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The diffusion of public eServices in European cities

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ABSTRACT

Using a novel dataset on the diffusion of public eServices at the city level in EU 15, this paper contributes to extant empirical literature in three ways. First, it extends the coverage of public eServices beyond eGovernment, investigating four service categories: Infomobility, eProcurement, eGovernment and eHealth. Second, it provides information for both a cross-country and cross-municipality comparison. Third, on the methodological side, it also extends the literature on composite indicators at a municipal level. Cities exhibiting the highest diffusion of public eServices are found to be medium-large, highly endowed with well-educated human capital, and characterised by a lively industrial atmosphere favoured by a reasonable number and variety of production and service activities. The relative performance of the European cities helps identify plausible directions to be taken for policies aimed at favouring the diffusion of public service innovation in Europe.

1. Introduction

The digital revolution has been deeply affecting the functioning and performances of public organizations over the past three decades, and has contributed to the emergence of path-breaking theories on the transformation of the public sector. In particular, ICT diffusion is quite instrumental to the widespread penetration of the New Public Management approach (Osborne & Gaebler, 1992; Osborne & Plastrik, 2000), which has long emphasized the dismantling of the Weberian model in favour of new managerial practices to improve public sector performance. Also public value theories (Moore, 1995) have paid increasing attention to the adoption of web-based technologies as they allow greater empowerment of users in the introduction of new public services, and favour bottom-up public sector innovations and network governance modes (Ansell & Torfing, 2014; Hartley, Sørensen, & Torfing, 2013).

Consistent with this increasing concern for ICT diffusion in the public sector, a relatively large number of empirical works have produced evidence on the development of new digitalised public services using a variety of methods (Arduini & Zanfei, 2014; Wirtz & Daiser, 2016). Nevertheless, comparative studies across and within countries are still facing substantial data limitations and are largely based on surveys and benchmarking analyses.

Two research gaps can be observed in extant empirical literature. First, previous studies have so far devoted most attention to a relatively narrow set of eServices, falling under the general label of "eGovernment", while much scantier attention has been devoted to services that respond more directly to users' needs, including inter alia eHealth, eTransportation/Infomobility, and eProcurement.[1] This implies a limited understanding of the actual and potential impact of new technology on the provision of frequently used services affecting every-day's life of individuals, of households and of companies.

Second, current research on digitalized public services does account for some heterogeneity, but this is mostly captured at the national level, while subnational differences are more rarely considered, mainly due to lack of reliable evidence. Once again, this is an important limitation, as a number of public sector decisions are increasingly decentralized and entail some degree of involvement of citizens at the local, and particularly at the city level (Heeks, 2006); and lower levels of government often exhibit a higher propensity to undertake organisational and technological change (Paquet & Roy, 2000). This paper contributes to filling these gaps in the literature on innovation in the public sector. On the one hand, the analysis is extended to explore a larger set of eServices, including some that are highly requested to satisfy every-day's life user needs. On the other hand, by adopting a subnational perspective, the paper helps identify local specificities in public eService diffusion. This

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[1] Other key service categories directly responding to users' needs, falling beyond the scope of this paper, include eEducation, eSecurity, eDemocracy and online availability of administrative data.

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should provide a useful guidance to the design of public policies, going beyond "one for all" solutions, which might be inappropriate for different areas within countries, and eventually lead to wasteful and ineffective allocation of resources for the development of digital society.

In particular, we present a detailed quantitative evidence on web-based services availability for 15 EU member countries, collected, at the local level and carried out in April 2013 (EIBURS-TAIPS database). Based on the data collected, we compute a Composite Indicator (CI), capturing the availability of individual public eServices categories at the national and subnational level.

In addition, economic and social variables, associated with the development of public eServices, at subnational level, are identified by using principal component analysis. Cluster analysis is carried out to single out groups of homogeneous cities and to allow a comparison across and within each group of cities on the basis of different levels of public eService development.

This exercise will allow to draw a detailed picture of public eService diffusion at a certain point in time, and will provide a support to policy makers for the evaluation of gaps to be filled in and for future planning.

The structure of the paper is the following. Section 2 briefly surveys extant empirical literature on public eService diffusion. Section 3 presents the data and the methodology adopted to compute the CI index. Section 4 illustrates the evidence on public eService diffusion based on the CI index at national and municipal level, and highlights structural and socio-economic characteristics of EU municipalities that are associated with such diffusion. Section 5 concludes.

2. Background empirical literature

Extant empirical literature on public services appears to be characterised by two main drawbacks: (a) low coverage of public eService categories other than eGovernment; (b) low albeit increasing level of geographical disaggregation of data on the diffusion of public eServices.

As far as service variety is concerned, empirical research in this field has mainly examined the diffusion of eGovernment identified with the digitalization of a relatively narrow set of public services. In fact, the main focus of most studies in this domain is on public eServices that generally fall in the following macro-categories: services generating income to the government (taxation, social contributions, customs); registration services (ownership, birth, marriage, mobility and mortality data); permits and licences (permissions for buildings and use of territory, implementation of regulations, passports, diplomas).[2] This per se corresponds to a narrow definition on the concept of eGovernment, which has prevailed in empirical and conceptual studies (Arduini & Zanfei, 2014; Bannister & Connolly, 2015; Zhang, Xu, & Xiao, 2014).[3] A few other service categories have received systematic attention as in the case of eProcurement (Cattaneo, Lifonti, Aguzzi, Bardellini, & Sadee, 2013; Huntgeburth, Parasie, Steininger, & Veit, 2012; Nurmandi & Sunhyuk, 2015), which has in fact been included as a minor subset of eGovernment activities by Capgemini in its periodic monitoring of digital services. By contrast, the consideration of other public eServices is scantier, as in the case of Infomobility (Yatskiv, Kopytov, & Case, 2013), and of eHealth (Hyppönen et al., 2013).

The second limitation in extant literature is that studies generally focus on country level data with limited or no subnational details. Comparative studies on different categories of public eServices as well as subnational details are normally circumscribed to individual countries. See for example Homburg (2013) for the diffusion of personalized eServices in Netherlands; Reggi, Arduini, Biagetti, and Zanfei (2014) for an analysis of regional performance in the diffusion of four categories of public eServices in Italy; Reddick (2004, 2009) for eService availability in US municipalities; Gilbert, Balestrini, and Littleboy (2004) for the case of British municipalities; Engström, Salehi-Sangari, and Wallström (2008) for Swedish municipalities; Huntgeburth et al. (2012) for German municipalities. Indeed, there have been attempts to overcome both limitations – low coverage of service variety and low geographical details – yielding some interesting, although not easily comparable, results. Bertelsmann Foundation (2002) proposed a balanced eGovernment index on three service categories: eDemocracy, eAdministration and eServices, contemporarily analyzed in the US, Canada and Europe at both national and local level. However, this attempt is based on information collected through case studies (60 online portals) and illustrates best practices rather than the general state of affairs.

Since 2003, the National Center for Public Performance at Rutgers University has provided a worldwide comparative analysis at the municipal level (Holzer & Manoharan, 2016). The delivery of eServices, citizen participation, together with the degree of security and usability are assessed through the evaluation of the largest cities websites (around 80) of the 98 countries ranked highest in the percentage of internet user. While this study provides a very rich set of longitudinal data on internet based public governance, its main use has been to construct a ranking of the top urban and metropolitan areas in the world, which largely coincide with capital cities. Unfortunately, this data source offers very limited details on the nature and characteristics of services provided through their official websites.

Pina, Torres, and Royo (2009) produce a benchmark to examine internet usage in the governance of sub national institutions- at the regional and local level- for 15 EU countries. Through a website analysis, transparency, interactivity, usability and website maturity are assessed for 319 entities, but the focus is exclusively on eGovernment.

European Commission promoted surveys allow to compare the availability of public eServices that loosely relate to eGovernment, including public procurement, with some limited subnational focus and with details on the degree of sophistication in their provision (Capgemini, 2012; Capgemini, Rand Europe, Idc,Sogeti & Dti, 2019). While these surveys do provide valuable information on the relative position of countries in eService delivery, they shed very little light on the socio-economic conditions underlying the diffusion of these services.

