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- Davide Arduini , University of Urbino "Carlo Bo"
- Federico Belotti - University of Rome "Tor Vergata".
- Mario Denni - Italian Competition Authority (Agcm).
- Gerolamo Giungato - Italian National Institute of Statistics (Istat)
- Antonello Zanfei - University of Urbino "Carlo Bo"


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# TECHNOLOGY ADOPTION AND INNOVATION IN PUBLIC SERVICES
# THE CASE OF E-GOVERNMENT IN ITALY*

*Davide Arduini°, Federico Belotti°°, Mario Denni°°°, Gerolamo Giungato°°°°, Antonello Zanfei°*

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## Abstract

Using data on 1,176 Italian municipalities in 2005, this paper discusses a number of factors associated with the development of a particular type of innovative activities, namely e-government services supplied by local public administrations (PAs). We find that municipalities which got involved into e-government are larger, carry out more in-house ICT activities and are more likely to have intra-net infrastructures, relative to PAs that do not offer front office digitalised services. They are also generally located in regions with relatively large shares of firms using or producing ICT, where many other municipalities offer digitalised services, and where concentration of inhabitants in metropolitan areas is not very high. The range and quality of e-government services supplied by local PAs tend to increase with their stock of ICT competencies, with their efforts to train workers, and with their ability to organise efficient interfaces with end-users. Moreover, there is a correlation between the range and quality of e-government services offered and the broadband infrastructure development of the geographic area in which local PAs are located. In more general terms, we show that the combination of internal competencies and context specific factors is different when explaining the decision to start e-government activities *vs.* the intensity of such activities. Regional factors, relating to both demand and supply of services, appear to affect only the decision to enter e-government activities. Competencies needed to expand and improve the quality of services are much more numerous and complex than the ones associated with the mere decision to start e-government activities.

JEL Classification: H830, 0330, O380

Keywords: Innovation system, Dynamic capabilities, Technology adoption, Electronic government, Innovation in services, Two-part model.

## 1. Introduction

In advanced economies the public sector has undergone pressures to augment transparency in administrative procedures and decision making processes as well as the efficiency of its services to citizens and business enterprises. These pressures are the result of a combination of factors, including increasing competition in the political arenas, institutional changes and technical progress. The use of digital technologies at all levels of Public Administrations (PAs) and the development of "e-government" services[1] are a key aspect of this transformation. However, studies on digital technology adoption, and on ICT based services supplied by public organisations reveal the existence of a considerable heterogeneity across EU countries and regions (Caldas *et al.* 2005, Torres *et al.* 2005). In other words, not all PAs are equally prone to get involved into e-government; nor are they equally active in this field. Using data on 1,176 Italian municipalities in year 2005, this paper contributes to our understanding of this diversity. More precisely we shall analyse the factors that are associated to the decisions of PAs concerning whether and how to get involved in e-government activities.

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° University of Urbino "Carlo Bo".
°° University of Rome "Tor Vergata".
°°° Italian Competition Authority (Agcm).
°°°° Italian National Institute of Statistics (Istat).

[1] Definitions of e-government include the following: *"…utilizing the Internet and the World-Wide-Web for delivering government information and services to citizens and firms"* (UN/ASPA 2002); *"…information system aided handling of public administration processes using information and communications technology"* (Tung and Rieck 2005); "*…the use of ICTs, and particularly the Internet, as a tool to achieve better government"* (OECD 2003).

The analysis carried out in this paper can be cast in a general framework that explains innovation as the result of a process wherein the competencies of innovating entities co-evolve with the technological, institutional and economic environment in which they are active (Nelson 1995). In this case, we shall focus on a specific category of innovators, namely public administrative bodies at the local level, which we shall dub with the term "municipalities" from now on. We shall use the provision of digitalised front office services to the citizens and to firms and other institutions (e-government), as a measure of municipalities' innovation. Furthermore, we shall consider the relevant technological, institutional and economic context for innovation to be largely represented by the "regions" where municipalities are located. While the choice of territorial aggregation is always arbitrary, we thought is sensible and feasible in terms of data availability to utilise the Eurostat NUTS2 level of analysis for Italy, which corresponds to the 21 sub-national regions that were institutionalised in 1970 following a constitutional provision of 1948[2].

In this general framework, we shall show that different competencies and contextual factors matter when considering innovation rate *between* or *within* municipalities. That is, the set of technical competencies and context specific variables that help to explain which PAs will offer digitalised front office services at a given moment in time (innovation rate between municipalities), is different from the set of factors associated with the intensity of e-government involvement of innovating PAs (innovation rate within municipalities). While "between factors" are related to the very decision of municipalities on whether or not to get involved in e-government activities, "within factors" are associated with the range and quality of services that will eventually be offered by PAs, once they decide to innovate.

This distinction is useful not only for analytical purposes but also from a public policy point of view. In fact, to the extent that innovation in services is an important driver for economic growth (Gadrey and Gallouj 2002, Evangelista and Savona 2003, Van Leeuwen and Van der Wiel 2003), it is crucial to be able to disentangle factors associated with PAs' decision to innovate and factors associated with specific characteristics of innovation that are carried out by public service providers. While promoting competencies and context specific characteristics of the former type (between factors) should be of paramount importance in areas where e-government services have not yet been offered or are at the embryonic stage of development; singling out the latter, within type of factors will provide guidance for further developing and improving digitalised front office services where these are already available.

The rest of this paper is organised as follows. Section 2 draws together different streams of literature to single out the key factors which can help explain innovation in public services in general and e-government in particular. Section 3 reviews some empirical studies on the development of digitalised services by PAs. Section 4 illustrates our datasets and discusses the empirical strategy we shall follow. Section 5 examines the results of the econometric exercise carried out on innovative activities of Italian municipalities. Section 6 concludes.

## 2. Background literature on innovation and implications for public services

While there is an increasing attention to innovation in services (Miles 1993, Andersen *et al.* 2000, Metcalfe and Miles 2000, Cainelli *et al.* 2006), analytical tools used to interpret this phenomenon are by and large derived from previous studies focused on firms' innovative activities in the manufacturing industry. Moreover empirical analyses are still rather scanty when innovation in services is considered, and even more so with reference to public services. Nevertheless, different streams of literature provide valuable insights and concepts that can be usefully adapted to analysing new service provision in the public sector. As anticipated in the introduction, it may be useful to focus on two broad categories of factors affecting innovation, whose importance and interaction has been increasingly emphasised in the literature, namely internal competencies of innovators and context specific characteristics.

[2] Further controls will be included using more detailed data at the provincial level (corresponding to Eurostat's NUTS3 codification), and at the municipal level, for such contextual data as the number of inhabitants and the share of population reached by broadband services respectively.

As particularly stressed by the evolutionary approach, our understanding of innovation can greatly benefit from the analysis of *competencies of firms and institutions*. This stream of literature views innovators as depositories of largely tacit knowledge incorporated in such firm specific assets as routines, skills, technical and organisational capabilities (Nelson and Winter 1982, Cohen *et al.* 1996). Such assets, normally identified with the comprehensive term "competencies", are the result of conscious efforts to invest in training of human capital and in institutionalised R&D. Moreover competencies originate from learning processes associated to production, to the use of technology and to the interaction with external parties (other producers, users, and institutions) which are themselves depositories of knowledge assets. Hence, while some competencies tend to be subject to strong inertia and are embedded in each firm or institution (as it is the case of routines), other competencies are subject to more rapid change (and obsolescence) and are affected by interaction with different sources of knowledge both internal and external to the individual organisation (Cohen *et al.* 1996).

Internal competencies are in turn a key driver of innovation, as they enable firms and other institutions to introduce new products, processes and organisational devices, and also to interpret and utilise knowledge that is located outside their own boundaries (Cohen and Levinthal 1990). As a result, diversities in competence accumulation help explain the heterogeneity of innovative behaviour and performances across firms and across institutions (Geroski 1999). Moreover, innovative performances are strongly influenced by the dynamic capability of organisations to absorb external knowledge, to coordinate internal and external resources, to adapt to changes in environment and to foster a pro-active role towards the environment itself (Pisano 2000, Zollo and Winter 2002, Helfat *et al.,* 2007; Teece, 2007).

The analysis of competencies has enabled scholars to provide a thorough illustration and interpretation of the innovative performance of large firms in a number of countries over long time spans (Chandler 1992, Dosi and Malerba 1996, Lazonick 2005). However, this approach has not been fully utilised yet for the study of innovation in the case of public service providers. A partial exception is represented by recent studies on ICT adoption by PAs in different countries, which identify different patterns of technological accumulation and associate these patterns to different indicators of productivity of public organisations (Caldas *et al.* 2005). We shall review some of these studies in greater details in Section 3. Suffice here to observe that capturing the role of internal competencies as drivers of public service innovation requires that a whole battery of indicators is used, particularly when dealing with the introduction of e-government. In fact, one needs to evaluate a variety of competence profiles concerning such complex items as the specialised training of workforce, the set up of technical infrastructures, the development of routines and back office organisational devices which are needed to supply advanced digitalised front office services. We shall make an effort to analyse how different types of competencies are associated with the development of new e-government services in Sections 4 and 5.

