energy usage and CO2 footprint in existing public buildings can be address by means of an intelligent ICT-based service that monitors and manages the energy consumption, and avoiding retrofitting.
ICT solution. Optimizing energy usage in smart buildings without retrofitting focuses on the control of HVAC (heating, ventilation and air conditioning) services, lighting and other electrical appliances [Aghemo et al., 13]. The use of intermittent heating controllers allow the internal temperature of a space to be lowered during non-occupancy periods, while maintaining the desired temperature during occupancy periods, when these periods are clearly defined [Fraisse et al., 99]. Commonly used lighting control strategies for energy savings are: time switching, which involves turning automatically on and off lights at scheduled times; daylight harvesting, which involves automatic adjustment of light; occupancy control, which involves turning luminaires on and off when the presence or absence of people is detected in a room or corridor; and a combination of the previous [Aghemo et al., 13; Dubois & Blomsterberg, 11]).
Efficient public lighting
Description of services. As public lighting represents a 2.3% in global electricity consumption and since possibilities for energy savings in the streets are numerous, being some of them able to reduce electricity consumption in even more than a 50% [Reusel, 08], energy-efficient programs in this field are welcomed.

ICT solution. An efficient public lighting network should be a wireless sensor network and may include points supervision (node status, whether it is connected to the network or not; battery power; luminosity level), control to switch on/off the luminosity level automatic programmed actions, actuation of nodes through a remote tool, dimming systems, diagnostic devices and alarms, and automation of information storage [Kostic et al., 09; Pantoni et al., 11].

Public gardens and parks

Description of services. Water used in urban landscape irrigation has been documented to reach 56% of the total water use in cities [Lohr, 2013], hence the need for smart technologies that lead to a sustainable water consumption in urban public gardens. Advanced irrigation controllers exhibit significant reductions in water use when compared with manual irrigation or irrigation with standard (time) controllers.

ICT solution. Irrigation controllers equipped with rainfall sensors or able to obtain ET0 allow water use reductions within 11% to 75% as compared with manual irrigations [Salvador et al., 11]. Wireless smart sensor arrays for measuring soil moisture and temperature permits fine scheduling irrigation for further water savings [Vellidis et al., 08].

Smart traffic and bus services

Description of services. The transport sector in EU is responsible for approximately 30% of total energy consumptions, 27% of total greenhouse gas (GHG) emissions [Falvo et al., 2011]. Additionally, traffic accidents and congestion impose an important economic burden to the society [Haque et al., 2013], which makes urgent a rationalization of urban processes to improve the quality of life, energy saving and the sustainability of the planet [Schaffers et al., 12].

ICT solution. Smart technologies in transport include different intelligent transport systems (ITS), such as wireless communications, control systems (collection of traffic data through detection of vehicles and pedestrians, etc.), monitoring and enforcement systems (different type of sensors, surveillance cameras, speed cameras, red light cameras, etc.), information management systems (traffic news broadcasting, public transport information sharing applications, etc.) and revenue management systems (different types of smart cards) [Calderoni et al., 14; Debnath, 11].

Metro management

Description of services. Subway systems are considered as the most convenient mode of public transportation in metropolitan areas [Murruni et al., 09].

ICT solution. ITS for metro services are mainly categorized in traffic management systems, traveller information systems and e-ticketing systems, which include track circuit sensors, Global System for Mobile Communications (GSM), balises, signalling system for speed control, monitoring cameras [Franklin, 13].

Smart parking

Description of services. Over a 30% of vehicles on the road in the central area of major cities are cruising for a parking spot that takes an average period of 7.8 minutes to be found [Arnott et al., 2005]. A long queue of vehicles driving around cause serious congestion with the blocking of only a few streets. Additionally, low speed cruising produce significant amounts of automobile emissions [Lan & Shih, 13] and increases air pollution.

ICT solution. In order to improve parking management, traffic authorities are building so-called Parking Guidance and Information (PGI) systems in many cities, which present drivers with dynamic information on parking within controlled areas and direct them to vacant parking spots [Geng & Cassandras, 12]. The information may be displayed on variable-message signs (VMS) at streets and intersections or it may be shared through the Internet [Teodorovic & Lucic, 06]. PGI systems are based on the development of autonomous vehicle detection and parking spot monitoring through the use of sensors placed in the vicinity of parking spaces for vehicle detection and surveillance [Geng & Cassandras, 12].