A few surveys do provide broad pictures of both demand and supply-side characteristics affecting eService diffusion at the country level. This is for instance the case of analyses carried out on a regular basis by Brown University[4] since 2000, which have offered a ranking of 198 countries based on eGovernment performance according to information availability, number and types of services delivered, and access rates by different categories of users. In a similar vein, Accenture,[5] since 2001, has been scrutinizing 22 countries (distributed in North America, Europe and Asia), accompanying the assessment of online service availability with indicators of service sophistication, and of citizens' participation and satisfaction.

Nevertheless, while these studies do offer sweeping overviews of global patterns of public eService delivery and of the structural conditions favouring or impeding their diffusion at the national level, they can hardly capture diversities within countries and the variety of services offered.

In summary, empirical research has more and more extensively assessed the development of digitalised services by public

[2] See CapGemini (2010a, p 35)

[3] The World Bank adopts a broader definition of eGovernment as the use by the government of information technologies (such as Wide Area Networks, the Internet and mobile computing) for different ends: "better delivery of government services to citizens, improved interactions with business and industry, citizen empowerment through access to information, or more efficient government management". Accordingly, eGovernment would cover mainly three dimensions (Mahmood, 2013, p.103): eDemocracy, eAdministration and eServices.

[4] http://www.insidepolitics.org/egovtdata.html

[5] https://www.accenture.com/us-en/insights/public-service/government-as-a-platform

administrations. However, the more data are comparable across countries, the less the details on services delivered and on subnational patterns of diffusion. Quite symmetrically, in-depth analyses of web-based service provision and of the socio-economic conditions underlying their diffusion can hardly be conducted in comparative terms. The ensuing empirical analysis is an attempt to overcome this trade-off that has so far impeded to capture the heterogeneity of this phenomenon, shedding more light on the national and subnational patterns of digital innovation diffusion without missing details in the variety of public eServices provided.

3. Data and methodology

This study combines the EIBURS-TAIPS Dataset (University of Urbino, Italy) on public eServices available in the largest municipalities of EU15 member countries, with Eurostat Cities Database (formerly Urban Audit) Dataset on structural and socioeconomic characteristics of the top cities in Europe.

The former dataset measures the degree of implementation and sophistication of public internet based services identified by exploring the websites of local governments. Manual web-scraping has been carried out in April 2013 by the EIBURS-TAIPS team of researchers using the criteria described below, in order to identify eServices and their degree of sophistication.[6] The resulting dataset covers four service categories (see Table A1-A4): Infomobility, eHealth, eProcurement and eGovernment characterised according to standard classification methodologies adopted in previous surveys which have been conducted separately on these service domains.

As for *eGovernment* we rely on the methodology used to conduct EU eGovernment surveys. These yearly basis surveys, started in 2001, take into account 20 public services, delivered mainly at the national level By considering a standard taxonomy of municipal functions, we consider a subsample of nine services (see Table A.1) targeted to both individuals and enterprises.[7] Following Capgemini et al., (2010a), the availability (online presence) and the sophistication level (using a 4/5-stage model),[8] specific for each service (see Table B.1), are analyzed.

Following the methodology introduced by Deloitte and Ipsos Belgium (2011), we extend the coverage of our analysis to a key service area only marginally covered by surveys on eGovernment, i.e. *eHealth*, whose importance is growing given the aging of European population. In particular, we measure and explain levels of availability of eHealth applications and services in public hospitals via 8 out of the 13 original indicators (Table A.2.) covering three main fields: electronic health records, health information exchange, teleHealth.[9] Differently from the Deloitte & Ipsos Belgium approach, we focus on public general hospitals (excluding specialized clinics) and we collect the data by means of manual web surfing (and not through Computer Aided Telephone Interviewing).

In line with the EU emphasis on sustainable development, we also cover *Infomobility* services and extend the approach adopted by DigitPA (2011), for Italian main cities. Data are collected on digitalization of services supplied by public transportation carriers to their end users as well as web-based services offered by public entities to users of private transportation systems (Table A.1).

A further service category taken into account is *eProcurement* here treated as a separate bundle of public sector activities, different from Capgemini et al., (2010a) which has traditionally considered this service domain as a subset of eGovernment. Three main aspects are scrutinized (Table A.3.): the level of visibility, the pre-award services (eNotification, eSubmission, eAwarding) and post-award services (eOrdering, eInvoicing and ePayment).

As geographical unit of observation of eService diffusion, we identify a sample of 229[10] cities in EU15 member states, representing a subset of the 322 cities monitored by Eurostat Cities (formerly Urban Audit) Database. In the case of eHealth the sample size exceeds 229, as data are collected for a total of 274 public hospitals. In fact, three public hospitals instead of one are observed for capital cities in each country.[11]

4. eServices: an index to measure public sector performance at the municipality level

To provide a ranking of European municipalities, based on public eService development across different domains, following Reggi et al. (2014), a synthetic indicator of public eService development is proposed. This is calculated as the average performance of each city in the four service domains (eGovernment, eHealth, Infomobility and eProcurement).

The availability is expressed as a dummy (1 when the service is delivered, 0 otherwise) and quality of eServices provided is expressed as weights increasing with quality indicators as specified below. For each service domain, an index is computed as a normalized weighted average of the services considered, to ensure the comparability of the scores of each city across the four domains. Specific weights are assigned to position services under observation in the quality scale.[12] In particular, each service included in the eGovernment category is evaluated according to its level of "sophistication" (0, 1, 2, 3, 4 or 5, where 0 equals to no interactivity and 5 equals the highest interactivity), assuming that each quality level is associated to a 20% incremental weight. Each of the three phases characterizing eProcurement (visibility, pre-award and post-award), is assigned the same weight and thus equally participates to average performance of cities and countries in this service domain. Multiple correspondence analysis, especially suited for categorical variables (Asselin, 2009), is used to compute the eHealth index combining data collected on the 9 service indicators identified according to the Deloitte&Ipsos methodology. Non-linear principal component analysis is used for the two sub-indexes: Public informed mobility and Private informed mobility and the Infomobility index is then obtained as the result of the average of the two aforementioned components.

[6] To ensure the good quality of the analysis and to minimize errors in datamining, each platform has been analyzed twice: by a research assistant and a senior researcher. Besides, before starting the analysis and to guide the two observers, on the base of the platform to be assessed, a sort of vademecum, defining the services (Table A1) and the level of analysis (availability, quality and interactivity: Table B1-2) have been designed.

[7] Differences in the distribution of powers among government levels do not assure that all nine services are provided at the municipal level in all countries.

[8] The five stages considered are: information, one-way interaction, two-way interaction, transaction, and targetization. The fourth and fifth levels can be considered expressions of a full development of the service online.

[9] Given our focus on services, the other five indicators originally monitored by the Deloitte&Ipsos survey are neglected as they mainly refer to infrastructural aspects.

[10] The sample is consistent with the overall statistical representiveness criteria adopted by Eurostat to carry out data collection for the Cities Dataset: 1- the coverage of approximately 20% of the national population, 2-correspondence with geographic distribution within the country (peripheral, central) and 3-correspondence with the size distribution of cities within the country(both medium and large sized towns).

[11] For capital cities, given the high numbers of hospitals, the selection is based, on the "World Hospitals' ranking on the Web" (http://hospitals.webometrics.info/en/Methodology).

[12] Proxies of service quality are used for eGovernment, in terms of interactivity levels (Table B.1), and in terms of presence or absence of specific service features or phases in the cases of Infomobility and eProcurement (Table B.2). Quality levels are not measured in the case of eHealth as a hierarchy across services is not generally acknowledged in this service domain.

Table 1
eServices diffusion in EU macro regions.