To better explain the introduction of innovation in general, and of e-government services as a special case of innovation in services, one also needs to acknowledge the importance of *context specific factors*. There is a general consensus on the role played by *demand conditions* as fundamental drivers for innovation. The hypothesis that an extensive and growing demand stimulates innovation was originally proposed by Schmookler (1962, 1966) and tested at different levels of analysis with a focus on manufacturing industry (Scherer 1982, Mowery and Rosenberg 1979, Bower and Kleinknecht 1999). Most contributions on innovation in services emphasise the importance of demand determinants of innovative activities (Gallouj and Weinstein 1997, Miles 2005) although there are few empirical studies concerning this issue (Cainelli *et al.* 2006). In the public sector case, more attention has been given to the role of governmental bodies in public procurement of advanced technology, hence as actors on the demand side (Zanfei 1998, Edquist *et al.*, 2000), than to the impact of demand on innovative activities carried out by PAs. This might have to do with the fact that PAs are not profit oriented, their activities are supposed to reflect more general welfare considerations and are hence less responsive to incentives generated by the existence of an extensive demand for new services. Nevertheless, given the increasing

budget constraints faced by PAs in most advanced countries, one may expect that PAs having access to larger pools of potential users (larger numbers of inhabitants or of user firms active in the area) will be more prone to undertake the effort to innovate their services[3].

Moreover, demand conditions affect the generation of innovation in a number of indirect ways, that is through the rate of innovation diffusion and via user-producer interactions. Potential users of new or improved products, processes and services are influenced in their adoption by the behaviours of other adopters. This is consistent with both standard epidemic models (Mansfield 1961, Davies 1979) which emphasise that more information and experience accumulates as the proportion of users increases, hence reducing the risk of further adoption; and with network externality models (Farrell and Saloner 1992, Shapiro and Varian 1999) which stress the increasing returns from technology adoption deriving from the interdependences among users. These mechanisms are likely to apply to innovation in manufacturing as well as in (public) services. It follows that PAs' decisions to set up new services, to expand their range or improve their quality are most likely to be influenced by their actual and expected diffusion, and hence by the (previous and contemporary) adoption of such services. Learning by using and user-producer interactions also impact on the rate and direction of innovation (Rosenberg 1982, Lundvall 1985, Von Hippel 1988). In fact, capable users accumulate unique experience by utilising and applying technology, they may directly introduce changes in the products (and services) they handle, and/or may transmit valuable knowledge to producers (and service providers). This will eventually translate into enhanced innovation.

While there is mainly anecdotic evidence on the importance of user-producer interaction as a determinant of innovation in services (Miles *et al.* 1995), few empirical studies systematically address this issue, particularly when public services are at stake (Limonard *et al.* 2005, Slot 2007). An empirical assessment of the role played by such mechanisms implies that measures of the quality of actual and potential users are introduced, besides indicators on demand quantities.

Apart from the characteristics of demand, innovation is affected by a number of other context specific factors and by the complex networks of relationships among the different actors involved in innovative activities (Lundvall 1992, Nelson 1993, Edquist 1997 and 2005, Malerba 2005). Important interdependencies can be observed between all parts of innovation systems, whichever might be the level at which such systems are defined, either national, regional or sectoral. These interdependencies include relationships between innovators and different categories of intermediate and end-users; but also the relationships that innovators set up with universities, with public research and training centers, with financial and labour market institutions, with policy makers and other social forces. The idea is that innovation reflects the variety of these linkages and interdependencies. Stated in slightly different terms, innovation will depend on the more general technological and institutional environment in which innovators are active (Freeman and Perez 1988, North 1990, Vaccà 1989). The quality of actors involved and of infrastructures supporting their action helps explain the heterogeneity of innovation performances across innovation systems.

The interactive and systemic nature of innovation is mediated by spatial factors, such as geographic proximity and localised knowledge accumulation. Emulation processes across innovators, user-producer interactions, knowledge exchanges and involuntary information leakages are favoured by close interaction and day-to-day contact between actors involved. There is large evidence of inter-regional variations in the generation and adoption of new technology, revealing that innovation tends to be geographically bounded (Antonelli 1990, 2000, Saxenian 1994, Baptista 2000, 2001, Asheim and Gertler 2005). The localised nature of innovation clearly has to do with the uncodified, tacit nature of a substantial part of the knowledge needed to innovate (Nelson and Winter 1982). The marginal cost of

[3] The number of inhabitants residing in the territory of a given public institution can also be negatively associated to ease of inter-personal relations which in turn reduce the actual need for advanced communication systems. Small towns and villages are generally characterised by more frequent and informal contacts between citizens and administrative bodies, which can be considered good substitutes for e-government services.

transmitting codified knowledge across geographic space does not depend on distance, but the marginal cost of transmitting, accessing, and absorbing tacit knowledge increases with distance. This leads to the clustering of innovation activities, especially in the early stages of an industry life cycle where tacit knowledge plays an important role (Audretsch and Feldman 1996, Howells 2002, Boschma 2005). Moreover, co-location of a large number of innovators in the same area will also create incentives for less dynamic firms and institutions to enter the innovation race, as they fear to be perceived as below average performers (Abrahamson and Rosenkopf 1993).

We expect that, much like the case of innovation in manufacturing firms, innovative activities of PAs will also reflect interdependencies among a variety of actors, especially those active in the same territory. It is quite likely that innovation is localised in the case of the public services, especially when the unit of analysis is the individual municipality, as in the case of the present study. This for at least three reasons. First, the tacit component of knowledge relevant for the development of e-government services is rather extensive, as these services are in their early phase of development and diffusion. Second, target users are mostly localised because the relevant political arena is also local in the case of municipalities. Third, public officers involved in service development and provision at the municipality level are likely to have more limited knowledge of demand and supply conditions the farther they move away from their territory.

## 3. Empirical studies on digital Administration (e-government)

This section focuses on empirical studies on e-government development and diffusion. Compared to many private sector organizations, PAs have been relatively slow in establishing and developing an on-line presence, especially when considering local administrative bodies. However, a number of studies have highlighted that a considerable heterogeneity exists across countries and regions in delivering on-line public services.

The study carried out by Capgemini (2007) for the European Commission measures the progress of on-line public service delivery across 31 European Countries. This study examines the web-based activities of more than 5,000 public administrations and 14,000 web pages providing 20 public services in the 31 participating countries. Data are provided on two core indicators of sophistication and availability of on-line services, measured across a basket of 20 services[4]. A "sophistication indicator"[5] is developed, according to which the $EU_{27}$ countries exhibit an average score of 76 on a scale from zero in the case of mere on-line information availability to 100 in the case of full electronic handling of relevant data[6]. With regard to the on-line "availability indicator"[7], Europe has advanced from 50% in 2006 to 58% in 2007 (100% would identify full availability). Nevertheless, there is a large variance of 50% in the case of the

[4] Services are grouped into 4 clusters: Income and fiscal services (taxes, social contributions, VAT, customs), Registration (car, company, natality & marriage, personal and business mobility, statistical data), Social services (health, libraries, procurement, job search, benefits) and Permits and Licenses (building, passports and other ID certification, education, environment management and protection).

[5] Four interactivity/sophistication levels of on-line services were developed: information available on-line, one-way interaction (downloadable forms), two-way interaction (electronic forms) and transaction (full electronic case handling).

[6] Europe has achieved an average overall sophistication maturity level that is between "two-way interaction" and "fully transactional". The progression in sophistication of services is important compared to 2006, when EU countries were stuck very close to the lowest level of two way interaction (electronic forms). The overall 76% score achieved in terms of sophistication maturity is the average of all the surveyed countries.

[7] The indicator is measured on the basis of a two-level structure: no full on-line availability (from stage 0 to stage 3 of the sophistication scale) and full on-line availability (status granted to all services that reach a level strictly above the 3rd stage of the sophistication framework). Hence a service will only be considered on-line (and receive marks) if it reaches a sophistication superior to stage 3. The Fully-available indicator is thus binary (1, 0).

sophistication indicator and of 85% in the case of on-line availability indicator between the most and least advanced European Countries[8].

The study highlights that European Countries greatly developed on-line services addressed to firms[9]: a 20% gap remains between the full on-line availability of services for citizens (50%) and for firms (70%). Another weakness is that only 36% of on-line services enable users to interact directly with PAs. Finally, Capgemini (2007) observes a generalised absence of integration between the front and the back office in public administrations: the lack of shared files, such as a computerized central register, often makes interaction on the net impossible.

Torres *et al.* (2005) studied the degree of implementation of on-line services offered by local administrations by focusing on the web sites of 33 EU cities with more than 500,000 inhabitants. The cities considered in their research were on average large in size, and included national capitals or other cities with high administrative relevance to the country in which they are located (Austria, Belgium, France, Germany, Ireland, Italy, Luxembourg, Portugal, Spain, and the United Kingdom). Data were obtained through municipal web sites in order to measure two different variables: Service Maturity Breadth (SMB) which identifies the number of services offered through the Internet from the 67 identified services; Service Maturity Depth (SMD) which counts services according to their level of interactivity (simple information dissemination, one-way communication, service and financial transactions).
In the sample the average share of the 67 surveyed services offered was 46.8% (SMB score). The most common service offered was municipal tax payment, which had been implemented by 85% of the cities. Other services such as library catalogue browsing, booking of sports facilities, public employment practices, public procurement, permissions for carriage loading, unloading of goods and driving in restricted areas, and public entertainment ticket sales were implemented in more than 70% of the cities. The SMD score showed that 43.6% of the services provided through the Internet in the cities studied were at a stage of simple information available on-line, whereas 38.4% were included in the interact category (downloading applications). The lowest percentage was shown by the transaction stage (18 %).