Water management (distribution and sanitation)
Description of services. In order to achieve the goals of water distribution optimization, and providing high quality of service to consumers, Advanced Metering Infrastructure should be implemented. Those infrastructures comprise two-way communications, advanced sensors (water quality sensor, pipe flow and junction pressure sensors), smart meters and an infrastructure for data management and treatment that improves the efficiency, reliability and safety of water delivery and use [Fróes & Portillo, 12; Shihu, 11].
ICT solution. AMI architecture make use of GSM communications, flow and pressure monitoring sensors, water quality monitoring sensors (chemical oxygen demand, biochemical oxygen demand, conductivity, pH, turbidity, etc.), smart water meters, leakage monitoring sensors and integrated supervisory control and data acquisition systems [Shihu, 11].
Security and emergencies
Description of services. Intelligent Operation Centers enable cities to manage large complex environments, communicate more effectively with citizens, understand the state of the city and collaborate between departments [Ding et al., 11].
ICT solution. Smart cities security and emergency management solutions are based on the use of sophisticated analytics engines, which automatically process the data and provide intelligent insights into key performance indicators and trends. Additionally, those analytics provide insight for future incident planning regardless of future budget constraints [Ding et al., 11].

Table 1: Description of innovative ICT applied to local public services

3 Methodology

The aim of this study is to analyze the key public services now being provided using ICT in the Spanish smart cities environment. In order to achieve this objective, we have carried out a research on Spanish cities collecting data about several local governments. Information was obtained and contrasted from 183 public sources: official websites, sustainable urban development plans, government and institutional reports, academic journals, books, trade media and websites (all the sources used can be consulted in reference (Pérez-González, 2014)). The research work was conducted between June and November, 2013. The cities chosen for the study were selected considering the capitals or main administrative cities of the Spanish Autonomous Regions. Except for Extremadura, where Badajoz was chosen instead of Merida, as the one selected is the largest regional city. Besides, 8 additional cities (A Coruña, Alicante, Bilbao, Cordoba, Gijon, L'Hospitalet, Malaga and Vigo) were selected to complete the sample due to their significance, size and activity in the smart cities environment, their lead in important technological projects or their stand out in the first Spanish smart cities ranking [IDC, 12]. The cities analyzed may be found in Figures 3 and 4.

Subsequently, according to the services identified in the literature review (Table 1), 12 services were considered in order to analyze their smart implementation in each of the 26 Spanish cities (Table 2). The indicators analyzed in the current research represent over a third part of a Spanish local government budget [Cebrián et al., 12].

For a given city, each indicator was valued from 0 to 3 in order to characterize its degree of development: maximum qualification to service provided with smart ICT in the whole city (3); services provided with smart ICT in parts of the city (suburb, street, etc.) received a 2; the services which local governments plan to provide with smart ICT received a 1; and the services that are not provided with ICT and are not planned received a 0.

Besides, with the information collected, an analysis of the services provided was carried out in order to classify cities in different groups based on the public services they provide with technologies that accomplish the smart city technological model [Telefónica, 11]. There is a cluster analysis performed with SPSS version 20.

Finally, a statistical inference with models of variance analysis (ANOVA) was made up in order to analyze whether the economic and demographic variables affect to smart cities' development in Spain. The ANOVA techniques are used to contrast the statistical significance of means differences between groups or levels of the independent variable and allow establish statistically the existence of relationships between variables [Hair et al., 2007]. Before the application of the ANOVA technique, it was verified that the essential requirements of normality through the Kolmogorov-Smirnov test (a value >0.05 was obtained which indicates normality in the sample) and homogeneity through the Levene's test (a value of >0.05 was obtained which indicates the homogeneity of the variances [Hair et al., 2007].

4 Results

In this section, the results of the current research are presented. Results related to the analysis of services provided using smart technologies are displayed first. Subsequently, the results that characterize cities based on which services they provide are described.

4.1 Services provided

Regarding to the services provided in Spanish cities by means of smart technologies, Table 2 highlights the amount of cities that consider each service and their relative degree of implementation: Active (fully active), Partially (partially active) or Planned (planned implementation). It is also displayed the total number of cities that have implemented each service to some degree (Implemented), the amount of services implemented or planned (Considered) and the number of those that have not announced intention of implementing it, i.e. have not considered it yet (Not Consid.). The number of cities that have not considered it yet (Not Consid.) is the subtraction between the total number of cities and those that have implemented or planned each service (Consid.).

The results stated that Spanish cities present a greater degree of implementation for those smart services related to energy efficiency and management: smart grid, efficient public lighting and efficient public buildings. Irrigation management technologies in public gardens are also interesting for municipalities as many of them use it partially or are planning to do it. However, it has to be pointed that all these services are only provided in restricted areas or as pilot projects. Additionally, within this group of services, it should be also emphasized that smart waste management and efficient public lighting systems are the ones more included in local governments' plans of implementation for the near future.