	Overall Index	eGovernment	Infomobility	eHealth	eProcurement
Northern countries	*0,62*	*0,76*	*0,58*	*0,35*	*0,78*
IE	0,56	0,68	0,53	0,16	0,88
UK	0,62	0,82	0,48	0,42	0,75
SE	0,70	0,88	0,77	0,32	0,83
DK	0,80	0,77	0,71	0,79	0,91
FI	0,42	0,65	0,44	0,08	0,53
Central countries	*0,48*	*0,59*	*0,57*	*0,12*	*0,66*
BE	0,38	0,49	0,65	0,13	0,27
FR	0,47	0,47	0,43	0,16	0,80
AT	0,49	0,56	0,55	0,20	0,65
LU	0,56	0,60	0,74	0,00	0,88
DE	0,44	0,49	0,62	0,06	0,59
NL	0,57	0,91	0,44	0,16	0,75
South countries	*0,36*	*0,50*	*0,30*	*0,14*	*0,51*
EL	0,21	0,29	0,23	0,09	0,23
ES	0,45	0,74	0,37	0,15	0,52
IT	0,40	0,61	0,36	0,16	0,49
PT	0,39	0,36	0,27	0,14	0,80
EU15	0.48	0,62	0,47	0,19	0,64

Source: Authors' elaborations on EIBURS-TAIPS Dataset.

4.1. Heterogeneity across and within countries: a comparison based on a synthetic index

A high degree of heterogeneity can be observed when looking at the diffusion of eServices in Europe. Here the Composite Indicator is calculated for all eService categories, as a mean of all weighted scores of municipalities aggregated at the country level for each of the EU15 member states (see Table 1).

The standard core-periphery hierarchy is confirmed in the public eService domain. Northern countries exhibit the highest level of eService development, generally scoring higher than the EU15 average (0.48), with the only exception of Finland (0.42). There is indeed a high variability within this group of countries as well, with Denmark (0.8) and Sweden (0.7) performing much better than the UK (0.62), Ireland (0.56), and of course Finland (0.42). Mediterranean countries instead systematically score below the EU15 average (Greece: 0.21; Portugal: 0.39; Italy: 0.40; Spain: 0.45), with a substantial difference between the lower bound represented by Greece and partially by Portugal, and better performing countries (Italy and Spain) with the latter exhibiting an eService diffusion rate closer to EU15 average. Central European countries score in between the two other groups of EU member states, some performing above the EU15 average (Austria: 0.49; Luxembourg: 0.56 and Netherland: 0.57) and some slightly below (Germany 0.44 and France: 0.47).

In particular, by replicating the analysis for each single eService category, the panorama becomes even more articulated. While Sweden and Denmark are best performers in almost all services, United Kingdom, although always above the EU15 average figures, is less performing in eProcurement and Infomobility.

Among the Northern countries, the profile of the weakest countries, Ireland and Finland, is quite variegated. Ireland, in fact, with 3 out of 4 services, above the EU average, is particularly well performing in eProcurement, while Finland, with only one service (eGovernment) above the EU average, is among the worst performing in eHealth.

Among the Mediterranean countries, generally characterised by a poor performance in most eServices, Spain and Portugal show excellent values of the index respectively in eGovernment (Spain: 0.74) and eProcurement (Portugal: 0.8).

Central European countries also exhibit quite heterogeneous patterns of specialisation. Indeed, if the Netherlands is the absolute best performer among European countries in the eGovernment domain (0.9), Luxembourg is among the best performers in the domains of Infomobility and eProcurement.

In general, data on the four eService domains confirm a large diffusion of eProcurement (0.64) and eGovernment (0.62), followed by Infomobility (0.47). This result is interesting as it supports the idea that eServices are more diffused in the domains in which the influence of national policy and supranational coordination is more substantial. Considering the intense coordination activity promoted at the EU level for eGovernment (European eGovernment action plans) and eProcurement diffusion, our results are perfectly in line with the administrative innovation policy literature. Indeed, the faster pace of adoption of these eServices may well reflect the combination of different innovation diffusion factors (Berry & Berry, 1999). On the one hand, it is the result of "mandate factors", i.e. national and supra-national directives and top-down governmental initiatives concerning technological, managerial and organisational standards to be adopted in these domains. On the other hand, it is the outcome of "competitive and learning factors", generating pressures for change in obsolete practices and for imitation of leading national experiences and best practices.

Table 2
Variances: Between and within.

	eGovernment	eProcurement	eHealth	Infomobility	Index
			Within Variance		
AT	0,01	0,05	0,08	0,01	0,01
BE	0,00	0,02	0,05	0,05	0,01
DE	0,01	0,04	0,02	0,04	0,01
DK	0,00	0,01	0,00	0,06	0,00
EL	0,02	0,03	0,01	0,02	0,00
ES	0,03	0,02	0,04	0,03	0,01
FI	0,03	0,05	0,01	0,03	0,01
FR	0,02	0,02	0,03	0,04	0,01
IE	0,01	0,00	0,05	0,00	0,00
IT	0,03	0,02	0,06	0,06	0,02
LU	0,00	0,00	0,00	0,00	
NL	0,00	0,03	0,03	0,03	0,01
PT	0,01	0,05	0,03	0,01	0,01
SE	0,00	0,01	0,13	0,01	0,01
UK	0,03	0,04	0,08	0,02	0,02
			Average Within Variance		
EU15	0,01	0,03	0,05	0,03	0,01
			Between Variance		
EU15	0,03	0,05	0,04	0,03	0,02

Source: Authors' elaborations on EIBURS-TAIPS Dataset.

Table 2 sheds some further light on the heterogeneous patterns of eService development in Europe, by highlighting the variance in eService availability within countries (i.e. across cities belonging to the same country) and between countries (i.e. across countries whose eService availability is obtained by aggregating data collected at the city level).

The dispersion is on average not very high within countries (0.01 when all EU15 countries are considered) and it is lower than between countries (0.02). The low variability within EU15 countries (considered on average) partly reflects the fact that, very small cities are excluded from the Eurostat Cities (formerly Urban Audit) database. By disregarding small cities and towns, heterogeneity within countries is substantially reduced especially in the case of those countries in which the share of national population in small size municipalities is particularly high.

Nevertheless, substantial differences emerge when specific countries and specific services are considered.

First, *on average* within country dispersion is much higher in some EU member states than in others, with Italy and the UK exhibiting the highest within country heterogeneity, while Denmark and Greece exhibit the lowest dispersion. Second, the within country dispersion is very high for some services, as in the case of eProcurement and eHealth, while it is relatively tiny in the case of eGovernment. The latter result is consistent with the fact that eGovernment has a relatively longer history of implementation, best practices have by now diffused across countries, and most cities have by now moved in the direction of providing at least part of their general government activities online. This finding further reinforces our argument that focusing only (or mainly) on eGovernment, disregarding other eService domains, does not permit to capture a very substantial part of heterogeneity both across and within countries.

Municipalities: a comparison across homogenous clusters

Spatial correlation and heterogeneity (within and between countries) introduce substantial complexities in comparative analysis. The solution proposed here is a three-step approach:

1. to identify a few "summary variables" (components) that can be held to be representative of different aspects of municipalities, drawing data from Eurostat Cities (formerly Urban Audit), by using principal component analysis (PCA);
2. to identify the clusters of municipalities based on the components mentioned above;
3. to proceed in making the comparative analysis, based on the availability and sophistication of eServices, at cluster level.

The aim of this procedure is to identify homogenous groups of European cities, regardless of the country they belong to, and to check how such clusters are characterised in terms of eService availability. Then after having pointed out the cluster of best performers, their structural and socio-economic variables allow to understand better the determinants of eServices development.

4.1.1. First step: identification of the variables for the PCA

To investigate differences in eService availability across clusters of comparable cities, we proceed to identify specific features according to which municipalities can be grouped. We particularly focus on distinctive characteristics of cities discussed in two main strands of literature, which have addressed respectively: 1- the adoption of innovation and, in particular, of public innovation at the city level (Bianchi, Marin, & Zanfei, 2018; Djellal, Gallouj, & Miles, 2013; Kankanhalli, Zuiderwijk, & Tayi, 2017; Simon & Nardinelli, 2002); 2- urban growth and urban smartness (Caragliu & Del Bo, 2012; Caragliu, Del Bo, & Nijkamp, 2011).

Drawing from these streams of contributions and relying on the available data (Eurostat Cities, formerly Urban Audit Database), we consider variables reflecting the following five main municipal aspects: the size and density of urban areas, their industrial structure, their financial and human capital endowments, social constraints and facilitators to (digital) innovation, and infrastructural development.