Another exploratory study of the digitalised services offered by the public sector in Europe was issued by the Oxford Internet Institute (Caldas *et al.*, 2005). The study reports the results of a survey carried out in 2003 by the Momentum Research Group for the Net Impact and sponsored by the Cisco Corporation. Some 1,112 public sector organisations located in eight European countries (France, Germany, Italy, the Netherlands, Poland, Spain, Sweden, and the United Kingdom) were considered to explore the conditions favouring the adoption and deployment of digital information network technologies. These technologies were divided into two groups: network services/infrastructures[10] and network applications[11]. Among the network services the most widely adopted sub-class were the security and virus-protection technologies (69% of the region's public sector organisations had access to these services). By contrast, only 25% of the examined PAs used Data and Document Management services and Communication services. As far as network applications are concerned, 75% of PAs utilised Organisational Control devices, which are essential for carrying out basic back office managerial control and reporting functions for the

[8] More precisely, five Countries have achieved performance of 90% (or above) in both indicators: Austria occupies the top position, followed by Malta, Slovenia, Portugal and the United Kingdom. Italy exhibits values of 70% for the on-line availability indicator and of 79% for the sophistication indicator; it ranks 11$^{th}$ in the former case and 16$^{th}$ in the latter.

[9] As a matter of fact the research showed that European governmental bodies developed above all services that produce a direct income for PAs supplying such services.

[10] Security and Virus-Protection (including Server Based Virus Detection and Containment and Real Time Intrusion Detection), Data and Document Management (including Remote Disaster Recovery Sites, Storage Area Networks and Content Caching), Communications (including Integrated Network for data, voice and video, Wireless LAN, Optical Networking, Voice over Internet Protocol, Internet Protocol Telephony and Virtual Private Networks).

[11] Organisational Control (including Finance and Accounting and Human Resources), Client/Customer Relations (including Customer or Citizen Relationship Management and External Web Portals), Internal Management Operations (including Content Management, Decision Support and Knowledge Management, Document Management, Resource Planning and Optimisation, Internal Web Portals).

organisation. These were the most widely used among public sector organisations, followed by Client/Customer Relations (43% of recorded PAs), which are designed to improve management of external transactions with the citizens and firms (front office), and Internal Management Operations (39%).

Caldas *et al.* (2005) grouped the examined PAs according to three main employment size classed in each of three main geographic European regions (North, South, and East) and, most importantly, they classified them according to three technology profiles (Advanced technology profile, Intermediate technology profile, and Basic technology profile). They find that the organisations with advanced and intermediate technology profile, in terms of extensive deployment of their network applications and services, are largely concentrated in the North (France, Germany, the Netherlands, Sweden, and the United Kingdom), followed by the South (Spain and Italy) and by the East (Poland), while the South almost matches the North in the share of organisations having only a basic technology profile. Moreover, the cross section variations showed that the leaders are found disproportionately among the larger organisations of the Northern European region.

The study also finds that the technological profiles of the examined public organisations are systematically associated with differences in performances. Using a sub-sample of public organisations Caldas *et al.* (2005) analyse the relationship between their adoption and mode of utilisation of e-network technologies, on the one hand, and, on the other hand, their managers' perceptions of efficiency in service provision. By combining the two types of empirical information within a mathematical model they obtain approximate estimates of the implied rate of growth in the sector-wide average number of "cases resolved per employee" in 2003-2008.

Organisations that had deployed internal and external web portals among their network services, were providing more than the minimum profile of networked applications (finance and accounting, and human resource management and training), and had also attained an above-median extent of deployment of customer or citizen relationship management applications on their network, were found to benefit greatly from the use of these technologies. The adoption of this form of "best practice" alone is associated with a more than four-fold increase in the annual percentage growth rate in cases resolved per employee. Nevertheless, the authors also find that organisations with a basic technology profile can be expected to have much greater gains in their performances than organisations that were considerably more advanced in their acquisition of e-network technologies. A possible explanation is that investments in ICT are beginning to reveal diminishing returns for the most advanced organisations.

## 4. Data sources and empirical strategy

In this section we illustrate the data and methods which we shall utilize to examine the factors affecting the innovative activities of Italian PAs. As anticipated in the introduction, our unit of analysis will be represented by local PAs (municipalities), and we shall use their involvement in the provision of digitalized front office services (e-government) as the dependent variable in our econometric exercise. We expect different factors at the municipality and contextual levels to be associated with the introduction of e-government services. These factors were selected drawing them from the existing literature on innovation processes, as recalled in Section 2. Let us first illustrate our data sources and then discuss how these are utilized for analytical purposes.

### 4.1 Data

Our empirical tests are based on data at both municipality and contextual (mainly regional) level[12]. As for variables at municipality level, data are obtained by merging two different surveys (see Appendix A for a detailed description of the datasets we used). One is the survey conducted by Italy's National Bureau of

[12] A variable only is collected at the level of the Italian provinces.

Statistics (Istat) in 2006 on the usage of ICT in 3,323 Italian local public administrations ("ICT-PA *(Istat)*" in Appendix A). It collects information on the diffusion and use of ICT in the local public administrations. The other is the survey carried out in 2006 by the National Centre for the Information Technology in the Public Administration (Cnipa) on the official websites of 1,825 Italian municipalities ("EGOV *(Cnipa)*" in Appendix A). It includes information on some 266 on-line services provided by the municipalities. The sample obtained at the intersection of the two datasets contains cross-sectional information referring to 1,176 municipalities in 2005[13].

Also regional variables are taken from different surveys. One is the 2005 survey on the usage of ICT in Italian firms with 10 employees or more ("ICT-FIRMS *(Istat)*" in Appendix A). Data on employees in ICT sectors come from the 8th General Industry and Services Census which was also carried out in 2001 ("CENSUS-FIRMS *(Istat)*" in Appendix A). Data on inhabitants at the municipality level are taken from the Istat project "Demography in Figures" ("RESIDENT POPULATION *(Istat)*" in Appendix A). The MIUR (Italian Ministry of University and Research) survey on the tertiary education ("MIUR" in Appendix A) provides data on the number of graduates in ICT disciplines as a measure of human capital endowments in fields relating to e-government. For all these variables where information is available at regional level, the same value is assigned to every municipality belonging to the same region. It results in no intra-regional variance and only in inter-regional variation at this level of analysis.

Finally, information on the diffusion of broadband infrastructure and services are taken from the Broadband Observatory ("BROADBAND OBSERVATORY *(Between)*" in Appendix A). These are the only data we have access to which are available at the provincial level. Table 2 reports a brief description of all the explanatory variables considered in the empirical application and their source. In Table 3 summary statistics are provided.

### 4.2 The dependent variable: the Front Office Index (FOI)

The dependent variable in our econometric exercise is a composite indicator measuring the availability and the level of interactiveness of on-line services for each administration.

Using a taxonomy introduced by Capgemini (2006), Cnipa organizes its data on 21,337 on-line services supplied by 1,825 Italian municipalities according to whether or not such services exhibit one or more of four specific characteristics (see footnote 5). These characteristics $D_i$ reflect different levels of interactiveness of on-line services: the possibility of downloading administrative forms necessary to receive the service ($D_1$); the possibility of exchanging interactive information about the service, such as asking specific questions and obtain answers ($D_2$); the presence of an authentication procedure through which the user can be identified and given a personal account, as a means to enhance security ($D_3$); the possibility to start and finish the transaction process completely on-line ($D_4$). The latter represents the most comprehensive level that can be provided for an on-line service. Note that each service may show none, some, or all of these features.

We followed two steps to build the composite indicator. First, based on the observed characteristics of the services, we employ Multiple Correspondence Analysis (MCA) to compute a weight for each of the four service's features. Then, the *score* for service *s* in the sample is computed simply as a weighted sum of its characteristics

[13] While the sample obtained at the intersection of the two datasets provides very rich information on a large number of local PAs in Italy, the geographic (regional) distribution and size distribution of municipalities in the sample differ from those of the Istat universe. However, it is worth stressing that the information in the sample is of great interest given that it represents more than 48% of the universe in terms of population and almost 15% in terms of number of municipalities and that it highlights several previously unknown aspects of both *back-office* and *front-office* activities of local PAs. In particular, information on front office activities concerns the quantity as well as the quality (level of interactivity) of on-line services offered to firms and individual citizens. Moreover, detailed data are available on the technical and organisational competencies of local administrative units, and on the characteristics both at the demand and the supply of services in the area in which municipalities are located.

$$score_s = 0.034 \cdot D_1 + 0.295 \cdot D_2 + 0.347 \cdot D_3 + 0.325 \cdot D_4$$

where $D_i$ (i=1,…,4) is a binary variable equal to one when service *s* exhibits the specific characteristic *i*. At the end of the first step we have a score for each of the 21,337 entries in the dataset reflecting the "intensity" of the on-line service in terms of quantity and level of actions it performs.