SERVICES	**Active**	**Partially**	**Imple-mented**	**Planned**	**Consi-dered**	**Not Consid.**
Smart grid	0	14	**14 (54%)**	5	**19 (73%)**	**7 (27%)**
Efficient public lighting	0	9	**9 (34%)**	9	**18 (69%)**	**8 (31%)**
Efficient public buildings	0	10	**10 (38%)**	6	**16 (61%)**	**10 (39%)**
Solid waste management	1	3	**4 (15%)**	11	**15 (57%)**	**11 (42%)**
Smart traffic	6	3	**9 (34%)**	4	**13 (50%)**	**13 (50%)**
Smart parking	0	8	**8 (31%)**	5	**13 (50%)**	**13 (50%)**
Public gardens irrigation	0	8	**8 (31%)**	3	**11 (42%)**	**15 (58%)**
Bus services	5	2	**7 (27%)**	4	**11 (42%)**	**15 (58%)**
Water sanitation	0	1	**1 (4%)**	6	**7 (27%)**	**19 (73%)**
Water distribution	0	4	**4 (15%)**	2	**6 (23%)**	**20 (77%)**
Security and emergences	1	3	**4 (15%)**	0	**4 (15%)**	**22 (84%)**
Metro / Local Trains management	2	0	**2 (8%)**	0	**2 (8%)**	**24 (92%)**

*** Whole numbers make reference to the amount of Spanish cities providing a given service, whereas numbers in brackets refer to same number in percentage**

Table 2: Public services provided with smart ICT in Spanish cities

Considering the case of an efficient management of public buildings, there is a variety of strategies aimed to implement those initiatives in new buildings. However, new efforts are needed in the cities in order to extend those practices to all public buildings. Despite of smart grid technologies are widely implemented within Spanish municipalities, they are only restricted to some urban areas or are pilot projects. No energy company has yet implemented a complete smart metering system across any of the cities studied.

Another group of considered services provided using innovative technologies are those related to urban traffic and transportation, i.e. smart traffic, smart parking, bus services, and metro or local trains' management. The most widely implemented smart services within this group are smart traffic, fully provided by 6 cities, and bus services, implemented completely in 5 municipalities. The case of the metro service should be considered unusual because most of the cities studied do not have a metro network, hence the negligible implementation of smart metro services.

Finally, within the group of services less considered by the 26 Spanish cities, there is only one city, Madrid, that presents an integrated and smart service of security and emergencies. The number of cities providing the service partially is three, whereas the remaining cities have not even planned to adopt the technology yet. It is also significant the low level of implementation of services related to water management: water distribution and water sanitation.

4.2 Groups of Spanish smart cities

Spanish smart cities differ from each other regarding to a variety of characteristics, such as population, economy, location, etc. However, cities offer a similar range of public services to their citizens, depending of their population (it is determined by law); therefore, it is reasonable to classify cities depending of the public services provided with smart technologies or planned to be provided. In order to classify the cities based on the criteria mentioned previously, a cluster analysis was carried out with the considered data. As highlighted in Figure 3, the 26 cities are aggregate around three clusters. In the first group, highlighted by a higher level of public services provided with innovative ITC, stand out the cities of Madrid, Santander, A Coruña, Pamplona, Malaga, Barcelona, Zaragoza and Valencia. A group of followers aggregates the cities of Sevilla, Las Palmas, Cordoba, Mallorca, Murcia, Logroño, Vitoria, Vigo, Oviedo, Bilbao and Valladolid.

Finally, the cluster of cities displaying a lower degree of development in public services provided with innovative technologies is formed by Toledo, Gijon, Badajoz, Santiago de Compostela, Alicante, Santa Cruz de Tenerife and L'Hospitalet.

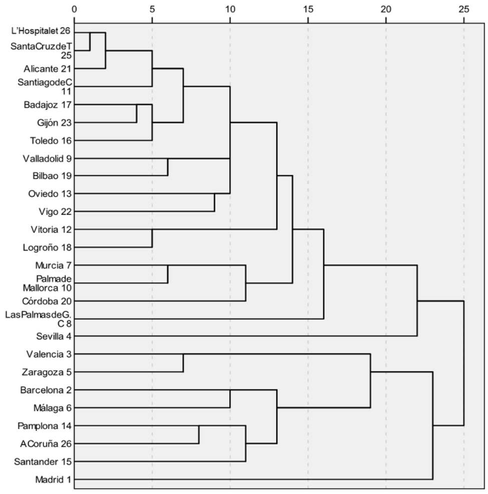


Figure 3: Dendogram of distances and clusters created for the Spanish cities (including public services provided or planned to be provided).