As for the *size and density of Municipalities*, we consider the *Number of inhabitants* in a given municipality and *Total resident population by square km*. These indicators may well capture factors affecting innovation on both the demand and the supply side. On the demand side, large cities are likely to be characterised by stronger pressures from well-organized users of new technology and services (Ho & Ni, 2004). This is especially true when geographic concentration of population can favour information exchanges and imitation among users. Such influence on collective behaviour facilitate large-scale adoption of innovation (Choudrie, Weerakkody, & Jones, 2005). On the supply side, the size of the municipality is associated with greater endowments of skills and capacities on the supply side (Norris & Moon, 2005). The larger the municipalities, the larger the availability of resources for innovation projects, hence the greater the likelihood that large-scale innovation is undertaken.

The most credited factor positively affecting innovation based on the Schumpeterian legacy is then *Industrial structure*. A potentially relevant, albeit rough, indicator in this respect is represented by the *Number of active firms*. More qualitative indicators of the composition of manufacturing and service activities in the local economy are also included: *Number of persons employed in provision of ICT services*, *Share of employment in financial and business services* -NACE Rev.1.1 J-K. An indirect measure of how advanced industry structure is might be the attention paid by the municipality to environmental issues, proxied by *Annual amount of solid waste (domestic and commercial) that is recycled*. This indicator helps capture how "green" the culture of a local production system is, which is inter alia one of the alleged key elements of "city smartness", and can be expected to positively affect innovation.

Then, we use the *Gross Domestic Product per inhabitant* in PPS as a measure of how rich the city is, and hence as a proxy of *Financial resources* available. We also introduce the Share of qualified workers (*working age population qualified at level 5 or 6 ISCED*), and the Share of low educated population (*Persons aged 25–64 with ISCED level 01 or 02 as the highest level of education*) as different socio-economic indicators of the composition of working population, representative of *Human capital at the municipality level*. Indeed, the literature supports the idea that a poor budget[13] and unskilled citizens,[14] translate into low quality users and suppliers of services, and this may impede or slow down the innovation process and constrain urban growth (Azad, Faraj, & Goh, 2010; Berry & Glaeser, 2005; Simon & Nardinelli, 2002).

We also consider some variables capturing the *Social constraints and facilitators to (digital) innovation*. On the negative side, we include two indicators that are the core of digital divide: the share of elderly population (*Persons over 65*) and the unemployed working age people (*Unemployment rate*). These indicators of course complement (on the negative side) measures of financial and human capital and of the composition of manufacturing and service industry. Among the potential facilitators of innovation, the literature on Smart cities has emphasized the role of participation to local democratic processes (Giffinger et al., 2007), here proxied by the *Participation rate at city elections*, and by the *Number of female elected as city representatives*, which can be expected to have some impact to innovation in decision-making and governance.

Finally, measures of *Infrastructural development* are introduced, including indicators such as the *Length of public transport network/land area* and the *Percentage of households with Internet* (Caragliu & Del Bo, 2012). Infrastructural development plays a leading role both in the literature on urban and regional growth (particularly the first variable) and in the one on eGovernment diffusion and adoption (UN Public Administration Programme, 2011). A relatively "soft" component of infrastructural development is represented by tourist accommodation capacity, as measured by *Total annual tourist overnight stays in registered accommodation*. The accommodation capacity of a municipality

[13] See in particular Moon, Welch, and Wong (2005); Singh, Das, and Joseph (2007); WEF (2010).

[14] According to Wood (2006), higher skilled population, especially if involved in knowledge-intensive services, can be expected to positively affect urban performance, being able to create new knowledge and to use more creatively existing technology.

represents a powerful attractor for tourist flows, which in turn may impact on the use of web based services and determines a pressure on city mobility (Narayan, Narayan, Prasad, & Prasad, 2010; Rosentraub & Joo, 2009). Furthermore, greater tourist activities imply a greater probability of having a website by a municipality (Dang Nguyen, Dejean, & Souquet, 2013).

A principal component analysis, computed on the aforementioned variables, is then applied. The usual preliminary check of the relation cases to variables[15] (at least 5 to 1) and the existence of substantial correlations (positive and higher than 0.3) among the variables have been considered. We proceed through several rounds in deleting variables either if they do not respect the KMO Measure of Sampling Adequacy for each variable[16] (> 0.5), or if they show a low communality[17] or if their factor loadings reveal a complex structure.[18] At the end of this process, 6 variables are selected. Because of missing data among those variable we end up with 164 observations out of the initial 229.[19] A single component (eigenvalues greater than 1.0), explaining 85.5% of the total variance is then extracted. The significance of the Bartlett Test and the sample adequacy with the KMO test (equal to 0.83) assure the correctness of the process. We repeat then the analysis by splitting the sample randomly into two halves and computing the principal component analysis in each half again. The validation process confirms the results previously presented. Although we observe the presence of outliers[20] (cases with a factor score larger than ±3.0), they do not affect the results obtained. Indeed, the PCA, computed by excluding those cases, confirms the pattern of communalities and the factor loadings found for the full dataset.

The PCA helps identify the key variables associated with public eService development, factors that were expected in the literature to positively affect innovation, such as: the size of municipalities (Population), the activity rate of manufacturing and service industries (Number of companies), and our (rough) indicator of attractiveness of the local area (Tourists overnight); as well as some clear inhibitors of (digital) innovation, such as the share of elderly population (Over 65) and of low qualified working age population (ISCED level 0, 1 or 2).

4.1.2. *Clusters identification*

As our primary target is to find homogenous groups of municipalities, based on the factor score, we use cluster analysis to identify groups of municipalities highly similar within each group but contemporarily highly dissimilar across clusters. We compare then the results coming from a hierarchical[21] and non-hierarchical (k-means) clustering method. By adopting the Calinksi and Harabasz index[22] (and the Duda and Hart index for the hierarchical method), as formal stopping rule, we observe that both rules point to 7 groups as the best clustering for the two methods.[23] We then proceed by observing the results of the two methods. Although the partition is not completely different, the hierarchical method generates clusters quite disproportionate in size,[24] so we adopt the K-means partition. In general, the seven groups show different sizes. We consider the factor score as a measure of development, with score increasing with improvements in the combination of innovation enhancers (e.g. industry structure, municipality size and area attractiveness) with innovation inhibitors (e.g. elderly people and low qualified working age population). (see Table 3a) From this perspective, one can easily characterise two very different clusters that clearly stand out at the two extremes in terms of presence of innovation enhancers and inhibitors. At one extreme one can observe the cluster which we identify as *"Lagging behind municipalities"* (medium size, least industrialized and poorest municipalities). At the opposite extreme, one can identify the cluster of *European big capitals*, collecting cities where national government bodies are located but, unlike other capital cities are

Table 3a
Differences among clusters: factor score vs eService diffusion index(CI).

	Factor score	CI
Lagging behind municipalities	−0.5	0.40
Medium size municipalities	−0.4	0.46
Lower income large municipalities	−0.1	0.46
Touristic, rich and large municipalities	0.3	0.53
Other capitals	0.9	0.51
Front runners	2.3	0.62
European big capitals	5.1	0.49

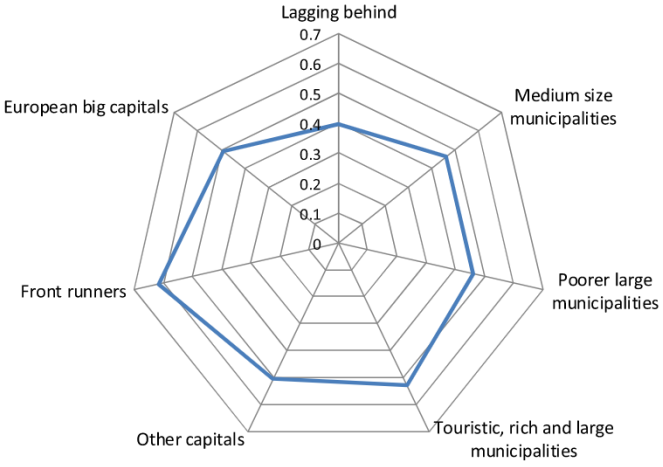

Fig. 1. eService index: comparing clusters.
Source: Authors' elaborations on EIBURS-TAIPS Dataset and on Eurostat Cities Database.