Second, we compute a final score for each municipality (the final unit of our analysis) by adding the scores received by the services it provides through its official website. This is our *Front Office Index* (*FOI*). It is a function of both the number of on-line services offered by the administration and the degree of "performance" of each of them.

Table 1 reports the distribution of the FOI index across macro-regions (as defined in Table 2), and across classes of municipality size and of ICT investment. It is worth noting that our Index takes the highest average values for municipalities located in the North-Eastern and Central parts of the country. It also clearly grows with the size of municipalities, measured in terms of number of inhabitants, and with the size of investments in ICTs by local PAs. In both cases, the distribution of values taken by the Index is particularly skewed in correspondence with the highest size classes. This is clearly the case of the 15 Italian cities whose size is above the threshold of 200,000 inhabitants, a size class which includes 14 out of the 15 municipalities officially classified as "metropolitan cities"[14]. We shall use multivariate techniques and controls for other sources of heterogeneity to further test how our indicator of PAs' innovativeness is correlated *inter alia* with the size of municipalities, with their geographical location and with patterns of ICT investments.

### 4.3 Independent variables and controls

In the light of the selective review of the literature carried out in Section 2 we singled out a set of variables which we deem to be associated with the development of e-government services. These variables can be assembled into two broad categories: characteristics of municipalities and contextual (mainly regional) features (see Table 2 for details on variable specification and sources they are drawn from).

*Municipality level variables* aim, above all, at capturing a large variety of *technical and organisational competencies* of local administrative bodies, which are key drivers of innovation according to evolutionary and resource based views of the firm. We distinguish three different sets of internal competencies:

a) Competencies that are *embodied in personnel* employed in the municipalities

This is the case of the variable named *Municipality ICT Empl* expressed by the number of employees whose core activities are related with ICT, i.e. software design, computer based operations and maintenance. This variable reflects the actual stock of human capital qualified for the development and provision of digitalised services. *Municipality ICT Training* is a dummy to identify whether in 2005 municipality *i* has undertaken specialised training programs in any of 5 technical fields that are relevant for e-government activities. Through this indicator we mean to capture the conscious effort made by the institution to improve the quality of competencies in these areas. *Municipality inHouse*

[14] According to the Italian Parliament's Laws ruling the administrative issues in metropolitan areas (L.142/90 and DLgs 267/2000) there are 9 "metropolitan cities", namely: Bologna, Bari, Firenze, Genova, Milano, Napoli, Roma, Torino, and Venezia. This list is to be integrated with 6 more cities recognised as metropolitan by individual Regions according to their own legislations. These are: Cagliari, Catania, Messina, Palermo, Sassari, Trieste, All of these cities, except Sassari, are lager than 200,000 inhabitants and are thus included in the top size-class in Table 1. The only non-metropolitan city listed in this size class of Table 1 is Padova. Interestingly enough, there are 10 regions, out of the total 21 NUTS 2 sub-national areas of Italy, where no cities above this threshold are located (Abruzzo, Alto Adige, Basilicata, Calabria, Marche, Molise, Sardegna, Trentino, Umbria, Valle d'Aosta).

*ICT* is expressed as the percentage of ICT related activities that are carried out in the public organisation by means of internal staff. This variable is informative of how capable the organisation is to take care of ICT activities with its own resources, without resorting to specialised external competencies.

b) Competencies that are *embodied in ICT based devices and instrumentation*

Indicators we used are: *Municipality intranet*, which measures the percentage of the computers available which are connected to a Local Area Network (LAN); *Municipality Broadband*, a dummy variable identifying whether or not the municipality's offices have a broadband access to the internet; and *Municipality OpenSource*, that is the share of open source systems out of the total number of software packages that are in use at the municipality's offices. Since open source software is less established as a technical solution, and its development is by and large based on the interaction among communities of experienced users, we consider its rate of adoption as an indicator of both the innovativeness of systems in use, and of the skills of technical personnel employed by the PA.

c) Competencies that are *embodied in the PAs' organisation*

To capture this aspect of internal competencies we introduced several indicators of how pervasive ICT is in the overall organisational structure of the municipality. Measures of this type are: *Municipality EDP-based activities*, expressed as the share of total activities carried out at the municipality level which are operated using EDP-based systems; *Municipality Interface*, a dummy identifying whether or not the PA has set up an ICT based system that allows the user to deal with a single on-line administrative interface (the so called "Sportello Unico" in the Italian technical jargon); and *Municipality Multichannel*, a dummy indicating whether or not the PA makes use of diversified channels to provide services, other than face-to-face contacts, that are not based on the web. These alternative channels include *inter alia*: call centers, mobile messaging or interactive cable TV.

While one might expect that most of these different sets of competencies should be positively associated with the municipality's ability to offer e-government services, at least two *caveats* apply here.

First, some variables might have a lower impact than others on digitalised service provision. For instance, being connected through an intranet (*Municipality intranet*) can be a sort of facilitating factor for the development of some services. In fact, the adoption of intranet connections implies a generalised improvement in the back-office activities of a PA, favouring the creation and diffusion of such information processing tools and communication devices as: shared mailing lists, document management and exchanges, on-line event scheduling, electronic support to the training of personnel. Such advancements of back-office infrastructure will eventually translate into better front-office services for user firms and citizens. However, it would be harder to argue that this represents a sufficient condition of e-government, as there is no guarantee that being logged to an intranet would enable a PA to get involved into digitalised services, especially if the employees whose computer are connected to the intranet are not skilled enough.

In a similar vein, one could submit that the impact of *Municipality multichannel* is quite uncertain. In fact, on the one hand the use of a variety of means to provide services can reveal that the PA has the capabilities and skills to offer advanced communication services the end-users (citizens, firms or other institutions). This would lead us to conclude that there might be complementarities between web-based channels and other means of communication with users of public services. On the other hand, when alternative channels exist and work correctly, we might expect PAs to have lower incentives to enter such a new, costly and risky activity as e-government. It follows that digital service provision might well be a substitute for, rather than a complement to, alternative channels.

Second, some competencies we have listed might contribute to explain differences in innovation "between municipalities", as they help identify which PAs will have a higher propensity to initiate e-government activities; however, the same factors might not at the same time be associated with a higher intensity of e-government provision, and hence they will not be a good predictor of "innovation within

municipalities". And viceversa. We do not have strong *a priori* on this, it will be interesting to "interrogate" the data and discuss this issue on a more informed basis. For the time being, we might observe that the decision to start e-government activities might not be heavily conditioned by the existing stock of ICT skills or by previous decisions to invest in training (as measured by *Municipality ICT Employees,* and *Municipality ICT Training* respectively), provided that some ICT activities exist and are at least partially carried out by means of an internal staff (this would be measured by *Municipality InHouse ICT*). In fact the latter would guarantee that a minimum threshold of owned competencies is reached, that some capacities exist to evaluate technological opportunities and to activate external services to complement internal resources. However, once a PA has already started e-government activities and aims at expanding or improving them, one might well expect that there will be a much higher need to increase the number of employees with some ICT skills, by either employing new experienced workers or training the existing ones.

Besides the indicators of internal capabilities which we have illustrated, a final characteristic one needs to account for at the municipality level is the *size of PAs*. Our variable *Municipality size* is expressed in terms of the number of inhabitants resident in the territory of the local PA. This indicator can be expected to capture mainly the potential demand for e-government services. Consistently with the literature on demand-pull innovation, on demand externalities, and on user-producer interaction which we reviewed in Section 2, we assume *Municipality size* to be positively associated with e-government development. There is a further reason to expect e-government to be positively related to size, i.e. the fact that small municipalities are likely to be characterised by easier and more frequent inter-personal interaction, closer and less time consuming contact between residents and local administrative bodies. This may *per se* reduce some of the advantages associated with e-government, that is the possibility of rapidly accessing and processing information without having to reach the service provider's location.

The considerations above on demand factors at the municipality level pave the way to a more thorough analysis of *context specific factors*, which can be largely captured at the regional level. We can consider two groups of such factors:

I. <u>*Other demand factors*</u>

To carry out a more detailed analysis of demand factors at a broader level (relative to the municipality level we have just considered), we first use variables that identify specific categories of users, such as *ICT User Reg* and *E-gov User Reg*. These are respectively expressed in terms of the percentage of total firms in the region that were reported in 2005 to have adopted ICT-based services in general or e-government services in particular. Unfortunately we do not have lagged data on use of digital services, which would enable us to test whether epidemic patterns of innovation diffusion, induced by previous adoption, can affect the development of e-government. Nevertheless, consistent with systemic approaches to innovation, we can expect that higher shares of firms that use digital services will be positively associated with more extensive and effective user-producer interaction, thus creating greater opportunities for PAs to offer new or improved ICT based services.

Besides, we attempt to capture how polarised demand is by identifying the percentage of inhabitants of the region that are concentrated in the capital city (*Capital Share Reg*). According to the literature on spatial diffusion of innovation, technology adoption tends to be more timely and intensive in locations where larger numbers of potential users are concentrated, especially in the initial stages of technical change (Glaeser 1999). As e-government is in its initial phase of diffusion, one might expect that the higher the share of population in capital cities and in metropolitan areas, the more these services will be concentrated there. Consequences on e-government diffusion and development in other areas of the region are twofold. On the one hand, a fast development of demand for digital services in metropolitan areas, stimulating highly innovative supply in those locations, might induce emulation effects. *Capital Share Reg* would then have a positive effect on e-government of municipality *i*, where *i* is different from the capital city. On the other hand, negative externalities

might be created, as skilled workers and financial resources will be attracted by the metropolitan areas where more demand for ICT services exists, thus crowding out investments and innovation capabilities. This would then have a negative impact on e-government in other areas. Our empirical tests will allow us to evaluate which forces will prevail in the Italian case.

