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An Analysis of the Adoption of Open Source Software by Local Public Administrations:

Evidence from the Emilia-Romagna Region of Italy

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Abstract

The wide diffusion of open source software (OSS) is driving discussion among scholars on a set of issues, including its adoption by public administrations (PA). Previous works only discussed one or a few factors that drive the decision to adopt OSS and did not addressed the potential benefits in terms of e-government that OSS may bring to PA. Our paper attempts to fill these gaps. The analysis is based on the Emilia-Romagna region of Italy and studies the adoption of software (both proprietary and open source) by local PA. The results show there is increased adoption of OSS in several different domains of application, both servers and desktop clients. Among the motivations to adopt OSS, only dependence on software suppliers seems to be important. Its adoption also positively affects the variety and extent of interactivity of local public e-services.

INTRODUCTION

Open source software (OSS) has grown in importance based on its wider diffusion and its reliability, both of which have improved at an outstanding pace at the public and private levels (Lerner et al., 2006; Fosfuri et al., 2008; Giuri et al., 2010). This increased use includes general users, private enterprises and public administrations (PA) which appreciate and are coming to rely on the advantages characterizing this alternative method of software production (Bonaccorsi & Rossi, 2003). This upsurge in interest in OSS has been accompanied by lively debate on the role of OSS in PA, which has attracted the interest of policy makers and practitioners in the field, and scholars in several disciplines ranging from computer science to economics (Von Krogh & Spaeth, 2007; Cassell, 2008; Federspiel & Brincker, 2010).

A large part of this interest is directed to the reasons for its adoption by PA (Waring & Maddocks, 2005; Ven et al., 2007; Huysmans et al., 2008; Cassell, 2008; Munoz-Cornejo et al., 2008). These contributions only concentrate on few factors that explain the adoption of OSS by PA. An evident gap in our knowledge is left relating to all of the relevant factors that are likely to explain the pattern of adoption as well as the benefits it may bring.

Our study aims to begin to fill these gaps by providing an empirical assessment of the adoption of OSS by local PA, those located in the Emilia-Romagna region in Italy. In particular, our main research objective is to provide evidence on the numerous factors that are likely to spur adoption of OSS at the level of local PA. Furthermore, we aim at investigating the benefits that this adoption entails.

Municipal governments are chosen as the main unit of analysis for several reasons. First, the budgets of local PA are shrinking which is obliging them to find new ways to manage these reduced central government resources more efficiently (Arduini et al., 2010). The necessity to save money can be alleviated by the adoption of OSS which saves money related to licensing costs (Mukerji et al., 2006). Moreover, local PA provide important public services to citizens, which means that they are often in direct contact with them. This allows them to collect opinions and feedback on changes to the quality of service from migration to OSS. Furthermore, local PA are often the most important customers of local small and medium sized enterprises (SME) providing software products and services (Laursen & Salter, 2006). Thus, their demand for software solutions may be an important driver of local industry development and, in particular, of firms providing OSS products and services. Finally, PA are under increasing pressure from national and international organizations (OECD, 2003; EC, 2006; UN, 2010), to improve their e-government provision and, in this area, OSS may have an important role to play.

This paper contributes to the literature on the adoption of OSS by PA. Our contribution is twofold. First, unlike many previous works that have focused on one or a few factors driving the decision to adopt OSS, we provide an empirical investigation taking into consideration several factors influencing the adoption of OSS by PA and we find evidence for the important role of suppliers in this decision. To our knowledge, this is one of the few attempts to provide a systematic empirical analysis of the topic. Second, we focus on a crucial issue and examine whether the adoption of OSS by PA has an impact on the level of e-government of the PA. We

show that the extent of OSS adoption has an impact on the variety and quality of local public e-services.

The paper is organized as follows. Section 2 reviews the literature, especially on the most recent developments concerning the adoption of OSS by PA. On this basis, we propose a conceptual model aimed at explaining the determinants of OSS adoption in local PA and the relationship with e-government performance. Section 3 describes the study methodology, including the main features of the survey that collected the data. Sections 4 and 5 present and discuss the principal findings, followed by a concluding section.

THEORETICAL BACKGROUND

Literature review

This section reviews the recent literature on the adoption of OSS by PA. We show that although some studies have been conducted, all of them examine only few of the many factors that explain the adoption of OSS by PA. Furthermore, there is still a lack of research on an important issue such as the realised benefits that OSS adoption may entail on the PA. Although the literature reviewed uses all kinds of PA as the unit of analysis, here we focus in particular on local government. We believe that local administrations in the form of municipal governments should be the focus of attention because of their important role in the provision of specific public services and the fact that they deal directly with citizens. Most existing work on OSS does not focus on the impact of OSS adoption and the factors driving adoption decision at the local level. This section discusses the recent literature and highlights the most important insights. Based on

this we propose a conceptual model to address two main issues: (i) the determinants of local government decisions to adopt OSS; and (ii) the effect of this decision on the level of e-government. The literature survey highlights the main determinants of OSS adoption by PA. We indicate the innovativeness of our study compared to the existing literature.

The adoption of OSS by PA has been heavily debated by both public administrators and scholars (Von Krogh & Spaeth, 2007; Federspiel & Brincker, 2010). For example, Lewis (2004, 2006, 2007, 2008) provides an empirical account of policies that public administrators put in place and aimed at supporting OSS. Three findings in particular are notable: (i) European countries experience the highest number of proposed and approved initiatives concerning OSS adoption by PA; (ii) the most widely diffused policies are advisory policies, preference policies and research policies; and (iii) policies targeting mainly local PA are gaining momentum.[i]

In the scientific literature, the focus has been on the role of PA relative to OSS. Its main concern is to understand why PA should adopt OSS solutions and how migration to OSS should be implemented. In this vein, Mukerji et al. (2006) provide a literature review highlighting the main benefits and challenges relating to the adoption of OSS by governments in both developed and developing countries. Its main contribution is in providing a list of the perceived benefits and challenges of using OSS. In terms of benefits, reduced licence fees are the most popular. Also, reduced dependence on suppliers of proprietary software is a popular argument for the adoption of OSS by PA. Finally, the possibilities to customize the software due to the availability of source code (customizability) and to run it on older computer systems (scalability) are among the

most prominent advantages. In terms of challenges, PA are usually very concerned about efficient customer support and accountability, at least in relation to OSS not supported by private companies. Also, the total cost of ownership (TCO) of OSS solutions compared to proprietary ones, is not always clear. Finally, lack of in house high-level technical skills is often a barrier to the adoption of OSS by PA.

Although it provides some important insights on the topic, the work referred to above is descriptive in nature and quite general in scope. A more specific work by Waring & Maddocks (2005) studies the use and implementation of OSS in the UK public sector, through case studies of six local governments and two central PA. Although the authors find a high degree of variability in OSS adoption and implementation, they find support for the claim that adoption of OSS by PA is related to both long and short-term cost savings, and greater scalability and customizability.

In line with these findings, Cassell (2008) investigates why local governments choose to migrate to OSS and the factors affecting the implementation process. This is a comparative case study based on migration to Linux by four municipal administrations in Europe. The reasons driving the migration decisions are reduction in dependence on private software suppliers and lower licence costs. Cassell (2008) finds that the organizational structure of the PA and the views and perspectives of personnel are the greatest influences in the implementation of OSS. Results are similar for the adoption and use of OSS in health care organizations, including lower software acquisition costs and the possibility to modify, combine and tailor the software to the

specific needs of the organization (Fitzgerald & Kenny, 2004; Valdes at al., 2004). One notable exception refers to the increased interoperability among different data standards that is seen as an additional determinant of OSS adoption (Kantor et al., 2003). An additional reason for the adoption of OSS is provided by a more generalizable study that provides empirical data collected through a survey and interviews (Munoz-Cornejo et al., 2008). The authors investigate the reasons for OSS adoption in 30 hospitals in the US and show the positive role played by software vendors in health system procurement decisions. Contrary to the common argument related to the dependence on suppliers of proprietary software, the authors find that software vendors are the initial factors facilitating the adoption of OSS in hospitals.

Finally, another important aspect in the decision to adopt OSS by PA is highlighted in work that takes the Belgian government as the unit of analysis (Ven et al., 2007; Huysmans et al., 2008). In particular, Ven et al. (2007) study migration from desktop operating systems based on proprietary software to OSS, in the Belgian federal government department of justice. This study points to the important function of government guidelines. This refers to the recommendations of the Belgian government for greater use of open standards and OSS in the procurement decisions of government departments. In a study of the decision by the Belgian federal public service economy about whether to adopt OSS as the main office suite, a similar argument is made (Huysmans et al., 2008).

Table 1 presents a taxonomy of the main contributions relating to the adoption of OSS by PA. The literature is organized in order of relevance. Overall, we believe that the determinants of

OSS adoption by PA and reported above can be grouped into three main categories: (i) economic determinants (e.g. reduced license costs, role of suppliers); (ii) technical determinants (e.g. customizability, improvement of users' technical skills) and (iii) institutional determinants (e.g. government guidelines).