[15] At this stage, it was necessary to drop the variables, which cause the largest loss of observations: public transport networks and solid waste recycling. In this way, the number of total observations is 188 with a ratio case variable equal to 11.

[16] Working age population qualified at level 5 or 6 ISCED, proportion of local companies producing ICT, and unemployment rate are the variables dropped because the score on the anti-image correlations was too low.

[17] Communalities represent the proportion of the variance in the original variables that is accounted for by the factor solution. In the case of *Proportion of employment in financial services*, the factor solution explains only 0.047 of the original variable variance in respect of the optimum represented by at least half of each original variable's variance.

[18] Density has high loadings or correlations (0.40 or greater) on more than one component.

[19] The sample extracted from the universe of EU15 cities according to Eurostat Urban Audit criteria is sufficiently large, diversified and statistically representative to ensure consistent results. Moreover, as the analysis is oriented to ensure a comparison among clusters of cities sharing similar characteristics from a structural/demographic/economic point of view, the belonging of municipalities to a given cluster is independent of their positioning in a country or another.

[20] Paris, Berlin, Rome and Madrid represent the outliers in our sample.

[21] In this case, it is assumed the Euclidean distance, as a similarity measure, and the average linkage, as agglomeration method. According to Everitt, Landau, and Leese (2001) this method, as confirmed by many simulation studies, would be reasonably robust and less affected by problems that hamper other methods like chaining, sensitivity to outliers, reversal points.

[22] Two of the best stopping rules, see also Milligan and Cooper (1985).

[23] Results are available at request.

[24] Hierarchical size groups: 103, 37, 11, 5, 4, 2, 2. Kmean size groups: 54, 23, 16, 4, 4, 46, 17.

Table 3b
Front runners vs European big capitals: looking behind the factor score.

	Social constraint (% of pop. Above 65)	Infrastructural development (Tourists overnight)	Financial resources (GDP in pps)	Industrial structure (no. companies)	Demographic aspects (Population)	Human capital (%of pop. With ISCED 0–2)
Front runners	19.6	8,825,767.8	39,275.0	106,977.5	1,600,688.8	20.8
European big capitals	18.6	21,668,455.0	41,675.0	216,909.3	2,925,866.0	18.3

Note: each column represents the average value of the observed variable within the cluster.
Source: Authors' elaborations on Eurostat Cities Database.

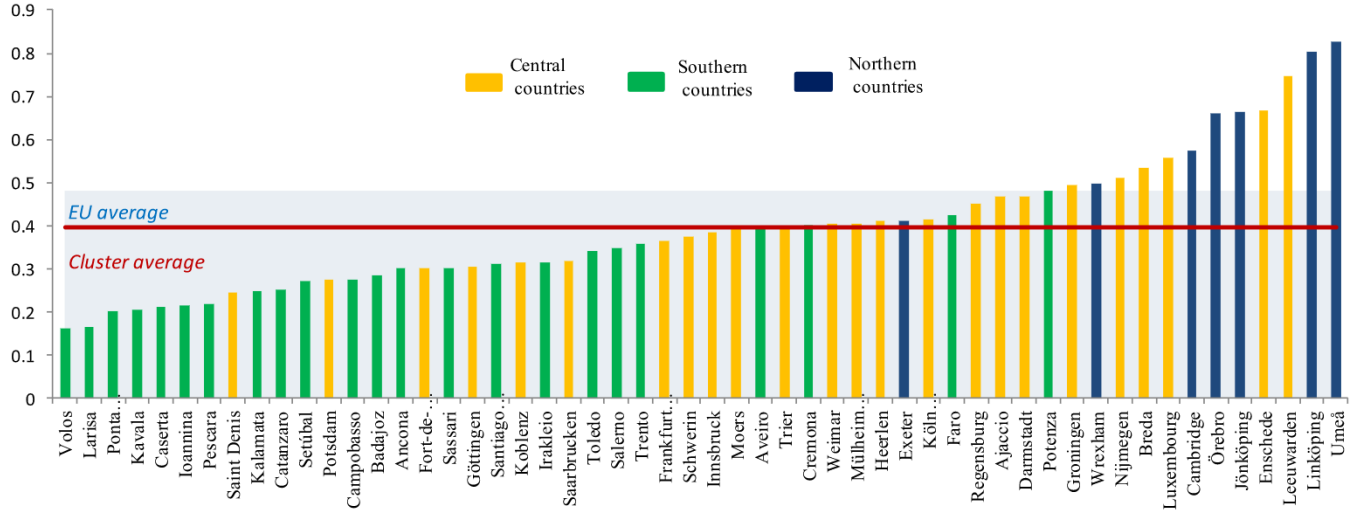

Fig. 2. eServices index distribution: *Lagging behind.*
Source: Authors' elaborations on EIBURS-TAIPS Dataset and on Eurostat Cities Database.

also characterised by a metropolitan extension and by a high presence of high innovation enhancers and low innovation inhibitors. The distinction across the other clusters is necessarily more nuanced, as they all exhibit different points of strength and weakness in terms of innovation potential.

We then proceeded to characterise each of the 7 clusters in terms of public eService performance, measured in terms of our composite indicator computed as described in section 4.1. The composite indicator of eService development is calculated for each cluster and compared to the average value of the same indicator computed for all EU15 countries. Contrary to the expectations, the highest score regarding eService diffusion (relative to EU15 average) is reached by the cluster of very large, rich and industrialized municipalities (*Front runners*) and not by the *European big capitals*. In other words, eService development does increase when moving from clusters at the lower bound towards the upper bound in terms of factor score, but this occurs in a non-linear way. Indeed, the average eService index by clusters (see Fig. 1) increases from the bottom level to upper clusters, identified by an increasing development/social complexity (factor score), it reaches its maximum in cluster of the *Front runners* and diminishes thereafter.

It thus appears that the combination of factors characterizing the cluster of the *European big capitals*, albeit consistent with an overall socio-economic and innovation performance that is the highest in EU15, does not guarantee a top performance in terms of public eService development.

Looking at the value of indicators characterizing the top clusters (exhibiting the highest factor score), i.e. *Front runners* and *European big capitals* (see Table 3b), Human Capital is the only enabling factor whose level is higher in the case of the former group of cities as compared to the latter. We suggest that this difference in the quality of Human Capital might help explain the better performance of *Front runners* in terms of eService development.[25] In the case of the *European big* capitals a discriminating factor is instead the average size of cities which seems to plays here as an inhibiting factort. These results confirm previous findings about the role of education in favouring web based innovation (Lee, Chang, & Berry, 2011, Seri et al., 2014). Adult literacy influences positively the eService diffusion by increasing the demand for innovation. Dang Nguyen et al. (2013) find a positive relation when considering total population, as a measure of municipalities' size. Our result builds on previous findings and suggests a non linear relation between eService development and the size of cities. This might have to do with the fact that the complexity of services and the level of coordination costs may significantly increase when cities expand beyond a manageable size. This aspect needs further investigation in future research.

4.1.3. *Services index: a cluster analysis*

Digging inside each cluster, we immediately notice that while eService performance is on average the lowest in the cluster of the *Lagging behind* (0,4 as compared to higher scores in the case of the other clusters, and an average score of 0.5 for EU15, see Fig. 2) the heterogeneity is highest within this cluster. Indeed, this cluster collects both the worst absolute performer (Volos) and the best absolute performer in Europe (Umeå). Twelve municipalities out of the 54 in this cluster exhibit an index larger than the EU15 average (6 of these are located in NL, 3 in SE and 2 in the UK, and one ia s small size Capital city (Luxembourg city)).

[25] The only other factor whose level is higher in the case of Front Runners as compared to European Big capitals is the percentage of population aged above 65 (labeled "Social constraint"), which is indeed an inhibitor of innovation adoption and thus cannot help explain why the former exhibit a better performance in terms of eService development.