II. *Supply factors*

E-government activities of PAs are affected by the presence of other innovative actors in the same area. Among these actors are the other municipalities offering digitalised services. We capture this factor by means of our variable *Municipal E-gov Suppliers Reg*, expressed as the share of e-government service providers out of the total number of local administrative bodies in the Region. Consistently with systemic as well as spatial innovation approaches, we expect this variable to be positively related to innovative activities of PAs. In fact, when a high number of innovators are located in a given area, knowledge spillovers will be facilitated and greater incentives are created for less dynamic institutions to enter the innovation race.

Interdependencies can be observed also between e-government service providers and local ICT producers. We proxy this factor with a separate variable we named *ICT Producer Ntnl Share* defined as the ratio between the percentage of employees in ICT manufacturing and service sectors out of the total number of employees in the Region, and the same percentage calculated at the national level. This factor will be positively associated to the development of e-government services for two main reasons. First, municipalities located in regions with higher shares of ICT producers will be in a better position to gain access to relevant technology, including both hardware and software. Second, where public and private markets overlap, as in the case of voice or image transmission over IP, a competitive presence of ICT service providers stimulates municipalities to expand the range of services offered through their city networks.

Another supply-side, context specific factor we wish to account for is the state of communication infrastructure. For this purpose we introduce *BroadBand Share*, defined as share of total population of the province where a municipality is located, which is reached by at least one broadband service provider. We consider a wide availability of broadband connections an important condition for the provision of advanced e-government services, because it reveals a high quality of infrastructure and might also reflect the existence of (actual and/or potential) competition in the provision of network solutions. Both the technological level and the degree of competition in the provision of network infrastructure are normally associated with higher rates of generation and diffusion of advanced communication services (Grubesic and Murray 2004).

We further control for the availability of a pool of qualified human capital, a factor particularly emphasised in studies on the generation and diffusion of innovation in ICTs (Bresnahan *et al.* 2002). To capture the role of this factor, we calculate the ratio between the percentage of graduates in ICT disciplines out of total graduates in the Region and the same percentage at the national level (*ICT Degrees Ntnl Share Reg*). Indeed, this indicator will at the same time reflect the qualitative level of actual and potential workers in ICT manufacturing and service sectors; and the competencies of potential users. In both cases the impact on e-government service provision should be positive.

Finally, we also introduce controls for macro-regions (see Table 2 for aggregation criteria). This will enable us to account for a number of other observable and unobservable sources of heterogeneity which might affect the provision of e-government services, including income levels, population size, and sectoral composition of the areas where municipalities are located.

### 4.4 The Econometric model

The choice of the econometric model strongly depends on the distribution of the dependent variable, namely the FOI index. Almost 30% of the observed municipalities do not provide on-line services, i.e. the composite indicator is nil for such units. Then, our dependent variable is continuous over strictly positive

values but takes value zero for a nontrivial fraction of the sample. Given the nature of our dependent variable we argue that a standard censored model would not be appropriate. In fact, municipalities can be thought of as solving an optimization problem, wherein the optimal choice might well be the corner solution, *y=0*. The case of limited dependent variables often arises in econometric analysis, especially when the behavior of economic agents is being modeled. The traditional approach in dealing with such a problem is the Tobit model. However, this approach imposes that the censoring mechanism derives from the same model that generates the outcome variable while in our case, the censoring mechanism and outcomes may be more flexibly modeled using separate processes[15]. A two-part model allowing the zeros and non-zeros to be generated by different densities, enables us to specify a model for the censoring mechanism and a model for the outcome, conditional on the dependent variable taking positive values. This allows to separate the estimation of a standard probit model (using all observations) from that of an OLS model (using only observations with FOI > 0).

Therefore, the first part of our model is a probit to analyze the municipality's decision to offer on-line services *via* its official website. This would then allow to explain innovation differences "between municipalities", i.e. which PAs have a propensity to offer e-government services. The specification is

$$P(FOI > 1 \mid x) = \Phi(\beta_o + \sum_{i=1}^{k} \beta_i x_i) \qquad (4.1)$$

where the dependent variable is a dummy equal to one if the FOI is greater than 0, $\Phi$ is the cumulative standard normal distribution, $\beta_0$ is the intercept, and $\beta_i$ and $x_i$ are the parameters and covariates vectors, respectively, both of dimension $k$.

The second part is a linear regression model to investigate the determinants of the intensity of e-government development in terms of both quality and quantity of on-line services. Using the terminology introduced earlier, this would allow us to explain innovation differences "within municipalities". The model we specify is

$$E(\ln FOI \mid FOI > 0, x) = \delta_o + \sum_{i=1}^{m} \delta_i x_i \qquad (4.2)$$

where the dependent variable is the natural logarithm of the FOI index (holding that FOI is greater than 0), $\delta_0$ is the intercept, $\delta_i$ is the parameters vector and, as in the probit model, $x_i$ represents the covariates vector. $m$ represents the number of variables included in the linear regression model.

Usually, the same regressors appear in both parts of the model (as it would be with $k = m$), but this may be relaxed if there are theoretical or empirical exclusions/restrictions. We started including the whole set of variables in both models. Then to select the best specification for each of the two models, a standard backward selection procedure has been applied based on two objective criteria, the Student's t-test and the Likelihood-Ratio test (LRT)[16]. In fact, starting from a specification with all explanatory variables, the least significant variable has been dropped sequentially so long as it was not significant at the chosen critical level of the two tests. We continued by successively re-fitting reduced models and applying the same rule until all remaining variables were statistically significant. See Appendix B for a discussion of model diagnostics used to check the consistency of results illustrated in this paper.

[15] For an in-depth treatment of the corner solution outcomes and censored regression models, see Wooldridge (2001).

[16] The LRT has been run sequentially by taking aside a variable at a time and comparing the goodness-of-fit between the full and the restricted model. The LRT says whether a relatively more complex model fits a particular dataset significantly better than a simpler model. In fact, adding additional parameters will always result in a higher likelihood score but this improvement is not always significant.

## 5. Results

Table 4 illustrates the results of the econometric exercise which we carried out using the data and methodologies discussed in Section 4. The whole set of independent variables illustrated in Section 4.3 and listed in Table 2, was used in both stages of the two part model. The last two columns of Table 4 report the results obtained from the final specification, following the entire selection procedure and controls for heteroskedasticity. It is important to note that all the independent variables we considered except one (*ICT Degrees Ntnl Share Reg*) turned out to be significant in at least one of the two parts of the model. Results from the final specification are by and large consistent with the view we have developed in this paper. As we suggested earlier drawing from different streams of literature, the specific kind of innovation analysed here, namely municipalities' provision of digitalized services, is the result of a combination of internal competencies and of context specific factors. Competencies that matter are embodied either in the personnel or in the technical devices they use, or in the organizational structure of the PAs. Context specific variables are mainly defined at the regional level (although we also have two additional controls for contextual factors expressed at the municipal and provincial levels, namely the number of inhabitants resident in the territory where the municipality is located, and the share of population in the province that is reached by broadband connections). This set of context specific variables encompasses a variety of demand and supply factors.

However, the econometric test helps highlight that different combinations of such variables are at stake when assessing the decision of PAs on whether or not to supply digitalized services, and when we consider the intensity of e-government activities (number and quality of services provided). In other words, factors associated to variations in innovative activities "between municipalities" are different from factors associated to differences in innovation "within municipalities". Outcomes from the probit specification in column 5 can be interpreted as "between effects", while those obtained from the OLS part of the model and reported in column 6 illustrate "within effects".

More specifically our econometric exercise yields the following sets of results.

First, *the environment in which municipalities are active, seems to influence the start up of digitalised services more than their intensity*. While technical competencies of PAs play an important role in explaining both innovation between and within municipalities, context specific variables are almost exclusively associated with differences in e-government provision between local administrative bodies. In the absence of an environment conducive to innovation, e-government is not likely to take off.

Second, among the context specific factors we analysed, *demand size and quality stimulate innovative entry in e-government service provision*. Demand size at the local level is captured by the number inhabitants resident in the municipality area (*Municipality Size*). It has a positive and significant impact on differences in innovation between municipalities, reflecting demand pull considerations as well as other bandwagon effects induced by demand externalities and user-producer interactions. It is worth recalling that the positive impact of the size variable might also reveal that the perceived advantages of e-government are lower in the case of small size municipalities. The easier and more informal communication, and the higher frequency of inter-personal contacts that normally characterise small towns and villages seem to reduce the need for electronic-based interaction between local PAs and end-users of services.