As evidenced in the table, none of the studies examined all of the three groups of determinants all together. In particular, most of the factors influencing adoption of OSS by PA were identified separately and the extant literature provides no guidance on how these factors are interrelated. Furthermore, to date, no study focused on a rather crucial issue, that is the existence of any realised benefit of OSS adoption for the adopting PA. Thus, we suggest that these are two of the most important gaps in our current knowledge of the phenomenon and our work aims at filling these.[ii]

Theoretical framework

To try to fill these gaps, we propose a conceptual model that takes account of the factors proposed in the literature that drive the decision of PA to adopt OSS. We moreover argue that OSS adoption could have an impact on the provision of e-government services by local PA and we include this relationship in the model. The model is tested empirically using the results from a large survey of local municipal governments in the Emilia-Romagna region of Italy.

The conceptual model is grounded on the results from the literature on OSS adoption by PA. Figure 1 depicts the model. The model contains four main constructs ("explanatory

variables", "controls", "OSS adoption" and "e-government performance") and four hypothesized relationships between the constructs (H1.a, H1.b, H2.a and H2.b).

The determinants of OSS adoption

The construct explanatory variables contains the most important determinants of OSS adoption by PA as they are presented by the relevant literature. The construct OSS adoption represents the decision made by a local PA to adopt OSS inside the organisation. This represents not only a decision of adoption or not, but also a decision on the extent of this adoption. We assume a strong link between the explanatory variables and adoption of OSS (hypothesis H1.a). Specifically, we contend that several factors contribute to the decision to adopt OSS at the level of local PA.

First, the adoption of OSS reduces expenditure on information technology (IT) by reducing the licence fees paid to proprietary software vendors (Ven et al., 2007; Cassell, 2008; Huysmans et al., 2008). Companies developing proprietary software usually charge high licence fees to cover development costs and ensure profit. OSS is basically a free alternative to proprietary software and, for this reason, an organization wanting to reduce the amount of licence fees paid will benefit from OSS adoption (Waring & Maddocks, 2005). Cost savings must thus be seen as an important determinant in the decision to adopt OSS.

Second, the adoption of OSS is likely to reduce dependence on firms developing proprietary software. Several studies show that dependence on a single software provider makes systems more vulnerable and that adopting OSS is a way of reducing this dependence on few

software providers (Mukerji et al., 2006; Ven et al., 2007; Cassell, 2008). On the other contrary, in some cases software vendors play a positive role in OSS procurement decisions. If this is the case, suppliers become the initial factors facilitating the adoption of OSS by local PA (Munoz Cornejo et al., 2008).

Third, the willingness to improve the programming skills of the employees of the PA (improvement of users' technical skills) can result in a higher probability of adopting OSS. Indeed, the adoption of OSS by a PA enables access to source code, which can result in more intensive development of in-house and user technical skills (Waring & Maddocks, 2005; Rossi et al., 2008).

Fourth, PA are able to take advantage of the development of internal skills and interaction with the OSS communities in order to modify software source code to suit their specific needs (Waring & Maddocks, 2005; Mukerji et al., 2006). This can result in a stronger pressure to adopt OSS by PA that are particularly interested on software customisation.

Finally, in some cases, the use of OSS by PA might be imposed by guidelines issued by a different administration (government guidelines), usually with a superior role. In particular, recommendations favouring the use of open standards and OSS aimed at facilitating communication between local PA and citizens and at reducing operational costs has been found to be consistent with decisions to migrate to OSS (Ven et al., 2007; Huysmans et al., 2008).

Although the conditions described above are likely to impact on the likelihood and extent of OSS adoption by PA, other factors may have an effect on this relationship, factors that

primarily reflect the resource endowments of PA. These factors are contained in the construct Controls and a link between this and the construct OSS adoption is hypothesized (hypothesis H1.b). The name of the construct derives from the fact that the strength of the relationship between controls and OSS adoption is likely to be weaker than that between the explanatory variables and OSS adoption and, for this reason, we are more interested in controlling for them than in estimating their impact on the adoption of OSS like for hypothesis H1.a. The construct controls include several factors.

First, local PA has an incentive to adopt OSS only if the municipality is endowed with a high-speed internet connection (broadband infrastructure). This is related to factors such as the possibility to download OSS for free from the internet and the necessity to interact with online communities to obtain feed-back and help (Bonaccorsi & Rossi, 2003).

Second, it has been suggested that OSS systems make considerably lower demands on in-house support and administration staff, allowing adopters of OSS to manage more hardware than IT administrators who do not use OSS. Thus, the ability to reduce administrator workload and allow a greater number of PCs to be administered by the same number of administrators would seem to be a benefit of using OSS in an organization (server management). In their survey of European PA, Ghosh & Glott (2005) found that PC-per-administrator ratios are much higher among OSS users than among non-users, indicating that OSS adoption may allow a lower administrative workload per machine.

Third, increased investment in capital goods reflects learning by doing and permits an organisation to produce its output more efficiently (Arrow, 1962). Such investment also promotes an organisation's "absorptive capacity" (Cohen and Levinthal, 1989). Lieberman (1984) has likewise argued that capital investments can be construed as absorption of new technology. An organisation's capital investment history and its accrued performance reflect accumulated experience, which in turn reflects a propensity to allocate capital expenditures to new technologies such as open source. This argument is analogous to that of Pennings and Harianto (1992), who find that prior investments in information technology affect the decision to adopt a new innovation. We contend that the propensity to adopt open source by PA is a function of its amount of expenditures in software and hardware. In particular, local PA with large software and hardware budgets are more likely to evaluate different products and services. For this reason, PA that previously used only proprietary software might be willing to try OSS and increase adoption in this way. On the other side, local PA, with few investment possibilities, may be more inclined to adopt OSS because of the marginal benefits (compared to better off PA) to be obtained from using zero-cost software.

Furthermore, size is identified as one the most important organizational characteristic predicting innovation adoption among organizations (Fagerberg et al., 2005; Naranjo-Gil, 2009). Thus, we expect that size of the organization will be an important factor related to the adoption of new systems such as OSS.

An innovation comes into an organization from outside usually via an early adopter (Rogers, 2003). Early adopters are respected people in their organization that others are willing to follow in their adoption decision. Furthermore, early adopters do not only act as role models, if in a position of power inside the organisation they also enforce the adoption of the innovation (Damanpour & Schneider, 2008). In line with these arguments, we assume that the decision to implement OSS in a local PA can be driven by a particularly enthusiastic employee, i.e. an early adopter, who is familiar with OSS through experience in work or as a hobby. If this person is in a position where he or she is able to influence the decision to adopt OSS, this may increase the probability of adoption by a local PA (specific provisions in favour of OSS adoption).

In the literature on PA, back-office refers to the tasks dedicated to running the administration that do not imply interaction between the agency and citizens. This implies government-to-government interaction as opposed to the more visible government-to-citizen interaction typical of front-offices. Specifically, back-office operations may require information exchange and knowledge sharing between various units, departments or organizations. PA with well-developed back-office structures might be more eager to use OSS because of the stronger reliance on open standards. Indeed, the ability to read and exchange data without encountering problems is an advantage that can be fully exploited by OSS use (Cerri & Fuggetta, 2007).

Overall, hypothesis H1.a and H1.b contribute jointly to our first research question: which among the many factors put forward in the extant literature contribute to increase the propensity to adopt OSS by local PA? Moreover, as a corollary to this, we ask whether it exists a different

behaviour in the pattern of adoption of OSS for servers compared to the adoption for desktop clients. A different behaviour is likely to point out evidence of a path of adoption of OSS by local PA.

The relationship between OSS adoption and e-government performance

The second relationship depicted in Figure 1 (hypothesis H2.a and H2.b) relates to the realized benefits from OSS adoption on the level of e-government of the PA. Providing a clear-cut definition of e-government is beyond the scope of the present work; suffice it to say that it relates to the role of ICT in making government services more accessible, more relevant to both citizens and firms, and more responsive to their needs. These objectives can be achieved only if a rich mix of IT capabilities, competencies and organizational administrative practices is implemented (Williams, 2008).

In our view, OSS software is an important instrument aimed at promoting e-government best practices. The European Commission has clearly stated that some of the most important characteristics of OSS such as availability of the source code, software reuse, efficiencies in the cost of development and license savings make it a key enabler for the spread of e-government services.[iii] According to this view, by reducing the costs of installing and maintaining software applications, OSS can help spread good practices in e-government more quickly. Here we test whether this argument can be supported (hypothesis H2.a). In particular, we expect the extent of OSS adoption by local PA to exert an influence on the levels of e-government via different channels.

First, by implementing OSS, a public administration can save on licence fees leaving more financial resources that can be used in other ways and especially for investment in the development of e-government (Comino et al., 2007).

Second, an increase in the adoption of OSS means that more and more employees in a particular PA are using OSS, thus improving their computer literacy. This can be interpreted as investment in human capital and can have beneficial effects in terms of improved e-government services through the delivery of improved services to citizens and firms (Moon & Norris, 2005; Damanpour & Schneider, 2008).

Third, the adoption of OSS by a PA allows employees with high technical skills in informatics (mainly programming skills) to modify the source code of the software allowing them to provide solutions tailored to PA and customers particular needs (Schedler & Summermatter, 2007).