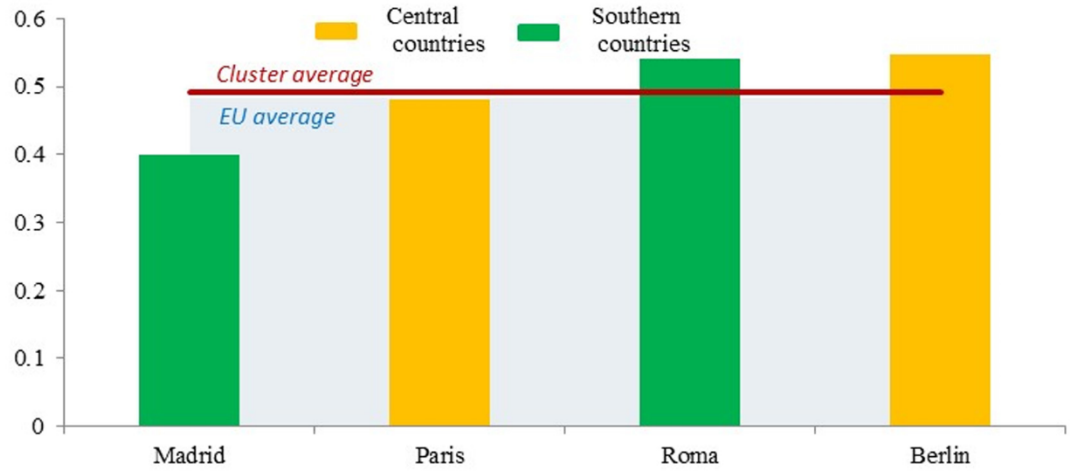

Fig. 3. eServices index distribution: *European big capitals.*
Source: Authors' elaborations on EIBURS-TAIPS Dataset and on Eurostat Cities Database.

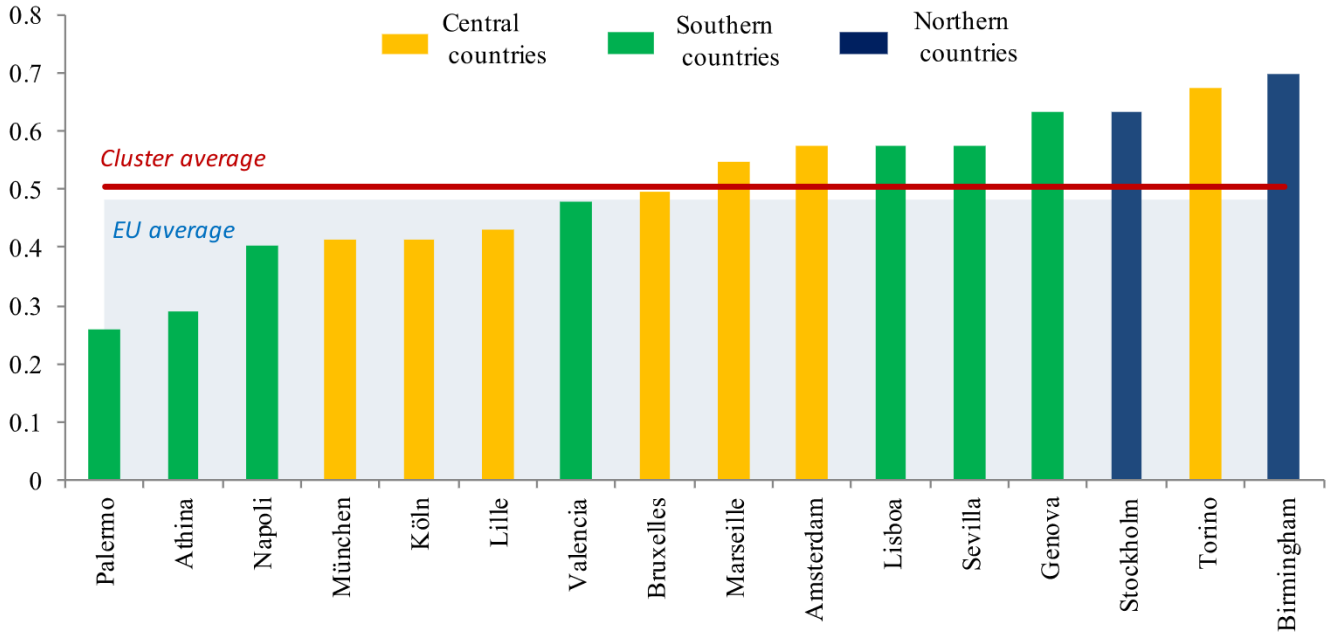

Fig. 4. eServices index distribution: *Other capitals.*
(Source: Authors' elaborations on EIBURS-TAIPS Dataset and on Eurostat Cities Database)

All the other municipalities, mainly coming from Mediterranean countries (IT: 10; ES: 3; EL: 6; PT: 4), have very poor performances.

On the other side of the clusters spectrum, the *European big capitals* cluster (Fig. 3), gathering Rome, Berlin, Paris, and Madrid,[26] includes a much lower number of cities, which exhibit quite similar performances in terms of eServices. Berlin appears as the most advanced (0.55), closely followed by Rome (0.54) while Madrid is the lowest performer (0.40), with an index below the EU-15 average and the cluster average (0.49).

The other European capitals are distributed between the clusters of the *Other capitals* (Fig. 4) and *Front the runners* (Fig. 5). In both cases, they are not the best performers in their groups, although they perform mostly above the EU average (except Athina: 0.29) and above their cluster average (except Bruxelles and Wien respectively). The best performers of these two clusters are instead Birmingham (0.70) and Milan (0.73) respectively. Hamburg and Palermo (0.26) are instead the correspondent lowest performers. The cluster of the *Front runners* is the only one with all municipalities exhibiting an eService index above the EU average.

The other clusters (Fig. 6–8) represent respectively the most industrialized among the medium-size municipalities, the poorest and the richest among the large municipalities. While the first two clusters are characterised by average indexes lower than the EU average, The cluster of the *Touristic, rich and large municipalities*, exhibits the second highest average index with 60% of its municipalities (10 out of 17).

5. Conclusions

Over the past decades, research on public sector evolution and

[26] London, Helsinki, København and Dublin are lost during the PCA process because of several missing values in the considered variables. This said, if they are considered as a separate cluster, all show index figures above the EU-15 average. In particular, København (0.86) and London (0.79) are really advanced.

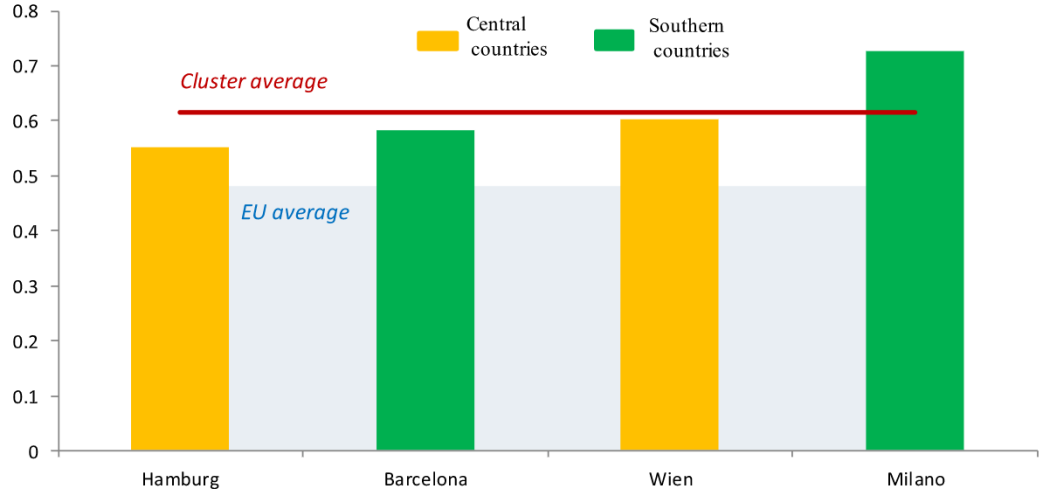

Fig. 5. eServices index distribution: *Front runners.*
Source: Authors' elaborations on EIBURS-TAIPS Dataset and on Eurostat Cities Database.