Demand conditions appear to play an even more important role at the regional level. Firms which have already adopted ICT services appear to have the highest impact on the decision of municipalities to get involved in e-government activities (see coefficient of *ICT User Share Reg* in column 5 of Table 4), highlighting that capable business users are of paramount importance for PAs. Of course, demand expressed by business firms has a positive impact on innovation because it generates revenues for the new services provided. However, this is only part of the story. ICT users may also stimulate other users and enhance diffusion; and they can learn by using technologies and transfer knowledge to suppliers. Even after controlling for ICT user firms, the impact of *E-gov User Share Reg*, i.e. the percentage of firms using e-government services, still remains positive and significant in our probit regression. Although we

do not have a data panel to evaluate how previous patterns of adoption affect diffusion, this result is largely consistent with the idea that innovation is favoured by pioneer users.

Third, *demand polarisation hampers innovation in public services*. This is shown by the negative coefficient of *Capital Share Reg* in column 5 of Table 4, indicating that a high weight of the region's capital will inhibit innovation elsewhere, especially in the early stages of development of new services. This result suggests that crowding out effects are likely to prevail in the presence of strong agglomeration processes: the larger the metropolitan areas, the more they will attract qualified human capital and financial resources, leaving little room to the development of new services elsewhere in the region.

Fourth, *emulation effects, knowledge exchanges, and competitive pressures can be observed on the supply side.* The most important factor positively associated with the decision to supply digitalised services appears to be the number of e-government providers in the region (see coefficient of *Municipal e-gov supplier Reg* in column 5 of Table 4). Emulation factors matter here, especially in the presence of increasing competition in the political arena at the local level. However, information leakages and learning from each other's experiences in the development of new services also play a role, given that developing new services implies high costs and risks. The presence of (private) ICT manufacturers and service providers in the region (*ICT Producer Ntnl Share Reg*) is also positively correlated with e-government development. This can be explained by the fact that municipalities will benefit from interactions with suppliers of hardware and software which are needed to design and implement digitalised services; and that greater competition with private service providers in some borderline areas, such IP-based telephony and value added services to business enterprises, might stimulate the innovativeness of PAs.

Fifth, *advanced communication infrastructures do not influence the start up of e-government but do affect e-government intensity*. The only context specific factor that seems to significantly impact on innovation within rather than on innovation between municipalities is the diffusion of broadband in the area where they are located (see coefficient of *BroadBand Share* in column 6 of Table 4). In other words, the degree of modernisation of network infrastructures (captured here at the provincial level) appears to be a sort of necessary condition for PAs to expand the range of digitalised services and to improve their quality. By contrast, the mere decision to start e-government activities (innovation between municipalities) turns out to be unaffected by the availability of broadband infrastructure (non significant coefficient of *BroadBand Share* in column 5). Embryonic development of e-government services can take place in the presence of relatively underdeveloped infrastructure, even in areas characterised by digital divide. However, more extensive and high quality services need broadband network services. Otherwise users would not be able to gain an effective access to information made available and the degree of interactivity of services would be undermined.

Sixth, *the decision to enter e-government activities is associated with a narrower range of internal capabilities, which are generally less complex, than capabilities needed to increase the intensity of digitalised services*. Differences in innovation between municipalities are not affected by the number of workers with experience in ICT nor by the efforts made to train existing workers. What seems to be important at this stage is that at least some activities of the local administrative body are EDP-based, and that at least part of these activities are carried out by means of in-house resources (see positive and significant coefficient of *Municipality InHouse ICT* and of *Municipality EDP-Based Activities* in the Probit regression, column 5). A possible explanation is that what is really necessary when taking the decision to start e-government services is to be able to understand the potentialities of technology and to activate links with external suppliers of technical skills and resources. Municipalities that engage in e-government do have an intranet and workers are connected to it (*Municipality Intranet*); however, no particular technical device or infrastructure is needed to enter this activity.

Increasing the range and quality of services is instead associated with a much wider set of more complex competencies (see OLS specification in the last column of Table 4). All the variables we have already mentioned are significantly associated also to innovation within local PAs. Other key variables are now at center stage. *Municipality ICT employees* and *Municipality ICT Training* are positive and significant here, reflecting the need to reinforce the human capital employed by the PA. Internal infrastructures also play a

stronger role when the intensity of e-government is considered: broadband access to the internet (*Municipality Broadband*) and the use of Open Source software solutions (*Municipality OpenSource*) are associated with the intensity of digitalised service provision. The former can be explained as a technical pre-condition to expand activities on the web. The latter is an indirect indicator of the quality of personnel using the new, far-from-being-established technology.

Finally, organisational competencies are also significantly associated with innovation within PAs, as indicated by the significance of *Municipality Interface* and of *Municipality Multichannel* in the last column of Table 4. The sign of the latter variable indicates that there can be complementarities between e-government and other channels used for communication with end-users.

## 6. Conclusions

Using evidence on some 1,176 municipalities in Italy, and combining several datasets on the characteristics of local PAs and of the territory in which they are located, we evaluate different factors associated to the development of e-government services.

We found that municipalities which got involved into e-government are larger, carry out more in-house ICT activities and are more likely to have intra-net infrastructures, relative to PAs that do not offer front office digitalised services. They are also generally located in regions with relatively large shares of firms using or producing ICT, where many other municipalities offer digitalised services, and where concentration of inhabitants in large cities or metropolitan areas is not very high. The range and quality of e-government services supplied by local PAs tend to increase with their stock of ICT competencies, with their efforts to train workers and with their ability to organise efficient interfaces with end-users. Moreover, there is a correlation between the range and quality of e-government services offered and the broadband infrastructure development of the geographic area in which local PAs are located.

In more general terms, the combination of internal competencies and context specific factors is different when explaining the decision to start e-government activities *vs.* the intensity of such activities. Regional factors, concerning both the demand and the supply of services, appear to affect only the decision to enter e-government activities. Competencies needed to expand and improve the quality of services are much more numerous and complex than the ones associated with the mere decision to start e-government activities.

The examined evidence is consistent with a view of e-government development as a process of gradual, step by step involvement, wherein municipalities initially engage into exploratory activities, favoured by an external context conducive to innovation and by very limited internal competencies. Once more efforts are made to expand and improve services supplied, more qualified competencies and more advanced environmental conditions need to be created. There is no guarantee that such circumstances occur, so that further development of e-government, now at the embryonic stage, is at risk. This calls for increasing investments in training, human capital formation and in hardware and software devices at the individual municipality level; and for greater efforts to improve the technological environment in which PAs are active, including investments to improve the quality and accessibility of digital communications networks.

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**Appendix A – Data source**

The data on the diffusion and usage of ICT at municipality level and on the on-line services offered through the official web sites of municipalities used in the econometric exercise are from two main surveys:

- *ICT-PA (Istat)*: it is the experimental survey on "Information and Communication Technologies in Local Public Administrations", conducted at the end of 2005. The survey is a census for municipalities with more than 60,000 inhabitants, and a sample survey for the others. The choice of the precision of the sample estimates has resulted in a sample of 874 municipalities. However, since some Regions and Provinces decided to extend the sample to the totality of their municipalities, the final sample is made of 3,323 units. Data collected refer to technological equipments (hardware, software, security), personnel and education activities in ICT, back office services, and connectivity;
- *EGOV (Cnipa)*: this dataset results from the survey carried out in 2005 by the Observatory of On-line Services (SOL), a teamwork of the National Centre for the Information Technology in the Public Administration (CNIPA), in cooperation with Istat. The survey uses the same sampling design of the survey on "Information and Communication Technologies in Local Public Administrations" described above. The only difference with respect to *ICT-PA* is that *EGOV* includes all the municipalities with more than 10,000 inhabitants, resulting in a final sample of 1,825 units. Using a web interactive survey platform, *EGOV* has collected information on 266 on-line services offered through the official web sites of municipalities. Elements of the on-line services investigated include the type of service, the economic and social area it belongs at, and the four categories reflecting the level of completeness of the entire process that can be reached on-line for that service by a user as explained in Section 4.1.

As to the sample, in both surveys the sampling design is stratified by region and class of demographic amplitude. Modalities of these variables represent the sampling frame, that is the planned domains of study which are population sub-groups for which estimates have been calculated. Hence, within each stratum the sample rate is computed in two steps. Firstly, it is calculated as the inverse probabilities of sampling given the actual response rate. Then, the final sample weight is calibrated using auxiliary variables with known domain distribution. The resulting estimates are statistically significant at regional level and, separately, class of demographic amplitude.

Data at regional level come from different sources:

- *ICT-FIRMS (Istat)*: it is the annual survey on the usage of Information and Communication Technologies by firms, conducted in application of the European Regulation (EC) no. 808/2005. The sampling design includes firms with 10 employees and more active in the following economic sectors: manufacturing (D); construction (F); wholesale and retail trade (G); hotels and restaurants (H); transport, storage and communication (I); real estate, renting and business activities (K); radio and television activities (O). The survey is a census for firms with more than 250 employees and a sample survey for smaller firms. The sampling design is stratified for level of economic activity, region of localization, and class of employees and includes more than 16,000 firms;
- *RESIDENT POPULATION (Istat)*: data on resident population come from the survey on "Municipal Resident Population by sex, year of birth and marital status", carried out by Istat since 1992 at Italian Population Registers. Data are available for all municipalities at http://demo.istat.it/index_e.html;
- *CENSUS-FIRMS (Istat)*: the 8th General Industry and Services Census conducted by Istat in 2001. Data are available at http://censimenti.istat.it/html/ind_home.asp;

- *MIUR*: data on graduates in ICT faculties come from the survey on university education carried out every year by MIUR (Italian Ministry for University and Research) available at http://statistica.miur.it/scripts/IU/vIU0.asp;
- *BROADBAND OBSERVATORY (Between)*: data on broadband diffusion are at provincial level. Figures are collected by the Broadband Observatory teamwork, a project created by Between in cooperation with the Italian Ministry of Innovation and Technologies and the Italian Ministry of Communication. It collects data on the availability of infrastructure, the diffusion of broadband services, and the demand for these services by households and firms at the level of the Italian Provinces.