Several other features may also be at work, which are likely to increase personal productivity and thus e-government performance. For example, OSS is believed to be more reliable (with higher quality and security) than proprietary alternatives, mainly because of the distinctive features of its development process (Waring & Maddocks, 2005; Mukerji et al., 2006).

Another benefit of OSS is that it has an impact on e-government performance due to its scalability. OSS programs can run on older hardware systems, which means that their implementation can save on frequent and expensive hardware upgrades leaving more money to

invest in the development of the e-government infrastructure (Irani et al., 2007; Chan et al., 2008).

Also, OSS relies mainly on open standards. Given that e-government frequently requires the ability to read and exchange data easily, OSS adoption may enable better ways to exchange and store public data. Open source code means that the user, as well as any other interested party, can check whether the program is well written and, if appropriate, can identify elements of danger for the stability and security of the code, and the software program as a whole. Given the importance for e-government of developing systems that do not allow external checking or undesirable release of information to third parties, adoption of OSS may contribute to better instruments for control, given the possibility of the user being able to inspect the code (Cerri & Fuggetta, 2007).

Finally, permission to modify the source code, which is a specific characteristic of OSS, implies software reuse (Haefliger et al., 2008). Software reuse allows PA that have adapted OSS to their particular needs, to transfer customized software to other PA, implying lower customization costs. The importance of software reuse within public administrations has already been observed in Ghosh et al. (2008). According to their results, 10% of European PA were willing and capable to release their software as open source. In line with this argument is the finding reported by Comino et al. (2010) who analyze the Open Source Observatory and Repository for European public bodies (OSOR) and find evidence of software reuse both within

and among European public administrations at different levels of government. For this reason, we expect the decision to adopt OSS to impact on the level of e-government.

The relationship between the use of OSS and performance in e-government is depicted in Figure 1. There is a causal relationship between the OSS adoption and E-government performance constructs, which are the variables of interest. We also expect the set of controls to influence the new outcome variable (hypothesis H2.b). This is the reason for the arrow linking Controls to E-government performance. This argument is supported by the findings of Arduini at al. (2010) who show that municipalities which get involved into e-government tend to be larger and to carry out more in-house ICT activities compared to those not involved into e-government. Moreover, they find a correlation between the range and quality of e-goverment services offered and the development of broadband infrastructure.

The conceptual model discussed above becomes an empirical model for estimation purposes. This involves transforming its main factors into well-defined variables that can be measured through appropriate indicators. Overall, the present work provides important, preliminary answers to the following research questions: (i) What are the factors affecting the decision of municipal governments to adopt OSS? Does it exist a particular path of adoption? (ii) Are there any benefits to be realized in terms of e-government implementation?

In Section 3 we explain how the conceptual model is operationalized based on data collected on the Emilia-Romagna region in Italy.

METHODOLOGY

To test the theoretical model derived from the literature, we collected data on local PA in Emilia-Romagna. This is a well-developed area of North-eastern Italy and one of the most dynamic areas in the country with above the national average Gross Domestic Product (GDP) per capita and annual GDP growth (Santarelli, 2004). In recent years this area has been characterized by strong investment to modernize local PA (Arduini et al., 2010). Investments include an optical fibre broadband infrastructure dedicated to the specific needs of PA which connects the whole territory, the adoption of specific regulations at regional administrative level, relative to information society issues and to a strong tradition of efficient and innovative PA. Finally, the Emilia-Romagna regional administration has been very active in the area of Information and Communication Technologies (ICT) and OSS, funding and directing several projects to understand these phenomena for the formulation of policy.[iv] The regional administration of Emilia-Romagna promoted and coordinated a European-wide project aimed at developing and exploring a set of key regional information society indicators with a particular focus on e-government issues, i.e. the UNDERSTAND project (Williams, 2008). Six other European regions participated in this project: Apulia (Italy), Comunidad Valenciana (Spain), Hessen (Germany), Wielkopolska (Poland), Wales (UK), and Yorkshire and Humberside (UK).

In line with our main research goal, the level of analysis is the local level of government, i.e. municipalities. Municipalities located in Emilia-Romagna region provide numerous basic services to citizens, such as sanitation, water, road maintenance, schools, food inspection and

other health related issues, and transportation. Data were collected in collaboration with the general administration of the Emilia-Romagna region and the regional competence centre for e-government and the information society (CRC).

First, in-depth, face-to-face interviews were conducted with six actors in the area of OSS adoption by the PA at the beginning of 2006. Table 2 lists job titles, size and type of organisation for each informant.

Each informant was interviewed once. The duration of interviews was 45 to 60 minutes; they were conducted by two people, with one researcher posing the questions and the other taking notes and asking supplementary questions. The interview protocol was designed following the theoretical model depicted in Figure 1. In particular, the four constructs were at the centre of questions specifically designed for face-to-face interviews. Table 3 links the constructs presented in Figure 1 to the relevant questions contained in the interview protocol.

In the first 10 to 15 minutes of the interview informants were asked about their general experience with OSS in their organizations. This provided information on a range of issues, which could be observed empirically, and allowed informants' insights to be compared with those of others. In the second part of the interview, informants were asked for detailed experience based on a list of questions related to the specific interest of the research: (i) factors affecting the decision to adopt OSS; (ii) the benefits the PA obtained from OSS adoption. During interviews, shorthand notes were taken which were transcribed following the interviews. Both

authors read the interview transcripts and used them to create a vocabulary describing the most important issues faced by PA in relation to OSS.

In particular, the interview data were analysed using two methods. First, the data obtained by dichotomous questions (e.g. “Does your organisation use OSS?”) and questions that required the respondents to provide specific categories (e.g. “What are the main OSS programs used by your organisation?”) were analysed by calculating descriptive statistics, such as measures of centrality and dispersion. Second, the narratives obtained by way of open-ended questions (e.g. “In your experience, what are the main factors driving the decision to adopt OSS?”) were coded and analysed. This included the coding of individual interviews data using the open coding technique in order to identify major themes and categories (Strauss & Corbin, 1990), development of summary sheets for each interview, and development of cross-interview data tables.

The purpose of the interviews was to obtain background information about OSS adoption in local municipalities located in Emilia-Romagna region and to collect opinions and experience that might confirm or deny the results in the literature. The perceived advantages and disadvantages concerning OSS adoption by local PA were discussed in depth. Overall, the interviews confirmed the results in the literature.

On the grounds of the results obtained in the qualitative part of the study, we built up a questionnaire with the purpose to submit it to local municipalities of Emilia-Romagna region. Questions contained in the questionnaire aimed at providing measures of the constructs of the

theoretical model. These measures were extracted by the results obtained in the qualitative study. In particular, we exploited information concerning the most diffused typologies of OSS programs and the most cited determinants of OSS adoption.

We conducted a survey of 341 municipalities, via a questionnaire submitted to the IT managers. The questionnaire was administered electronically and was available for on-line completion between May and June 2006. A total of 90 responses was obtained, yielding a response rate of 26.4%, which is considered good for on-line questionnaires (Czaja & Blair, 2005). Our tests show that there are no statistically significant differences between the distribution of sample units across provinces and population classes and the corresponding distribution of the 341 units constituting the population of reference ($\chi2(3)=5.18$ and $\chi2(8)=7.12$, respectively). Hence, our survey enabled reasonable sample size appropriate for statistical analysis, yielding results that are generalizable to the whole population of local municipalities located in Emilia-Romagna region.

The questionnaire was aimed principally at collecting detailed data on the software, proprietary as well as open, installed on the hardware infrastructures of the organizations and to obtain information on the typology and extent of OSS adoption by local PA. We also asked about software solutions relating to the number and the typology of proprietary software and OSS in different domains of application, such as operating system, web browser, mail client, office automation, web server, mail server, file server, as well as domain specific and dedicated software. Overall, 20 different types of software programs were identified. For convenience, we

group them into three main categories according to their domain of application: (i) general purpose software installed on desktop clients; (ii) software installed on server machines; (iii) domain-specific software (dedicated software).

The data collected through the survey allowed us to compute a simple index, defined as the intensity of OSS adoption, based on number of OSS installations over total number of software installations (both open source and proprietary). This index provides a measure of the theoretical construct OSS adoption and, as shown in Section 4, can be used to disentangle marginal adoption of OSS from more consistent and effective use. It should be noted that this proxy does not only measure PA adoption decision (i.e. whether or not a particular municipality adopts OSS tout court), but it takes advantage of the information collected and measure the extent of OSS adoption.

The data obtained from the questionnaire were integrated with information on the state of the art in ICT from the local PA that had participated in the UNDERSTAND project (Williams, 2008). The project studied the local PA in Emilia-Romagna. Information was collected in eight broad categories: on-line and interactive services; monitoring of services usage; organization and human resources; ICT training; ICT systems; ICT policies; Internet/broadband connection; and barriers to ICT usage. The combination of the different data sources allowed us to build a unique dataset containing important information about the adoption of OSS by local PA.

Table 4 presents the main attributes proposed in the conceptual model depicted in Figure 1, and describes the variables used to proxy for them. In the same table we provide a reference to

the theoretical rationale behind the choice of the measure. Finally, we indicate the data source from which the measure was extracted.

Descriptive statistics concerning the variables are provided in Table 5; Table 6 shows the extent of correlation among the variables proposed.