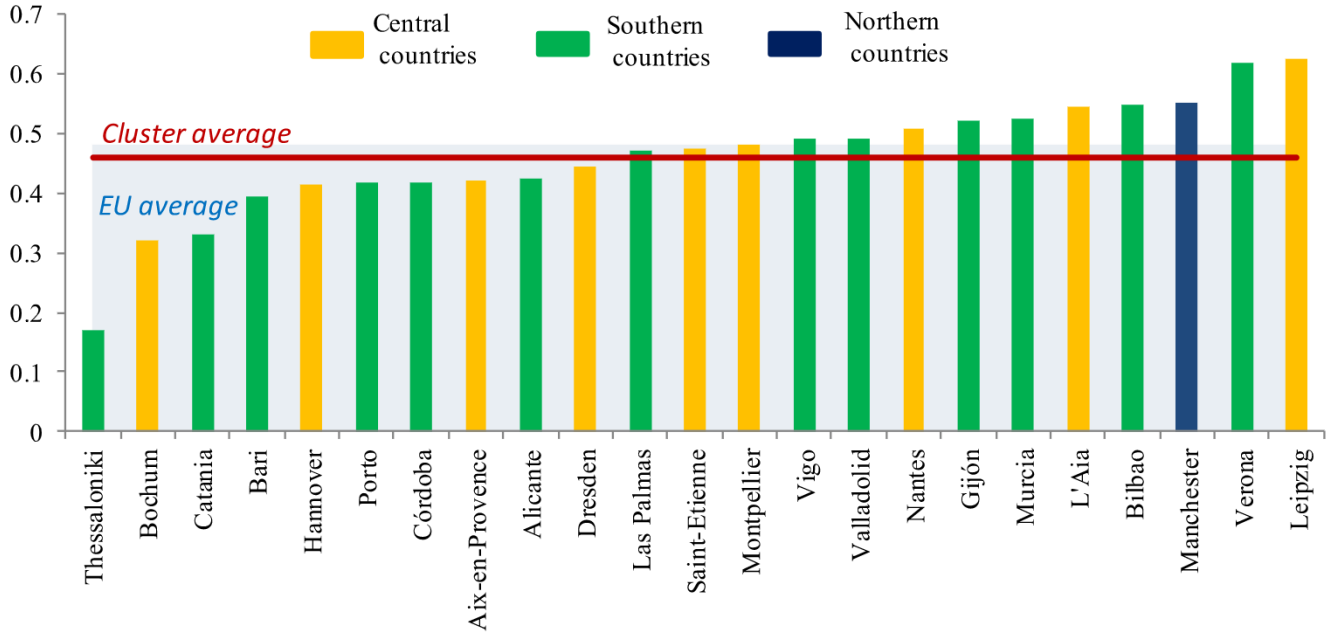

Fig. 6. eServices index distribution: *Medium size municipalities.*
Source: Authors' elaborations on EIBURS-TAIPS Dataset and on Eurostat Cities Database.

innovation has proceeded hand in hand with the diffusion of digital technologies. In this context, the development of web-based public services represents a further step in the process of transformation of public administrations, of increasing empowerment of users and of new value creation. Nevertheless, public sector entities are not equally well placed in the exploitation of opportunities opened up by digital technologies, and the development of public eServices is all but an easy task.

This article explores the diversity that exists in Europe in terms of web-based services. It contributes to fill two gaps in the empirical literature on innovation in the public sector: the scarsity of studies on the multidimensional nature of public eServices and the lack of attention to the subnational features of their diffusion. This study, based on an extensive web-surfing conducted at the city level, photographs the diffusion of eServices in four service categories: Infomobility, eHealth, eProcurement and eGovernment, for 15 EU member states. From a methodological perspective, in order to ensure the comparibility among homogenous units, it proposes a two step-approach based on two multivariate methods: a principal component analysis identifying the main factors out of a set of indicators, capturing the economic, demographic and structural characteristics of municipalities, and a cluster analysis grouping the municipalities on the base of those factors. Thanks to the clusterization, the eService diffusion can be scrutinized beyond the country and platform level, by opposing groups of economically and structurally similar municipalities.

The overall picture of Europe, which emerges, exhibits some rather usual traits in terms of broad aggregates of nations: Northern countries, although with exceptions, show a much higher rate of diffusion compared to the Southern countries, with Central European member states performing in between.

However, a substantial heterogeneity in the patterns of public eService development can be observed both across and within countries, especially when different service domains are explored. As expected, the "mandate, competition and learning factors" play a role in discriminating diffusion patterns across eService categories. The largest

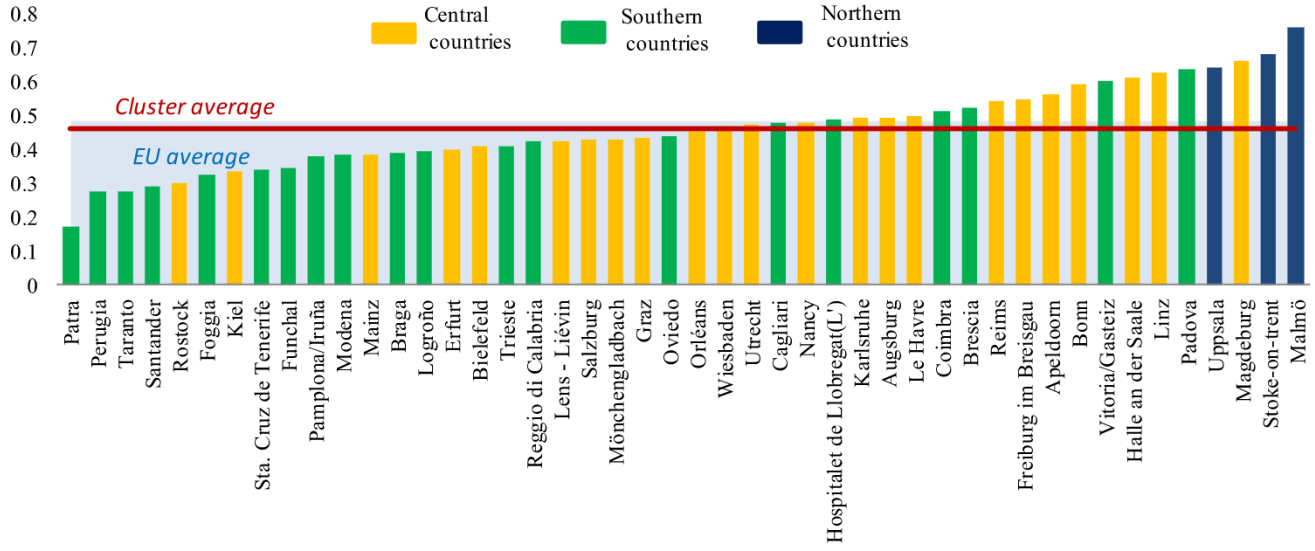

Fig. 7. eServices index distribution: *Lower income large municipalities.*
Source: Authors' elaborations on EIBURS-TAIPS Dataset and on Eurostat Cities Database.