**Appendix B – Model diagnostics**

As far as probit model is concerned specification tests are very important since in discrete choice models errors in specification can cause the estimators to be inconsistent (Yatchew and Griliches 1985).

Firstly, the use of regional-level explanatory variables may induce the multicollinearity problem. Whenever two or more predictors are correlated with one another, the coefficients cannot be uniquely estimated. The primary concern is that as the degree of multicollinearity increases, estimated standard errors increase and coefficients estimates become insignificant. To analyze multicollinearity, we use the variance inflation factor (VIF). As a rule of thumb, a variable for which the inverse of its VIF value is lower than 0.1 can be considered as a linear combination of other independent variables. In our case, the highest VIF value is 1.81, associated to the regional number of employees in ICT sectors relative to the national mean (*ICT Producer Ntnl Share Reg*), whose inverse is well above the tolerance level of 0.1.

Secondly, the presence of variables at municipality level in the probit specification, especially those related to the size of the municipality, can cause the error term to be heteroskedastic. This would render parameters estimates inconsistent. Here the problem is examined performing the Lagrange Multiplier test proposed by Davidson and MacKinnon in their 1984 paper. It consists in running a regression for the variance of the error term with the variables suspected to induce heteroskedasticity as regressors and then test the parameters vector of the variance model to be all equal to zero. The choice of the variables to be included in the variance regression is made considering first all the variables in the main equation of the probit model and then removing those which result to be individually not significant. At the end, two variables, *Municipality Size* and *Municipality Intranet*, turn out to be a potential source of heteroskedasticity. Then we estimate a heteroskedastic probit model including these two variables in the variance equation. Moreover, we use also heteroskedastic-robust standard errors to make the latter robust to other non-detected kinds of misspecifications. The 'heteroskedastic-robust' estimates are reported in the fifth column of Table 4. As expected, parameters estimates differ; nonetheless all covariates are still significant showing that the possible heteroskedasticity in the error term does not alter our results.

Diagnostics of the OLS model is rich as well. First of all, investigation of the VIF values associated to the OLS regressors suggests the absence of any correlation between the independent variables. Then, we examine normality and heteroskedasticity. As to the former, even if unbiasedness of OLS estimates only requires errors to be identically and independently distributed, normality is necessary for valid inference. Similarly, heteroskedasticity does not cause OLS coefficient estimates to be biased. However, the variance (and, thus, standard errors) of the coefficients tends to be underestimated, inflating t-scores and sometimes making insignificant variables appear to be statistically significant. Both visual inspection (*q-norm* plot[17] for normality and *residual-vs.-fitted* plot for heteroskedasticity) and statistical tests (the Shapiro-Wilk W test for normality and Breusch-Pagan test for heteroskedasticity) do reveal that the normality and the homoskedasticity assumptions need further attention. Then, our remedy has been twofold. First, a simple way to pick up some heterogeneity in data is to introduce macro-regions (North-

[17] *Q-norm* plots the quantiles of a variable against the quantiles of a normal distribution. For the details of all the diagnostic tests used here, see Greene, 2008.

East, North-West, Center and South, see Table 2 for composition) dummy variables. Since variables in OLS are all but one at municipality level, macro-regions dummies are likely to capture most of the localization effect on the dependent. Finally, we estimate robust standard errors.

Standardizing the values obtained for the regions of South Italy, a statistically significant deviation is reported for North-East regions (*Macroarea 2*) and Centre regions (*Macroarea 3*)[18] in comparison with the average value of the South, whereas the coefficient concerning North-West regions (*Macroarea 1*)[19] does not result to be significant (Table 4, last column). Then, outcomes show that e-government service supply provided by Italian municipalities (FOI) is a non-homogeneous and strongly asymmetrical process presenting intensities which vary according to the geographical localization of every municipality. Robust estimates (Table 4, last column) only cause the variable *Municipality Intranet* to become insignificant. Hence they corroborate the results showing that residual non-normality and heteroskedasticity do not eventually affect validity of our inference.

[18] Regions exhibiting the highest FOI levels are in the Central part (Tuscany and Marche) and in the North-West (Emilia Romagna, Trentino Alto Adige e Friuli Venezia Giulia) of Italy.

[19] It is much likely that this result is affected by the importance of Lombardy, located in *Macroarea 1*, which is characterized by a very high number of small municipalities showing low levels of the FOI.

**Table 1 – Distribution of the FOI Index across macro-regions, classes of municipality size, and classes of ICT investment**

| Variables<br>Classes[1] | Mean of the FOI Index |
|---|---|
| **Macro-Region** | |
| *Macroarea 1 (North-West Regions)* | 0.0267 |
| *Macroarea 2 (North-East Regions)* | 0.0581 |
| *Macroarea 3 (Center Regions)* | 0.0573 |
| *Macroarea 4 (Mezzogiorno Regions)* | 0.0294 |
| **Municipality Size** | |
| *Over 200,000 inhabitants* | 0.8169 |
| *Between 60,000 and 119,999 inhabitants* | 0.3141 |
| *Between 20,000 and 59,999 inhabitants* | 0.1644 |
| *Between 10,000 and 19,999 inhabitants* | 0.0921 |
| *Between 3,000 and 9,999 inhabitants* | 0.0452 |
| *Up to 2,999 inhabitants* | 0.0144 |
| **Investment in ICT** | |
| *Over 100,000 euro* | 0.1345 |
| *Between 30,000 and 99,999 euro* | 0.0518 |
| *Between 10,000 and 29,999 euro* | 0.0230 |
| *Up to 9,999 euro* | 0.0131 |

[1] As for the variables *Macro-Region* and *Municipality Size*, the choice of the classes is based on the classification adopted by Istat. Classes of the *ICT Investment* variable, instead, are made according to the quartile of the variable distribution so as to have intervals of (almost) the same amplitude.

**Table 2 – Variables description**

| Variable | Description | Year | Source of data |
|---|---|---|---|
| **Dependent variable** | | | |
| *Front-Office Index* | Municipality's E-gov level composite indicator | 2005 | EGOV (*Cnipa* ) |
| **Municipality characteristics** | | | |
| *Municipality Size* | Municipality's inhabitants | 2004 | RESIDENT POPULATION (*Istat* ) |
| *Municipality ICT Empl* | Number of municipality's employees who have the ability to develop, operate and maintain ICT systems; core activities of their job are related with ICT | 2004 | ICT-PA (*Istat* ) |
| *Municipality ICT Training* | Binary variable taking on the value 1 if municipality has sponsored at least one of the following training programs: office automation, operation systems, web, data management, and European Computer Driving License | 2005 | ICT-PA (*Istat* ) |
| *Municipality InHouse ICT* | Share of ICT-related activities operated with internal staff. ICT-related activities taken into account are: project management, software development, hardware management, software management, systems management, network management, database management, ICT-related security, web/internet technologies development and management, web content management, data entry, PC users assistance, ICT training, and e-commerce systems | 2005 | ICT-PA (*Istat* ) |
| *Municipality BroadBand* | Binary variable taking on the value 1 if municipality has broadband access to the Internet. We consider broadband as a transmission capacity that is faster than primary rate ISDN, at 2 Mb/s | 2005 | ICT-PA (*Istat* ) |
| *Municipality EDP-based Activities* | Share of internal activities operated through EDP-based systems | 2005 | ICT-PA (*Istat* ) |
| *Municipality Interface* | Binary variable taking on the value 1 if municipality has single EDP-based interface to the user (identified in Italy with the terminology *"Sportello Unico dell'Amministrazione Pubblica", SUAP)* | 2005 | ICT-PA (*Istat* ) |
| *Municipality OpenSource* | Share of open-source system software used. Software considered is: operative system software for server and that for PC desktop, office automation, web server, e-mail client, Data Base Management System, and security software | 2005 | ICT-PA (*Istat* ) |
| *Municipality Intranet* | Share of laptop and desktop PC logged in Intranet out of the total number of laptop and desktop PC | 2005 | ICT-PA (*Istat* ) |
| *Municipality Multichannel* | Binary variable taking on the value 1 if municipality uses at least a web-alternative channel to provide its services. Web-alternative channels are: call center, mobile technology such as SMS and WAP/GPRS/UMTS, and digital television | 2005 | ICT-PA (*Istat* ) |