Selecting only those cities that have implemented the public service technologies at some point (i.e. active and partially) the resulting cluster analysis is more disaggregated (Figure 4), passing from 3 to 5 groups. The first group almost does not change as Madrid, Zaragoza, Valencia and Barcelona stay inside. The differences between the clusters are generated when considering only the public services implemented; it originates the birth of two new groups which plan the provision of many services with ICT.

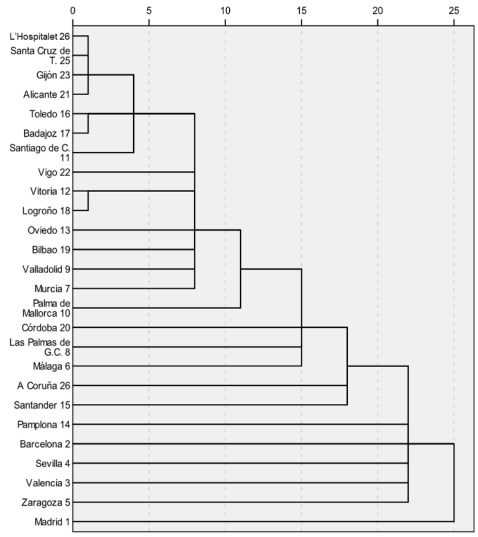


Figure 4: Dendogram of distances and clusters created for the Spanish cities (public services provided)

Even if the main objective of this work are identifying and describing the public services provided with ICT as well as classifying the Spanish smart cities, we have gone further. In fact, a statistical analysis through ANOVA models has been developed in order to contrast if some economic and demographic data like income per family, municipal debt and population have any impact in the development of smart cities. The results of this contrast may be found in Table 3. Based on the value taken by the significance, also called "p-value", the resulting relationships are statistically significant when the significance value is smaller than 0.10 (significant at a confidence level of 90%). No significant relationships are found between the variables and, therefore, there is not a statistical relationship between the income per family, the municipal debt and the population of the Spanish smart cities and its implementation of smart technologies for public services provision.

5 Discussions

The analysis of the results highlighted in the previous section is presented focusing in two main aspects: services provided and groups of cities.

5.1 Services provided

Regarding to public services provided with innovative ICT, the main criteria that favor the adoption of some services rather than others are the economic value of the investments needed to implement smart technologies and their profitability in the short and medium term. This is being highlighted by the fact that the services provided are mainly those that allow expenditure reductions or those that enhance the energy efficiency of public buildings and in public lighting. Additionally, within the public services provided with innovative technologies most widely adopted, it could be emphasized those services that require lower technology investments and fewer complexity [Bitcarrier, 12], such as the smart management of traffic, the bus services or the management of garden irrigation. Economic considerations can describe as well the low degree of implementation of services provided with innovative ICT for waste management, water distribution and water sanitation. As those services are generally externalized and provided through concessions granted to private companies for time periods from 4 to 10 years, the provider companies reject investments in new technologies that probably will not recoup subsequently.

Clusters of cities attending ICT implementation in public services	**Average income per family (in euros)**		**Average population**	**Average public debt of municipalities (in thousands of euros)**
1	24.478		1.398.709	2.063.560
2	22.736		316.706	236.155
3	25.226		344.113	170.387
4	24.180		170.198	57.547
5	23.770		272.306	131.310
	F Value	2,784	4,142	3,902
	Significance (P value)	0,486	0,133	0,198

Table 3: ANOVA Analysis using economic and demographic data

On the other hand, the wide spread of smart grids could be explained considering the appreciable economic resources of energy companies that allow them to carry out large smart meter installations. Additionally, customer fidelity to energy companies is high and that works in favor of the profitability of their investments in new technologies, as the long term return is virtually granted.

Therefore, from the data analyzed, it can be stated that services that make a difference in the quality of life of the citizens, but which do not represent a significant expenditure reduction for the municipality, are not considered for their implementation with innovative ICT. That could be the case of integrated security and emergency services.

5.2 Clusters of Spanish Smart cities

Regarding the classification of cities depending on the use or use projection of innovative ICT in their public services, the results of the research highlight three groups. First, an advanced group of 8 cities that contains the municipalities that provide more services. After, the bigger group which includes 12 cities that provide, or plan to provide, between 5 and 9 services. Finally, there are six cities that provide between 1 and 5 services although not in the whole city.

When using only data of services provided (active and partially) and not provided (both planned and not considered), groups change and some cities modify their position. Sevilla enters in the first group whereas other cities (Santander, Pamplona, Malaga and A Coruña) move to the second.