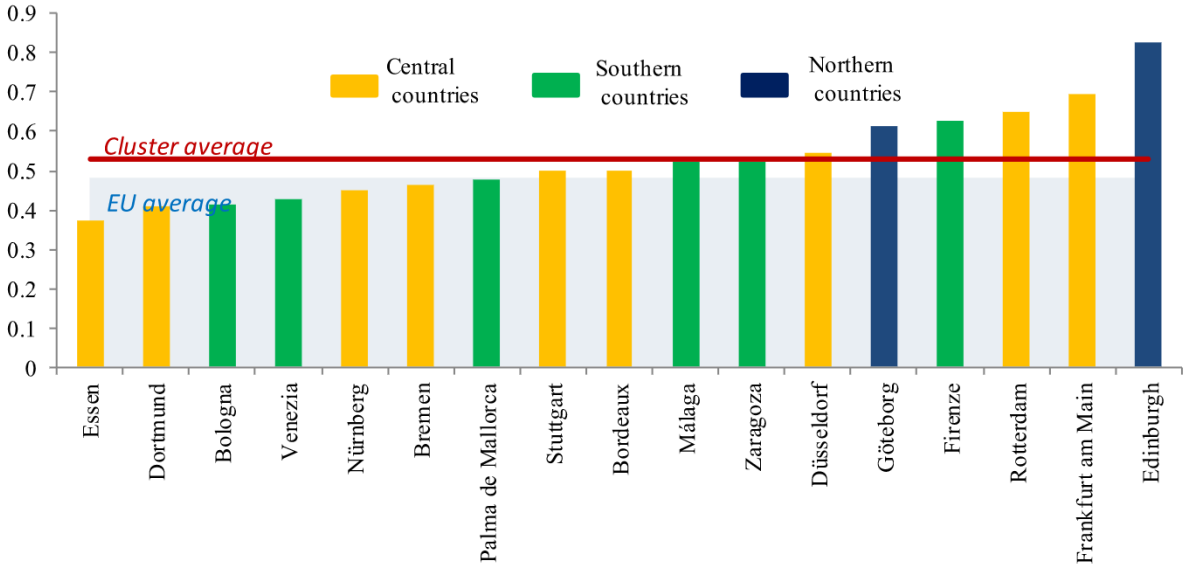

Fig. 8. eServices index distribution: *Touristic, rich and large municipalities.*
Source: Authors' elaborations on EIBURS-TAIPS Dataset and on Eurostat Cities Database.

diffusion is observed for the eServices where the coordination activity promoted at EU level was highest: eProcurement and eGovernment. closely followed by Infomobility, while eHealth scores less than one-third of the previous ones. Moreover, the largest share on heterogeneity across and within countries is observed in domains other than eGovernment, where more investments ought to be allocated.

The pratical implications of our analysis emerge better when moving to the municipal perspective. Our analysis helps identify the profile of cities that are best performers in this specific area, the municipalities mostly in need of improvements and a benchmark for each cluster group. A roughly sketched identikit of best performing cities includes a medium-large size in terms of population, a high endowment of qualified, well educated and trained human capital, and a lively industrial atmosphere favoured by a reasonable number and variety of production and service activities. By contrast, congestion and coordination problems associated with very large metropolitan areas and overcrowded industrial districts might generate more administrative problems than those that digital technologies may help tackle. For each cluster, a ranking by eService performance is possible. One can thus detect the municipalities where further improvements are needed, as well as the best performing ones, whose experience could represent a valid reference in order to support a quick catching up.

Although our analysis relies on data referring to eService availability at a given moment in time, it sheds light on diversity in the digitalization of government in Europe. Moreover, our dataset on public eServices, combined with Eurostat statistics at the city level, makes it possible to identify the determinants of differential performances at the national and subnational level. As such, the dataset may hence be used as a useful benchmark for future comparisons.

In this respect, future research should be devoted to identify the best method ensuring an effective collection of the informations needed to evaluate the eService diffusion in Europe at the municipal level in order to monitor its evolution over time and ensure a periodical update. From this perspective, it is very promising that Eurostat has recently

undertaken efforts in the direction of measuring public sector innovation, and of eService development in particular, using mixed data-mining methods (Bianchi et al., 2019). Future research is also called for in the direction of further exploring the characteristics of cities that can favour public eService development.

Aknowledgments

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Appendix A. Domain sources and characteristics

Table A.1
ITS/Infomobility (ITIC-Between, 2010).

Unit of analysis	LOCAL PUBLIC TRANSPORT COMPANIES		
Service list	Public Informed Mobility	*Online info to users while travelling*	Public transport companies providing online information to users (e.g. waiting times, strikes, delays, failures, etc.)
		Online time table consultation	Public transport companies offering the possibility to consult the online timetable of public transport network
		Online travel planning	Public transport companies offering timetables with route planning (travel planner) on the web
		Online ticket purchase	Public transport companies offering web based payment systems
	Private Informed Mobility	*Info to car drivers while travelling*	Public transport companies providing online information to travelers about traffic or parking
		Electronic road or parking toll	Public transport companies offering a electronic ticketing system of parking spaces

Table A.2
eHealth (Deloitte & Ipsos Belgium, 2011).

Unit of analysis	HOSPITALS	
Service list	*Videoconferencing/Video consultations between patients and doctors*	Dedicated and formal use of facilities such as consultations between patients (either at home or outside the hospital) and hospital medical staff (for clinical purposes)
	Electronic Patient Records (EPR)	A computer-based patient record system, which contains patient-centric, electronically maintained information about an individual's health status and care. The system allows online access to patients
	e-booking	Electronic appointment booking system
	Online clinical tests	Computer-based system for electronic transmission of results of clinical tests. The system allows online access to patients
	e-referrals	Hospitals offering the possibility to external health actors to make appointments for their patients
	Telemedicine service (tele-homecare/tele-monitoring)	The provision of social care at a distance to a patient in his/her home, supported by means of telecommunications and computerized systems
	Online chronic disease management	Home care services using ICT can contribute to the management of long duration/slow progression diseases
	Online ticket payment	Hospitals offering webbased payment systems for visits and clinical tests

Table A.3
eProcurement (Capgemini et al., 2010b).

Unit of analysis	MUNICIPALITY	
Service list	**eProcurement Visibility**	
	Publication of general information on public procurement	General information on public procurement made available on the municipality websites
	Publication of notices to official electronic notice boards	Official electronic board on the municipality websites where procurement notices are made
	Link to e-procurement services	Link to a web page (owned by the municipality or by external parties) providing eProcurement services
	eProcurement (Pre-Award Phase)	
	e-NOTIFICATION	Publication of tenders and procurement notices on the web
	Online registration of supplier	Creation of user accounts and profiles with related roles
	e-mail alerts for suppliers	Possibility for the suppliers to receive email alerts about forthcoming calls and notices of their interests
	e-SUBMISSION	Submission of proposals online
	Assistance services to the supplier	*E*-mail, chat, audio/videoconferencing communication for Question and Answer sessions between eProcurement operators and bidders
	Online supplier help session	help services to assist suppliers in the preparation of online tender
	e-AWARDS	Publication of awarded contracts
	Online information about awarded contracts	The website publishes the contracts awarded and their winner
	e-auctions	Availability of tools to carry out real-time price competitions
	eProcurement (Post-Award Phase)	
	e-ORDERING	Automatic placement of orders online
	e-catalogues	Online order from e-catalogues through eProcurement website
	Electronic market	Electronic market hosted by the eProcurement website, for online interaction between buyers and suppliers
	e-INVOICING	Delivery of electronic invoices
	e-invoicing service	E-invoicing services managed by the eProcurement website
	e-PAYMENT	Online payment of contracts
	e-payment service	Online payment services, managed by the eProcurement website

Table A.4
eGovernment (Capgemini et al., 2010a).

Unit of analysis	MUNICIPALITY	
Service list	*Online local taxes*	Declaration, payment, notification of assessment
	Online registration school	Standard procedure to register children at kindergarden
	Online registration of residence	Standard procedure to register the residence in a local area of town
	Online payment fines	Standard procedure to pay fines at municipal police office
	Online personal documents	Standard procedure to obtain an international passport and an identity card
	Online public library	Standard procedure to consult the catalogue(s) of a public library to obtain specific information regarding a specific carrier (Book, CD, etc)
	Online birth/marriage certificates	Standard procedure to obtain a birth or marriage certificate
	Online registration of a new company	Standard procedure to start a new company

Appendix B. Services supplied by government level and their sophistication

Table B.1
Sophistication levels by service.

SERVICES	Sophistication levels considered
Local taxes	0–1–2-3-4-5
Libraries	0–1–2-3-4-5
Kindergarden registration	0–1–2-3-4
Certificates	0–1–2-3-4
Application for building permission	0–1–2-3-4
Registration of a new company	0–1–2-3-4
Identity card request	0–1–2-3-5
Fine payment	0–1–4-5
Residence registration	0–1–2-4

Sources: Capgemini et al., (2010a).

Table B.2
Measuring service availability and quality.

	QUALITY
eHealth	Not measured
Infomobility	Presence/absence of quality features: multi-channel delivery, advanced functions and applications
eProcurement	Presence/absence of quality features associated with each phase: visibility, pre-award, post-award phases.
eGovernment	Interactivity stages

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