**Table 2 – Variables description** *(cont.)*

| Variable | Description | Year | Source of data |
|---|---|---|---|
| **Regional and contextual characteristics** | | | |
| *Capital Share Reg* | Share of inhabitants living in the regional capital city out of the total regional population | 2006 | RESIDENT POPULATION (*Istat* ) |
| *Municipal E-gov Suppliers Reg* | Share of munucipality providing at least an E-gov service out of the total number of municipalities in the region | 2005 | ICT-FIRMS (*Istat* ) |
| *ICT User Share Reg* | Simple mean of shares of ICT user firms out of the total number of firms in the region. ICT is: using extranet, internal automated systems for purchases, internal automated systems for payments; using Internet for banking and financial services, staff training, and acquiring digital information and services; providing products catalogue on web site; purchasing products/services via Internet | 2005 | ICT-FIRMS (*Istat* ) |
| *E-gov User Share Reg* | Simple mean of shares of e-Gov user firms out of the total number of firms in the region. E-gov is using municipality web site to: obtain information; download formats; submit formats and complete the service process | 2005 | ICT-FIRMS (*Istat* ) |
| *ICT Producer Ntnl Share Reg* | Ratio of the number of employees in ICT sectors in that region to the national mean. To define the ICT sectors we follow the OECD classification. As for manufacturing, ICT sectors include: manufacture of office, accounting and computing machinery (sector 3000 based on ISIC Rev. 3.1), manufacture of insulated wire and cable (sector 3130), manufacture of electronic valves and tubes and other electronic components (sector 3210), manufacture of television and radio transmitters and apparatus for line telephony and line telegraphy (sector 3220), manufacture of television and radio receivers, sound or video recording or reproducing apparatus, and associated goods (sector 3230), manufacture of instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process control equipment (sector 3312), and manufacture of industrial process control equipment (sector 3313). As for services, ICT sectors are wholesale of computers, computer peripheral equipment and software (sector 5151), wholesale of electronic and telecommunications parts and equipment (sector 5152), telecommunications (sector 6420), renting of office machinery and equipment, including computers (sector 7123), and computer and related activities (sector 72) | 2001 | CENSUS-FIRMS (*Istat* ) |
| *ICT Degrees Ntnl Share Reg* | Ratio of the number of graduates in ICT faculties in that region to the national mean. According to the OECD definition, ICT faculties include: engineering and engineering trades, manufacturing and processing, architecture and building, life sciences, physical sciences, mathematics and statistics, and computing | 2005 | MIUR |
| *BroadBand Share* | Share of population out of the total provincial population reached by at least a broadband access provider | 2004 | BROADBAND OBSERVATORY (*Between* ) |

**Table 2 – Variables description** *(end)*

| Variable | Description | Year | Source of data |
|---|---|---|---|
| **Macro-Regional dummies** | | | |
| *Macroarea 1* | Dummy for north-west regions: Valle d'Aosta, Lombardia, Piemonte, and Liguria | - | - |
| *Macroarea 2* | Dummy for north-east regions: Veneto, Friuli-Venezia Giulia, Trentino-Alto Adige, and Emilia Romagna | - | - |
| *Macroarea 3* | Dummy for center regions: Toscana, Umbria, Lazio, and Marche | - | - |
| *Macroarea 4* | Dummy for Mezzogiorno regions: Abruzzo, Molise, Campania, Basilicata, Puglia, Calabria, Sicilia, and Sardegna | - | - |

**Table 3 – Descriptive statistics**

| Variable | Number of observations | Mean | Standard deviation | Min | Max |
|---|---|---|---|---|---|
| **Dependent variable** | | | | | |
| *Front-Office Index* | 1176 | 0.087 | 0.168 | 0 | 2.02 |
| **Municipality characteristics** | | | | | |
| *Municipality Size* | 1176 | 24.63 | 101.30 | 0.08 | 2,553.9 |
| *Municipality ICT Empl* | 1176 | 2.79 | 11.13 | 0 | 208 |
| *Municipality ICT Training* | 1176 | 0.23 | 0.42 | 0 | 1 |
| *Municipality InHouse ICT* | 1176 | 0.46 | 0.35 | 0 | 1 |
| *Municipality BroadBand* | 1176 | 0.36 | 0.48 | 0 | 1 |
| *Municipality EDP-based Activities* | 1176 | 0.38 | 0.13 | 0.02 | 1 |
| *Municipality Interface* | 1176 | 0.23 | 0.42 | 0 | 1 |
| *Municipality OpenSource* | 1176 | 0.19 | 0.27 | 0 | 1 |
| *Municipality Intranet* | 1176 | 0.44 | 0.46 | 0 | 1 |
| *Municipality Multichannel* | 1176 | 0.13 | 0.33 | 0 | 1 |
| **Regional and contextual characteristics** | | | | | |
| *Capital Share Reg* | 21 | 16.00 | 11.12 | 4.73 | 48.46 |
| *Municipal E-gov Suppliers Reg* | 21 | 0.12 | 0.08 | 0.02 | 0.35 |
| *ICT User Share Reg* | 21 | 0.25 | 0.04 | 0.20 | 0.31 |
| *E-gov User Share Reg* | 21 | 0.92 | 1.29 | 0.31 | 6.12 |
| *ICT Producer Ntnl Share Reg* | 21 | 0.82 | 0.31 | 0.44 | 1.76 |
| *ICT Degrees Ntnl Share Reg* | 21 | 0.97 | 0.32 | 0.18 | 1.80 |
| *BroadBand Share* | 103 | 0.79 | 0.13 | 0.41 | 0.99 |

**Table 4 – Estimation results: Probit and OLS**

| Variable | Full Models | | Selected Models | | Heteroskedastic Robust Estimates | |
|---|---|---|---|---|---|---|
| | Probit | OLS | Probit | OLS | Probit | OLS |
| | *1* | *2* | *3* | *4* | *5* | *6* |
| **Municipality characteristics** | | | | | | |
| *Municipality Size* | 0.065*** | 0.001** | 0.070*** | 0.001** | 0.094*** | 0.001** |
| | *0.009* | *0.000* | *0.008* | *0.000* | *0.015* | *0.000* |
| *Municipality ICT Empl* | 0.062 | 0.010** | | 0.010** | | 0.011** |
| | *0.062* | *0.004* | | *0.004* | | *0.005* |
| *Municipality ICT Training* | -0.077 | 0.192** | | 0.196** | | 0.177** |
| | *0.133* | *0.094* | | *0.094* | | *0.090* |
| *Municipality InHouse ICT* | 0.381** | 1.053*** | 0.447** | 1.058*** | 0.560** | 1.063*** |
| | *0.192* | *0.140* | *0.178* | *0.137* | *0.219* | *0.136* |
| *Municipality BroadBand* | -0.047 | 0.255*** | | 0.220*** | | 0.251*** |
| | *0.109* | *0.084* | | *0.082* | | *0.330* |
| *Mun. EDP-based Activities* | 1.232*** | 0.710** | 1.220*** | 0.641** | 1.292*** | 0.720** |
| | *0.419* | *0.333* | *0.413* | *0.331* | *0.456* | *0.331* |
| *Municipality Interface* | 0.056 | 0.300*** | | 0.295*** | | 0.281*** |
| | *0.131* | *0.091* | | *0.090* | | *0.084* |
| *Municipality OpenSource* | 0.034 | 0.303** | | 0.341** | | 0.265* |
| | *0.239* | *0.151* | | *0.149* | | *0.152* |
| *Municipality Intranet* | 0.276** | 0.175* | 0.261** | 0.195** | 0.556** | 0.124 |
| | *0.123* | *0.095* | *0.119* | *0.092* | *0.220* | *0.094* |
| *Municipality Multichannel* | 0.258 | 0.312*** | | 0.288** | | 0.288*** |
| | *0.200* | *0.112* | | *0.111* | | *0.106* |
| **Regional and contextual characteristics** | | | | | | |
| *Capital Share Reg* | -0.019*** | -0.001 | -0.020*** | | -0.021*** | |
| | *0.005* | *0.005* | *0.005* | | *0.006* | |
| *Municipal E-gov Suppliers Reg* | 2.642*** | 0.176 | 2.717*** | | 3.216*** | |
| | *0.655* | *0.466* | *0.629* | | *0.690* | |
| *ICT User Share Reg* | 1.696 | 1.729 | 2.590* | | 2.944* | |
| | *1.729* | *1.437* | *1.475* | | *1.758* | |
| *E-gov User Share Reg* | 0.058 | 0.081 | 0.104** | | 0.124** | |
| | *0.077* | *0.072* | *0.051* | | *0.052* | |
| *ICT Producer Ntnl Share Reg* | 0.392* | -0.169 | 0.483** | | 0.484* | |
| | *0.23* | *0.197* | *0.210* | | *0.251* | |
| *ICT Degrees Ntnl Share Reg* | 0.254 | -0.234 | | | | |
| | *0.274* | *0.268* | | | | |
| *BroadBand Share* | 0.163 | 1.021*** | | 0.772** | | 0.897** |
| | *0.46* | *0.387* | | *0.338* | | *0.376* |
| *Constant* | -2.037*** | -5.219*** | -1.987*** | -4.872*** | -2.293*** | -5.094*** |
| | *0.480* | *0.446* | *0.412* | *0.303* | *0.486* | *0.334* |
| *Macro-Regional Controls* | NO | NO | NO | NO | YES | YES |
| *Num. Obs.* | 1176 | 815 | 1176 | 815 | 1176 | 815 |
| *Pseudo* $R^2$ / $R^2$ | 0.322 | 0.343 | 0.318 | 0.338 | | 0.352 |
| *LR-test (Wald) / F-test* | 466.29 | 24.44 | 461.62 | 37.24 | (134.88) | 33.99 |