Data collected through the survey is analysed in three ways. First, we provide a preliminary description of OSS adoption by local PA in our sample by means of univariate analysis. In particular, we present frequency distributions for municipalities adopting OSS and for three main categories of OSS programs: (i) software installed on desktop clients; (ii) software installed on server machines and (iii) dedicated software. The analysis aims at providing a general picture of the adoption of OSS by local PA in quantitative terms.

As a second step, we use bivariate statistics to test the correlation between the intensity of OSS adoption and relevant characteristics of the local PA (bivariate analysis). In particular, we investigated the extent of correlation between the features of the local PA in our sample and intensity of (OSS) adoption (IA). We measured the correlation between the perceived barriers to greater ICT usage and the intensity of adoption of OSS within PA. Bivariate statistical test appropriate to the nature of the variables (dichotomous, ordinal or continous) are implemented in order to check whether there are statistically significant differences among groups of PA, with different intensity of OSS adoption across several important factors.

Finally, while the above analysis aims at showing that some of the factors highlighted in the literature exhibit significant correlation with the intensity of OSS adoption by local PA, we

examined whether these relationships were significant if we consider explicitly those factors that may influence adoption contemporaneously. To this end, we implement two distinct econometric models to empirically validate the theoretical hypothesis developed in Section 2.2 (econometric analysis). In the first model, we concentrate on the factors that are likely to affect the intensity of OSS adoption of local PA (hypothesis H1.a and H1.b). The model is estimated using ordinary least squares (OLS) taking the intensity of adoption of OSS (desktop clients, servers, and overall) as the main dependent variable. We conducted proper regression diagnostics to control for heteroschedasticity (we computed robust standard errors), multicollinearity (the variance inflation factor is well below the threshold level) and the presence of influential observations (Cook index is always well below the threshold level).

In the second model, we empirically test the relationship between extent of adoption of OSS in local PA and e-government performance (hypothesis H2.a and H2.b). The latter is measured relying on an index proxying availability and level of interactivity of local public e-services provided by the PA. This index is taken from the UNDERSTAND dataset and was calculated following European guidelines and the methodology developed in Benchmarking eEurope-online public services (see Williams, 2008). One advantage of this index is that it contains information on type of e-services (such as public records and certificates, social security, public libraries and central services, services for enterprises, education, employment services, vehicle and patenting, health, local taxes) and also the extent of the interactivity. Three different levels of interactivity are considered: (i) the website of the organization provides

information on specific local public services only; (ii) downloadable forms are available; and (iii) it is possible to complete transactions online.[v] The model was estimated using OLS and, as for the previous model, appropriate diagnostic tests were conducted to check for the presence of heteroschedasticity, multicollinearity and influential observations.

FINDINGS

Descriptive analysis

A first finding refers to the overall number of local PA in our sample that reported adoption of OSS solutions. Figure 2 shows that almost 70% of PA had installed at least one OSS program. Among these, 15% can be categorized as unaware adopters. Unaware users are those municipalities which reported no adoption of OSS, but from the questionnaire it emerged that they had some OSS applications installed on their hardware.

For programs installed on desktop clients, we present the frequency distributions according to the intensity of OSS adoption for different kinds of applications: desktop operating system (Figure 3), e-mail client (Figure 4), office automation (Figure 5) and web browser (Figure 6). Overall, considering different types of programs and grouping local PA based on extent of OSS adoption, we find substantial variance. For instance, OSS is less likely to be implemented as the desktop operating system or email client (i.e. 80% of PA in the sample were non-users in this respect) other than as office suites or internet browsers (number of non-users reduces to 50% of the sample).

If we take account of domain of application relative to operating system, office automation and internet browser, the distribution of PA according to the intensity of OSS adoption reveals that a large majority has not adopted these programs and that the heaviest OSS users are characterized by low intensity of adoption (e.g. 14 PA out of the 16 adopting OSS as desktop operating system show intensity of adoption of between 1% and 10%). For email client, according to Figure 4, the largest part of OSS adopters present high level of adoption, with eight out of sixteen municipalities adopting an OSS email client showing intensity of adoption of 75% to 100%.

For servers, Figure 7 depicts the intensity of OSS adoption according to different types of programs: web server, mail server, print server, file server and terminal server. For web and application servers, the majority of municipalities in our sample have adopted OSS solutions and more than 20% of municipalities use OSS exclusively to manage their web servers, and 60% reported an intensity of adoption of OSS higher than 10%. For application servers the figure is 70%. For other types of servers, although OSS is not the most widely diffused software, at least 10% of municipalities manage their servers almost exclusively via OSS.

Figure 8 is a scatter-plot where the horizontal axis measures the intensity of OSS adoption for desktop clients and the vertical axis shows the extent of adoption of OSS on server machines. The municipalities in our sample are clustered on the left side of the graph and the distribution is almost vertical. Indeed, most of the surveyed PA had adopted OSS for servers, but

fewer use OSS for desktop clients. This path of adoption of OSS, first going upward and then turning to the right, may reveal a preference in the decision to adopt OSS.

In terms of software tailored to the specific needs of the PA (i.e. dedicated software), eight main domains of application have been identified: economic and financial accounting, demographic statistics, management of local taxes, administration of personnel services, management of attendance and absence, protocol system and management of resolutions. Overall, none of these areas presents a significant rate of OSS adoption; for this reason, no figures are reported here.

Bivariate analysis

The results of bivariate correlations are presented in Table 7. The characteristics of the PA that were found to change according to the intensity of OSS adoption are: (i) the presence of government guidelines concerning an e-government strategy; (ii) the extent of employees' ICT skills (as measured by the presence of an ICT department and the provision of training in ICT); (iii) licensing costs; and (iv) quality of local public e-services provided to citizens. We found evidence of a strong correlation between the intensity of OSS adoption and four barriers to ICT usage: (i) flexibility of suppliers; (ii) low level of interoperability; (iii) small number of ICT employees; and (iv) high costs.

Overall, these results provide preliminary evidence on the role of the factors in the conceptual model in the adoption of OSS by local PA. We found the extent of correlation between the size of the local PA and the intensity of adoption of OSS was strongly significant.

We found that local PA that provide training to employees in ICT related topics are more likely to adopt OSS. Finally, the extent of interactivity of public e-services is positively correlated to the intensity of OSS adoption. In terms of the barriers to ICT usage, we found that the higher the ICT suppliers' lack of flexibility the higher was the level of OSS adoption.

Econometric analysis

As for the first econometric model, that addresses our first research question (hypothesis H1.a and H1.b), the results are presented in Table 8. It is interesting that only the coefficient of the number of software suppliers is significant and positively related to the intensity of OSS adoption. All other things being equal, having an additional software supplier increases average total intensity of OSS adoption by 1.32% (column 1 in Table 8). A similar result was obtained for adoption of OSS on desktop clients where the coefficient is significant and positive when the dependent variable is the intensity of adoption of OSS on desktop clients (column 2 in Table 8) rather than the general intensity of OSS adoption. In this case, the magnitude of the increase is lower at 1.08%. The coefficients of licensing costs, technical skills in ICT, need for customization and existence of government guidelines were found not to be statistically significant for explaining the extent of adoption of OSS of local PA in our sample.

As for our second research question (hypothesis H2.a and H2.b), results of the second econometric model are presented in Table 9. The coefficients of number of employees working in ICT departments and existence of a broadband internet access have positive and significant

values. Also, the coefficient of intensity of adoption of OSS is positive and strongly significant for desktop clients and in the more general case.

DISCUSSION

We discuss the main findings of our study with particular reference to the contributions to the literature.

The first important finding from our survey is the non-negligible number of local PA that have adopted OSS (70% of the PA surveyed). We also identified several unaware OSS users (13% of the sample), which is in line with the results obtained in the FLOSSPOLS study (Ghosh & Glott, 2005).[vi] The non-negligible share of users adopting OSS but unaware of it, points to the important role of information for OSS success in PA. Our results extend the main theoretical findings in Comino & Manenti (2005) in the context of PA. These authors show that a public policy involving government informing a share of users about the existence and the characteristics of OSS, is welfare increasing.

In contrast to studies that focus principally on well-defined types of OSS products, such as the Linux operating system or the Openoffice suite, our study collects information on software types installed on the hardware systems of individual local PA. We show the considerable variation in the behaviour of PA relative to the typologies of software adopted and the extent of this adoption. If we take only the adopting PA into consideration, the intensity of OSS adoption for desktop clients is low (i.e. less than 10%) with the notable exception of OSS e-mail clients, while OSS adoption for servers is usually high (more than 50%).

In line with this result, we found that local PA are more likely to start the adoption of OSS for server machines, later moving on to desktop clients (Figure 8). This finding refers to the number and type of users usually affected by software migration on server machines. This finding confirms the role of OSS in the management of critical services for servers where several different OSS applications are supported by large communities of developers and users (Franke & von Hippel, 2003).

Our study reveals a negligible extent of OSS adoption of domain-specific software. This was largely expected based on the interviews with ICT suppliers of local PA. Firms pointed to how the market for dedicated software is dominated by a small number of local suppliers. This means that need for customization and strong ties with clients are very important and, thus, migration to OSS is likely to be characterized by prohibitive switching costs.