According to our classification, the factor that determines that a city belongs to one of the groups is the intensity of its use of innovative ICT in the provision of services. At this point, it might be interesting to identify the features that impel a city to provide more public services with innovative technologies.

In this sense, the lack of academic research explaining why some cities are more advanced than others, an analysis through ANOVA models has been developed. We have studied economic (income per family and municipalities' public debt) demographic (local population) criteria. The results show the variability of cities in each group with different budgets, debt and population. None of these factors is key when providing smart city services. Therefore, these factors do not explain why some cities provide more innovative services. However, from the revision of the 183 public information sources it is interesting to point that cities in groups 1 and 2 have strategic plans on technology for the smart city which indicates that the local government's will seems to be a decisive factor.

It is also outstanding that close to the cities in the advanced group, there are technological universities, innovation centers or big companies specialized in ICT for the smart city. Once the politic decisions are taken, the technologic environment around the city appears to be another key factor complementary to the local government's will.

6 Conclusions

The rise of smart cities is due to a conjunction of several factors, outstanding the technological as a consequence of a fast development of hardware, software and networks. Additionally, this technology has experimented a cost reduction and is now available for most cities around the world. There are also important social and economic factors between the causes of the rise of smart cities. First, citizens are making an intensive use of IT as well as demanding new types of public services. Regarding the economic factor, most western countries are heading an economic crisis that is impelling governments to reduce budgets and increase efficiency. Within this context, local authorities are unavoidably participating in the adoption of IT and the opportunities it offers, as this administration level is responsible of providing a great variety of services that affect directly to the quality of life of its citizens.

The literature review shows that the research has been focused in delimiting the smart city concept as well as analyzing the technologies involved. Descriptions of case studies or the simple technological approach are common. However, there is a lack of research reaching deeper into the identification of the public services that cities are now providing with innovative ICT.

In the current work, an exhaustive analysis of public information regarding Spanish smart cities has been carried out. The aim was to identify what services they are providing, how powerful and which factors make some of them more usual than others. As a result of the research, we have identified the services more often provided by Spanish cities as well as described why they are more usual. We may conclude that the public services more commonly implemented in the Spanish smart cities are those that require lower investment, are less complex and produce cost savings at short and medium term. In particular, smart grid, efficient public lighting, efficient public buildings are the most usual, followed by smart traffic, smart parking, bus services management and the irrigation systems in public gardens.

The few cases of ICT use in the provision of water and waste management deserve to be highlighted. As these services are outsourced in contracts of within 4 and 10 years, the company provider could avoid the risk of not amortizing the investment. In order to solve this problem, we advise cities to include in the bid of specifications for tenders the obligatory nature of using innovative technologies integrated in the smart city platform.

The identification of the services more often provided and the less common, as well as what moves local authorities to do it, could also be a guide for IT companies. It might help to identify the services with the highest potential, primarily in those cities that plan to provide that service but they still have not do it, and which are the authorities' criteria to choose the services provided.

Starting from the identification of the services provided, a classification of cities has been carried out. Considering the most positive vision (i.e. public services provided and those planned to be provided by local governments) there are three groups of cities depending of their use of innovative technologies for service provision. First, an advanced group of 8 eight cities, including Madrid, Santander, A Coruña, Pamplona, Malaga, Barcelona, Zaragoza y Valencia. A group of followers is constituted by Sevilla, Las Palmas, Cordoba, Mallorca, Murcia, Logroño, Vitoria, Vigo, Oviedo, Bilbao, and Valladolid. Thereafter, a smaller group with the less active cities (Toledo, Gijon, Badajoz, Santiago de Compostela, Alicante and Santa Cruz de Tenerife).

This listing depending on services will be useful for local authorities in their efforts to identify those best practices that deserve further study and the pioneers who might help as advisors.

The groups composition and their features allow to conclude that different cities behavior are not motivated by economic or demographic factors. Actually, the main factor for the development of a smart city is the will of local authorities, followed by the presence near the city of universities, technology centers or great companies that work on IT for cities.

7 Limitations and Future Work

It is required to indicate as main limitations of this work that it is based on public information sources and its timeframe. We have to take into account that the fieldwork took held between June and November 2013, but the smart cities continue advancing quickly, so data and results might change in the future.

Overcome the information and time limitations developing a public database with the evolution of public services provided with innovative ICT in the Spanish smart cities is one of the future work outlined. A comparative analysis between Spanish and international smart cities could also be interesting. Additionally, we plan to study the variables that affect the development of smart cities.

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