In our study some of the more relevant factors proposed in the literature as the drivers of OSS adoption were correlated to the extent of OSS adoption (Table 7). However, when we take account of the influence of other factors by implementing multivariate statistical techniques, results change considerably. In particular, licensing costs, need for customization, government guidelines and ICT technical skills were found not to contribute to the decision to adopt OSS.

One of our core findings is related to the central role of software vendors in the decision of local PA to adopt OSS. On the one side, higher levels of OSS adoption imply a higher probability of avoiding vendor lock-in, which is reflected in the high number of software

suppliers serving the local PA. On the other side, software vendors can be the initial adopters and providers of OSS, thereby passing on the adoption decision to their clients.

The other important finding from this study is that the extent of OSS adoption has an impact on the variety and quality of local public e-services. Our review of the literature provides a qualitative discussion of how and to what extent the intensity of OSS adoption explains the level of interactivity among online services. We identified several channels through which this may take place. Unfortunately, we were not able formally to test for each of these characteristics. However, the coefficient of share of employees working in the ICT department of an organization was found to be positive and statistically significant, providing support for this finding (see Table 9).

CONCLUSIONS

The present study contributes to understanding the determinants of OSS adoption by local PA, and the realized benefits of this decision. Previous works only discussed one or a few factors that drive the decision to adopt OSS and did not addressed the potential benefits in terms of e-government that OSS may bring to PA.

The results of our survey show that several municipalities have adopted OSS (almost 70% of the sample) and that 75% of municipalities manage servers exclusively through OSS. Nevertheless, we find that a non-negligible share of respondents are unaware users (15% of the sample). If we compare the intensity of OSS adoption between clients and servers, there is clear evidence of an adoption path. Among the determinants of OSS adoption by local PA we find that

the choice to adopt OSS relies heavily on software suppliers. We also find support for the hypothesis that OSS adoption brings benefits to the PA in terms of e-government performance.

The present study has some limitations. First, although this is one of the first studies that provides an analysis of the adoption of OSS by local PA that can be generalized, thanks to the information collected on 90 local PA located in the Emilia-Romagna region of Italy, we are not able to apply econometric models other than OLS because we could not fulfil the requirements of asymptotic theory. We also cannot measure directly some of those factors often claimed to be important drivers of OSS adoption in PA, i.e. software quality, reliability and security, which are difficult to measure but also often tell only a part of the story. Our study takes account of only one particular geographical area, i.e. the Emilia-Romagna region of Italy. Although we have shown that Emilia-Romagna is at the forefront in e-government (Williams, 2008), the results obtained are strongly dependent on the nature of the local PA surveyed and reflect particular points of view. In addition, the advantages and disadvantages of OSS adoption generally are not as clear-cut as the results obtained from our study. Although we found a relationship between the intensity of OSS adoption at the local level and a measure of e-government performance, this result may be heavily dependent on our inability to formally test the channels through which this takes place. We try to support our arguments in discursive terms in this study, but future research should investigate these points more thoroughly, using formal instruments. Future work should try to address all the points mentioned above to extend our results. We believe that the insights gained from this study will serve as a guide and foundation for future work aimed at

investigating the determinants of OSS adoption in local PA and the impact of this adoption on e-government performance.

Our findings have important implications for policy makers and the scientific community. Our study contributes to the literature in showing that software suppliers have a strong role to play in OSS adoption by local PA. This is a new result in the literature on local PA as the main unit of analysis.[vii] A striking result perhaps is the lack of significance of the coefficient of licence fees, which is often advocated as one of the main reasons for PA adopting OSS (Waring & Maddocks, 2005; Mukerji et al., 2006; Ven et al., 2007; Cassell, 2008). Finally, we show that the adoption of OSS is important for e-government and especially the level of variety and interactivity of the local public e-services provided by PA to citizens and firms. However, further analysis is needed to unravel the factors at work, although we provide some preliminary arguments in this paper.

For policy makers, the results of our study show that, rather than relying on policies mandating the adoption of OSS, consideration should be given to policies aimed at increasing awareness of the existence and main advantages of open source alternatives to proprietary solutions. Policy makers should take into consideration the existence of a favourite path to OSS adoption. The local PA surveyed are characterized by high levels of OSS adoption on servers compared to desktop clients. This finding is probably explained by the number and typology of software users affected by software migration on server machines, and tends to contest with results from previous studies (Huysmans et al., 2008). Finally, policy makers should take

account of the important role of software suppliers. On the one side, relying on OSS may prevent lock in to a situation where, once a program has been purchased, the PA is reliant on the supplier's decision in relation to its modification. On the other side, software suppliers can be an important channel of information for PA about new OSS solutions.

AUTHOR NOTE

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FIGURES

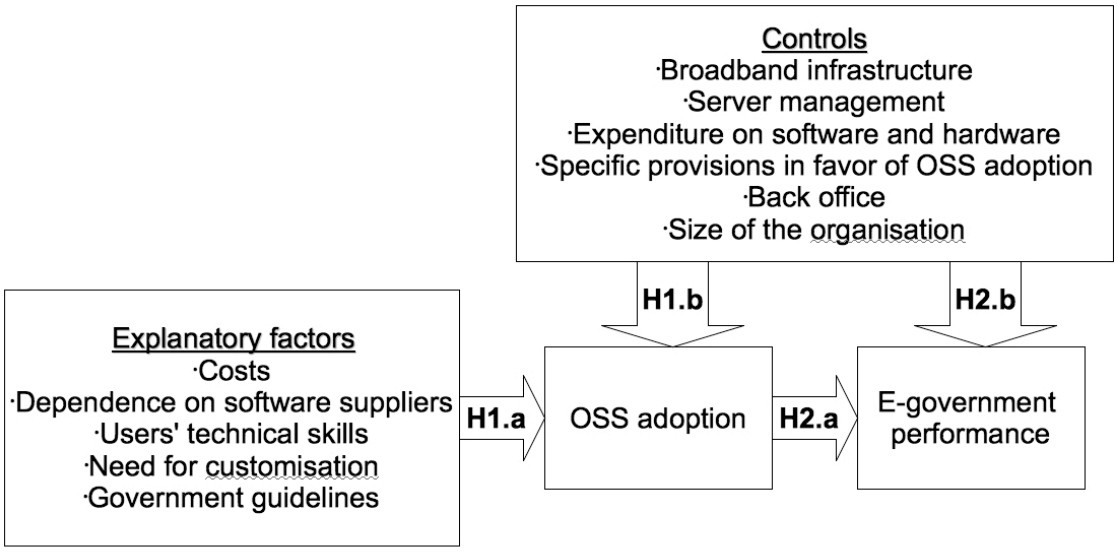

Figure 1: Conceptual framework of the adoption of OSS in local PA

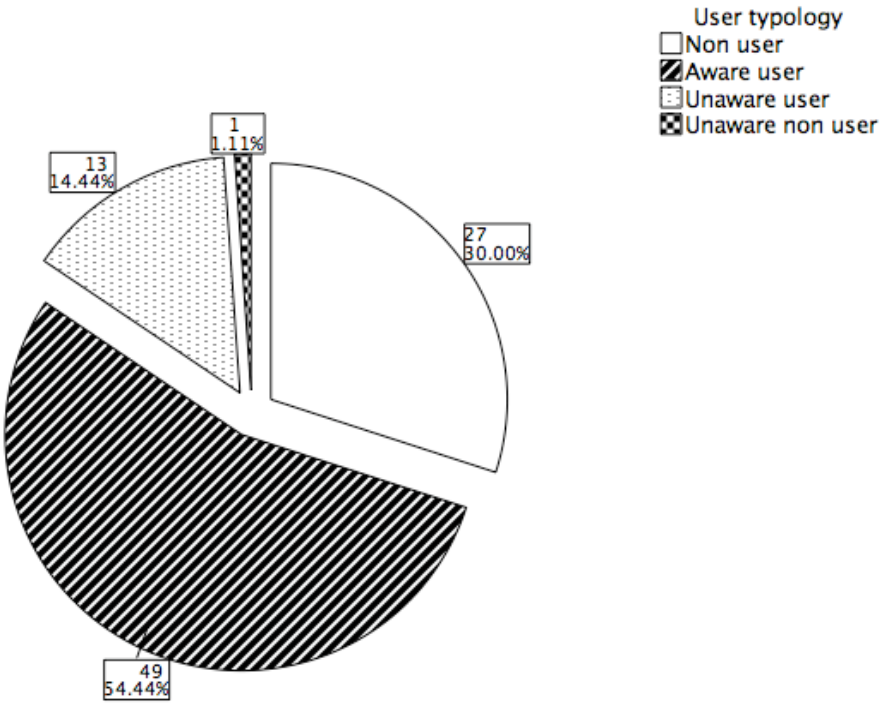

Figure 2: Municipalities adopting OSS by user typology

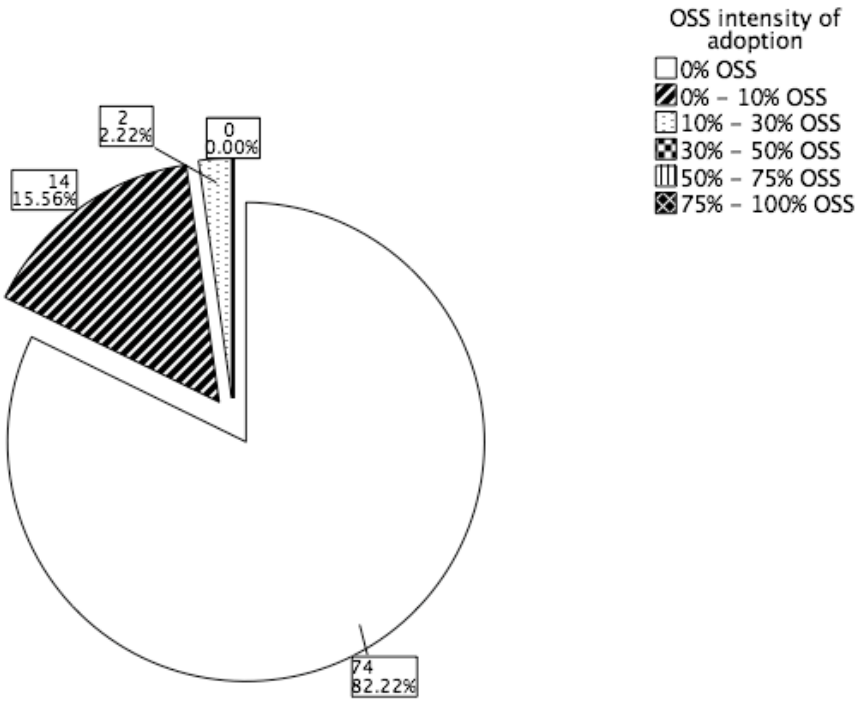

Figure 3: Municipalities adopting OSS by intensity of adoption – Desktop operating system

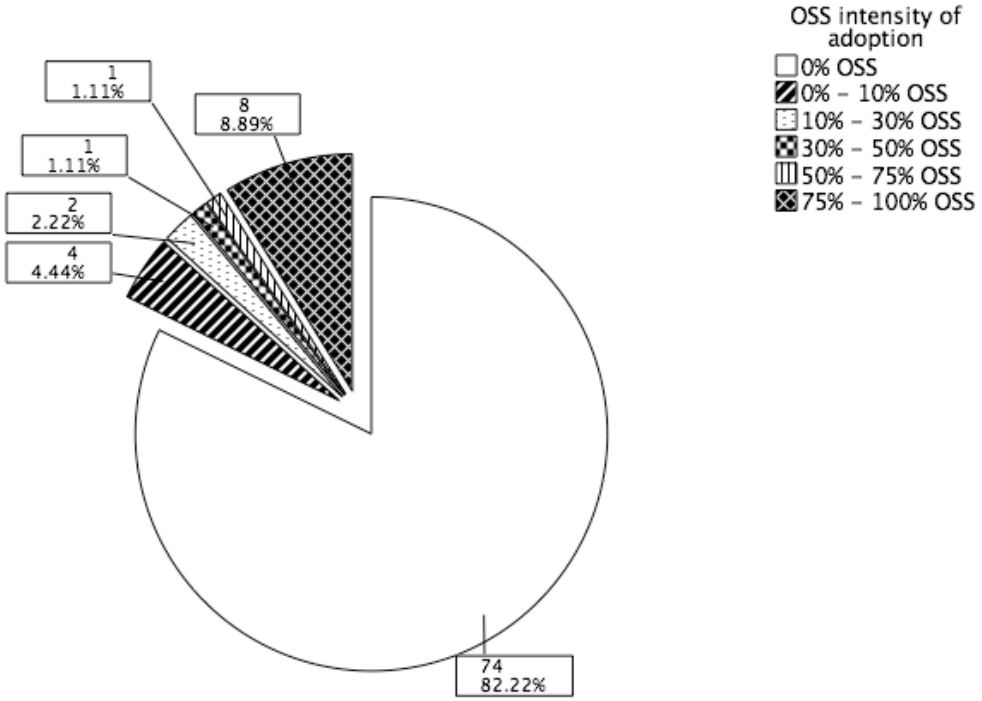

Figure 4: Municipalities adopting OSS by intensity of adoption – email client

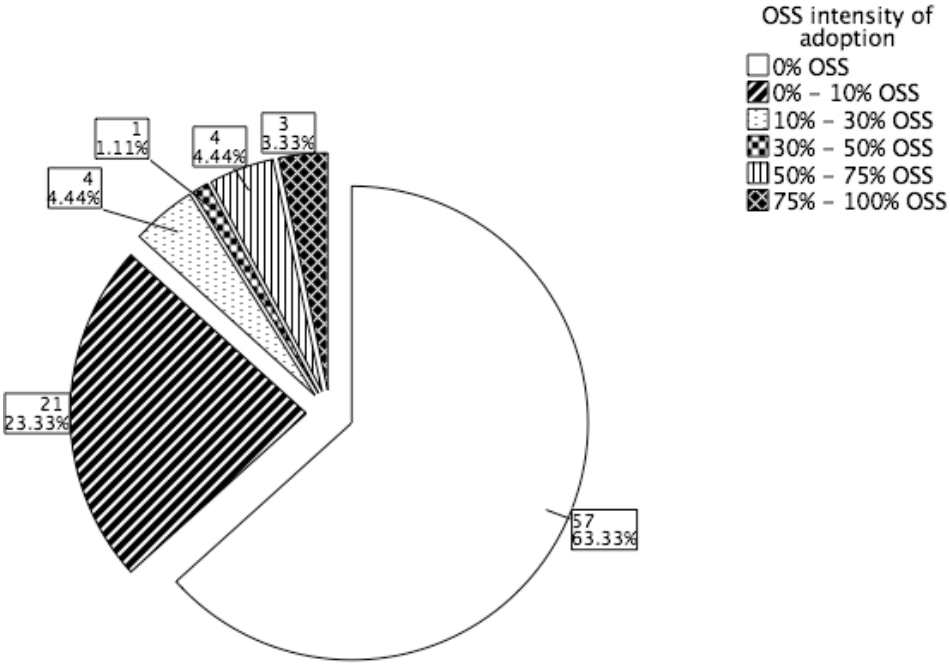

Figure 5: Municipalities adopting OSS by intensity of adoption – office automation

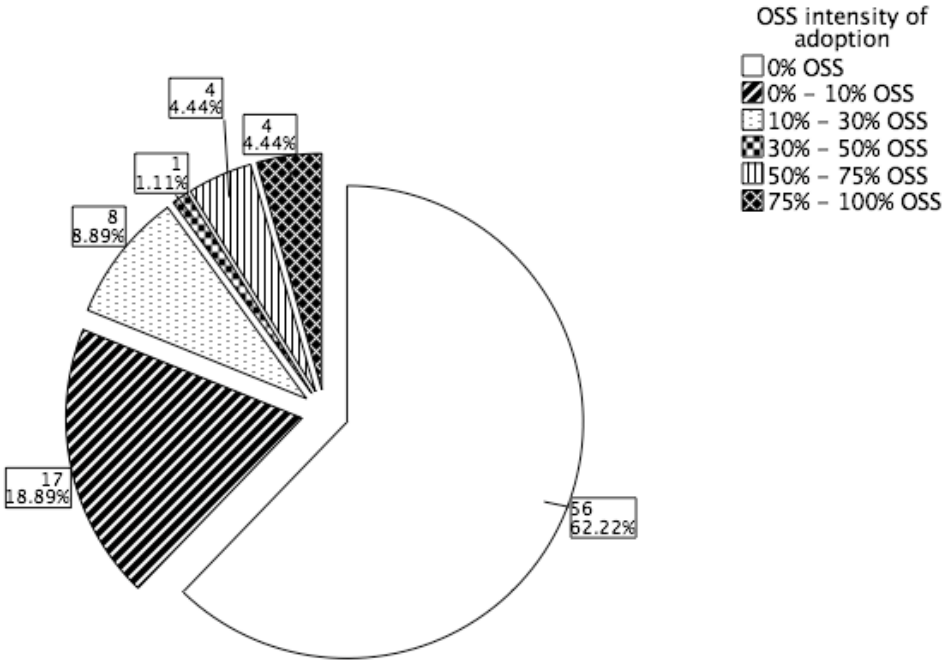

Figure 6: Municipalities adopting OSS by intensity of adoption – internet browser

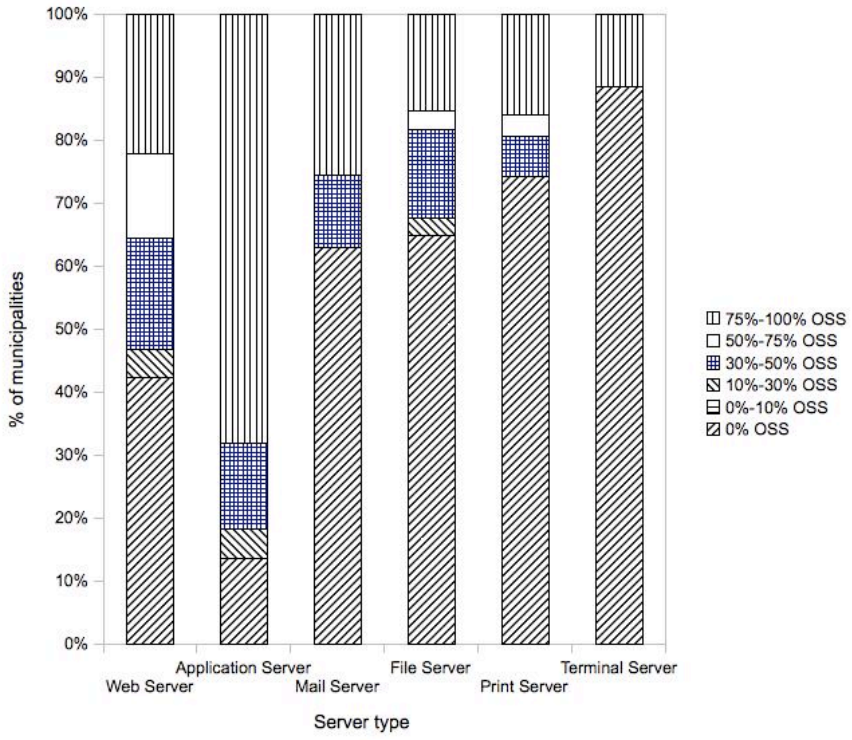

Figure 7: OSS intensity of adoption - server

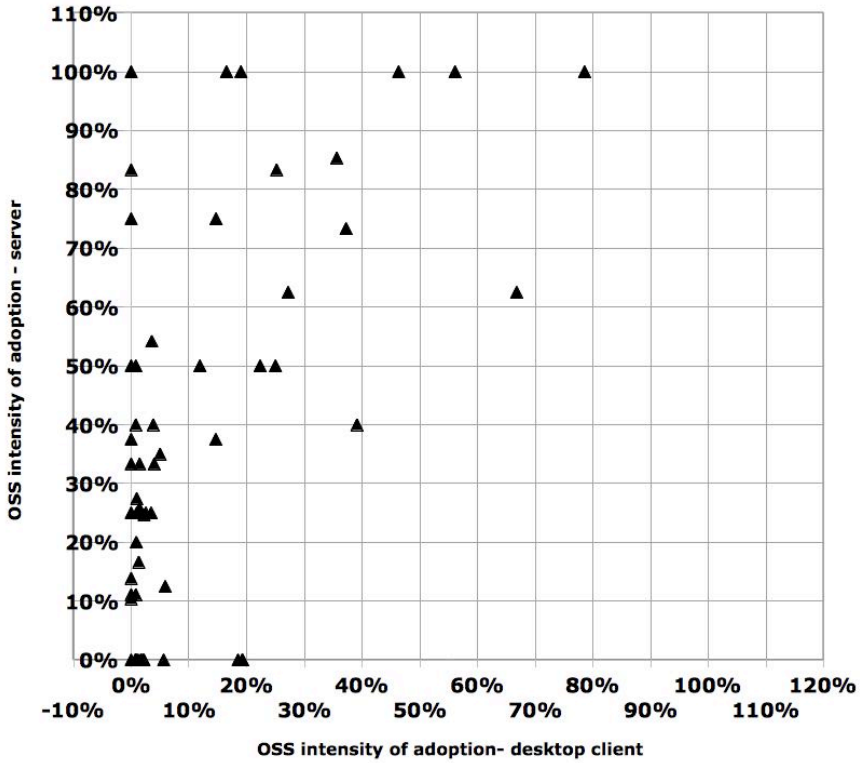

Figure 8: Scatter plot of OSS intensity of adoption: desktop client vs server

TABLES

Table 1: Classification of papers

Paper	**Theoretical perspective**	**Method**	**Geographical scope**	**Type of OSS**	**Subjects**	**Unit of analysis**	**Main findings**
Cassell (2008)	Why governments choose to migrate to OSS and what factors affect the implementation	Comparative case studies (semi-structured interviews and documentary evidence)	EU	Linux	Migration managers	4 European municipal governments (Vienna, Munich, Schwabish Hall, Treuchtlingen)	Reasons to migrate: independence, cost savings Factors affecting migration: organizational structure, personnel views, political support
Huysmans et al. (2008)	Reasons for not adopting OSS desktop software	Descriptive case study (interviews)	Belgium	Openoffice	Chief information officer, project manager and account manager	Belgian federal public service economy	Reasons to adopt: cost, government guidelines Reasons not to adopt: data-intensive nature of the tasks
Mukerji et al. (2006)	Role of OSS in fostering e-government	Literature review	Governments in developed and developing countries				Benefits: costs, vendor lock-in, customizability, scalability Challenges: customer support, high variability in quality, accountability, TCO, legal complications, users' technical skills
Munoz-Cornejo et al. (2008)	How and why is OSS adopted within the health care system?	Survey and semi-structured interviews	US (Baltimore, Washington and Northern Virginia area hospitals)	Both general purpose and domain specific software	IT managers	Hospitals	Limited adoption mainly of general purpose OSS Pivotal role of software vendors in facilitating OSS adoption Perceived disadvantages: lack of in-house development, security, quality and

							accountability
Rossi et al. (2008)	Evaluation of the migration to Openoffice in a PA	Experimental design (22 users)	na	Openoffice			Adoption increased reaching the 25% of total office automation tasks Impact on productivity is minimal Lack of functionalities is a minus
Tapia and Maldonado (2009)	Mandated OSS policy to remedy digital divide and to build up a skilled ICT workforce	Descriptive case study (30 interviews and documentary evidence)	Venezuela		Government officials	Policies and institutions relating to OSS	Strongly centralized nation with predominant role of government Establishment of software companies for several purposes (software development, educational and training duties)
Ven et al. (2007)	Reasons for undertaking a desktop migration in a large PA	Descriptive case study (interviews)	Belgium	Linux and Openoffice	Director of the IT department	Belgian federal government of Justice	Cost, vendor lock-in, government guidelines
Waring and Maddocks (2005)	OSS use and implementation in the UK public sector, together with the realized benefits	Case studies (documentary evidence)	UK			6 local governments and 2 central governments	High degree of variability in OSS implementation Long and short-term savings Reliability Scalability Customizability

Table 2: Main characteristics of key informants

Job title	Type of organisation	Size of the organisation
Director of IT department	Municipality	Small
Director of IT department	Municipality	Large
Director of IT department	Municipality	Large
IT manager	Local health authority	Large
IT manager	Firm	Small
IT manager	Firm	Medium

Table 3: Relationship between theoretical constructs and interview protocol

Theoretical construct	**Questions in the interview protocol**
Explanatory factors and controls	In your experience, what do you think are the main factors driving the decision to adopt open source software? In general, what do you think are the main barriers to implementing OSS in a PA?
OSS adoption	Does your organisation adopt OSS? What are the main OSS programs that have been adopted into your organisation?
E-government performance	How would you define and measure the performance of your organisation with respect to e-government?

Table 4: Description of the variables

Attributes	Variables	Description	Reference	Data source
		OSS adoption		
Extent of adoption of OSS	IA_total	Total – share of OSS programs over the total number of programs installed	Own computation	Interviews and questionnaire
	IA_server	Server - share of OSS programs over the number of programs installed on server machines	Own computation	Interviews and questionnaire
	IA_client	Client - share of OSS programs over the number of programs installed on desktop clients	Own computation	Interviews and questionnaire
		E-government performance		
E-government performance	E-gov	Index measuring the variety and extent of interactivity of local public e-services	Arduini et al. (2010)	UNDERSTAND project
		Explanatory factors		
Software costs	Licence fees	Amount of licence fees over the total number of PCs	Ghosh & Glott (2005)	questionnaire
Dependence on software suppliers	Suppliers	Number of software suppliers	Ghosh & Glott (2005)	UNDERSTAND project
ICT technical skills	Exp_train	Share of expenditures in training over the total	Ghosh & Glott (2005)	UNDERSTAND project
	Empl_ICT	Share of employees working in the ICT department over the total	Ghosh & Glott (2005)	UNDERSTAND project
Need for software customization	Need_cust	Variable taking value 1 if the local PA relies on external customization of software and 0 otherwise	Ghosh & Glott (2005)	UNDERSTAND project
Government guidelines	OSS_act	Variable taking value 1 if the local PA issued guidelines to promote OSS usage and 0 otherwise	Arduini et al., (2010)	questionnaire
		Controls		
Broadband infrastructure	Broadband	Variable taking value 1 if the local PA has a broadband internet access	Arduini et al., (2010)	UNDERSTAND project

Server management	Server_man	Share of application servers and web servers over the total	Ghosh & Glott (2005)	UNDERSTAND project
Amount of investments in software and hardware infrastructures	Exp_soft&hard	Share of expenditures in software and hardware over the total	Arduini et al., (2010)	UNDERSTAND project
Specific provision in favour of OSS adoption	ICT_strat	Variable taking value 1 if the local PA issued guidelines to promote ICT usage and 0 otherwise	Arduini et al., (2010)	UNDERSTAND project
	Chairman	Variable taking value 1 if the local PA has a chairman with informatics portfolio and 0 otherwise	Own computation	UNDERSTAND project
	E-gov_strat	Variable taking value 1 if the local PA issued guidelines to promote E-government practices and 0 otherwise	Arduini et al., (2010)	UNDERSTAND project
Back-office infrastructure	Back office	Share of file, mail, print and terminal servers over the total	Own computation	UNDERSTAND project
Size	Size	Number of persons resident in the territory of the local PA in 2006	Arduini et al. (2010)	Emilia-Romagna statistical office

Table 5: Descriptive statistics

Variables	**Unit of measurement**	**Descriptive statistics**				
		N	*Mean*	*SD*	*Min*	*Max*
E-gov		90	0.37	0.17	0	.81
Exp_soft&hard	%	90	2.65	9.41	0.04	67.7
Exp_train	%	90	0.12	0.39	0	3.23
Empl_ICT	Unit	90	3.92	8.41	1	58
Back office	%	79	74.2	27.5	0	100
IA_total	%	90	15.1	19.4	0	88
IA_server	%	90	26	31.9	0	100
IA_client	%	90	7.47	15.1	0	79
Suppliers	Unit	90	3.23	3.55	0	20
Licence fees		90	187	379	0	3097
Server_man	%	79	25.8	27.5	0	100
Need_cust	Unit	76	0.76	0.43	0	1
ICT_strat	Unit	90	0.3	0.46	0	1
OSS_act	Unit	87	0.14	0.35	0	1
Broadband	Unit	90	0.78	0.42	0	1
Chairman	Unit	90	0.32	0.47	0	1

Table 6: Correlation table

	Inter	Exp_soft&hard	Exp_train	Empl_ICT	Back office	IA_total	IA_server	IA_client	Suppliers	Licence fees	Server_man	Need_cust	ICT_strat	OSS_act	Broadband	Chairman	Egov
E-gov	1																
Exp_soft&hard	0.2	1															
Exp_train	-0.22	0.41	1														
Empl_ICT	0.35	0.19	-0.34	1													
Back office	0.08	0.05	0.1	-0.11	1												
IA_total	0.51	0.03	-0.2	0.47	0.11	1											
IA_server	0.47	0.02	-0.24	0.41	0.09	0.91	1										
IA_client	0.38	-0.04	-0.15	0.39	0.05	0.75	0.5	1									
Suppliers	0.13	0	-0.17	0.19	0.31	0.25	0.21	0.19	1								
Licence fees	0.05	0	0.03	-0.04	-0.02	0.12	0.01	0.3	-0.06	1							
Server_man	-0.08	-0.05	-0.1	0.11	-1	-0.11	-0.09	-0.05	-0.31	0.02	1						
Need_cust	0.3	-0.01	-0.26	0.4	0.04	0.23	0.17	0.36	0.13	-0.04	-0.04	1					
ICT_strat	0.45	0.02	0.05	0.31	0.18	0.39	0.37	0.27	0.17	-0.02	-0.18	0.23	1				
OSS_act	0.21	-0.04	-0.11	0.25	-0.02	0.31	0.24	0.27	0.07	0.01	0.02	0.05	0.17	1			
Broadband	0.41	-0.01	-0.15	0.24	-0.14	0.28	0.22	0.33	0.23	0.06	0.14	0.29	0.18	0.17	1		
Chairman	0.23	0.18	0.04	0.16	0	0.1	0.12	0.03	-0.04	0.06	0	0.13	0.06	-0.05	0.12	1	
E-gov_strat	0.22	0.02	-0.04	0.4	-0.06	0.29	0.28	0.24	0.24	0.01	0.06	0.25	0.68	0.25	0.19	0.1	1

Table 7: Main characteristics of the PA and perceived obstacles by OSS intensity of adoption

	Intensity of Adoption (IA)			**Statistical Test**	
	Absent	*Moderate*	*High*	*Kruskal-Wallis*	*Pearson*
	IA = 0%	*IA<20%*	*IA>20%*	χ^2	χ^2
Characteristics					
Average size	4.65	13.58	47.79	17.42*	
Broadband	0%	10%	21.4%		4.9
E-gov strategy	25%	20%	50%		6.74**
ICT strategy	14.3%	27.5%	50%		5.73
Size of ICT dep	21.4%	45%	63.6%	1.05	
Presence of ICT dep	28.6%	42.5%	63.6%		8.4**
ICT training	25%	42.5%	68.2%		11.7*
Extent of interactivity of public e-services	28.6%	37.8%	46.5%	10.39*	
Average licence fees	2.33	2.05	1.93	7.62**	
Average number of suppliers	2.1	3.4	5.1	5.63	
Perceived barriers to ICT usage					
Defects in purchased software	17.86%	7.50%	4.55%		2.93
ICT suppliers lack of flexibility	0%	7.50%	36.36%		16.68*
Lack of integration between applications (interoperability)	25%	25%	59.09%		8.69**
Lack of qualified ICT staff	57.14%	30%	13.64%		10.96*
Difficult to recruit or retain ICT qualified staff	10.71%	10%	27.27%		3.88
Lack of an updated ICT strategy	32.14%	20%	18.18%		1.79
ICT expenditure too high	57.14%	57.50%	27.27%		6.02**
Premature introduction of new versions of existing software	14.29%	12.50%	4.55%		1.32

* and ** denote statistical significance at the %1 and 5% test level.

Table 8: Factors affecting the intensity of OSS adoption

	(1)	(2)	(3)
Suppliers	1.32*	1.08**	1.47
	(0.538)	(0.385)	(0.926)
Licence fees	-0.0067	0.00052	-0.021
	(0.00648)	(0.00516)	(0.0113)
Exp. soft&hard	0.18	0.061	0.56
	(0.173)	(0.0965)	(0.504)
Empl. ICT	-0.18	0.12	-0.68
	(0.218)	(0.169)	(0.477)
Exp. train	-2.94	-1.13	-14.4
	(3.790)	(2.800)	(12.20)
Server man.	0.0098	0.0021	-0.031
	(0.0759)	(0.0534)	(0.152)
Need cust.	4.72	5.10	-0.74
	(3.965)	(2.843)	(10.47)
Broadband	4.83	4.53	0.046
	(4.398)	(2.663)	(13.63)
Chairman	-1.12	-4.07	2.34
	(4.566)	(3.044)	(8.975)
Egov	1.11	1.01	-0.070
	(6.057)	(4.136)	(11.09)
ICT strat.	7.55	4.13	10.8
	(5.968)	(3.781)	(11.66)
Constant	2.36	-4.93	26.2
	(6.413)	(4.337)	(21.43)
Num. Obs.	66	66	66
R^2	0.221	0.229	0.137

Standard errors in parentheses, *p< 0.05, **p< 0.01, *** p< 0.001

Table 9: Factors affecting e-government performance

	(1)	(2)	(3)
Exp. soft&hard	-0.00097	-0.00086	-0.00095
	(0.00454)	(0.00479)	(0.00457)
Exp. train	-0.012	-0.013	-0.011
	(0.108)	(0.112)	(0.108)
Empl. ICT	0.0052***	0.0047***	0.0058***
	(0.00121)	(0.00127)	(0.00118)
Back office	-0.000055	-0.000070	-0.000063
	(0.000476)	(0.000495)	(0.000473)
IA total	0.0019*		
	(0.000803)		
IA client		0.0029**	
		(0.000960)	
IA server			0.00075
			(0.000406)
OSS act.	0.044	0.045	0.057
	(0.0509)	(0.0496)	(0.0498)
Broadband	0.12**	0.12**	0.13**
	(0.0444)	(0.0434)	(0.0441)
Chairman	0.048	0.056	0.046
	(0.0319)	(0.0316)	(0.0319)
E-gov. strat.	-0.056	-0.057	-0.059
	(0.0363)	(0.0351)	(0.0362)
ICT strat.	0.066	0.075	0.074
	(0.0376)	(0.0384)	(0.0380)
Constant	0.22***	0.22***	0.22***
	(0.0399)	(0.0410)	(0.0409)
Num. Obs.	77	77	77
R^2	0.467	0.471	0.453

Standard errors in parentheses, * p< 0.05, **p< 0.01, ***p< 0.001

i Preferential policies are those that give preference to the implementation of OSS but its uses is not mandatory. Advisory policies allow implementation of OSS; research policies are those based on specific studies or general initiatives concerning OSS.

ii We also believe that the findings reported above are strongly contingent on the methodology adopted, the typology of OSS, and the unit of analysis used. In particular, most works rely on case study methods. Although extremely useful for providing qualitative insights, case studies are seldom able to assure generalization to a population beyond similar cases (Yin, 2008). In terms of types of OSS, almost all the studies referred to deal with the Linux operating system or the Openoffice productivity suite. Very few investigate the adoption of different OSS typologies, such as programs for web, mail or print servers, or domain specific software. Finally, the unit of analysis is generally national government and there are very few studies that look at OSS adoption by local governments.

iii For further details see http://ec.europa.eu/information_society/activities/egovernment/index_en.htm

iv For further details see http://www.regionedigitale.net/homepage-en?set_language=en&cl=en .

v Further details on how the index was built, and information on its implementation, can be retrieved from the UNDERSTAND project website (http://www.understand-eu.net/).

vi FLOSSPOLS was a major large-scale study that collected data on actual and potential demand for OSS solutions in European PA. The survey included 13 European countries in year 2004.

vii The only exception is Munoz et al. (2008) who show the role of software vendors in the context of American hospitals.