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ICT diffusion in public administrations and business dynamics: Evidence from Italian municipalities

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Abstract

Public administrations have been adopting information and communication technologies (ICT) to transform their internal organization and provide better public services to citizens and firms. However, the external benefits, despite being deemed relevant, have been empirically overlooked. We first explore the relation between ICT diffusion in public administrations and business demography at the municipal level by studying the Italian context. Our results show that ICT diffusion in the PA contributes to significantly reducing the death rate of firms and boosting their turnover rate. The adoption of ICT in the PA also exerts a positive impact on the firm birth rate, although it is not statistically significant. These results shed light on the importance of promoting e-government and framing coherent digital agendas as public instruments for supporting entrepreneurship and regional economic development.

KEYWORDS
ICT, public administration, firm entry, firm exit, municipalities

JEL CLASSIFICATION
H54, H83, L26, R11

1 | INTRODUCTION

Information and communication technologies (ICT) are general purpose technologies (hence-forth, GPT; Bresnahan and Trajtenberg, 1995), which are extensively diffused across industries and institutions, and generate pervasive cross-sectoral socio-economic effects. In principle, ICT diffusion can spur the efficiency and the effectiveness of many human activities. So far, this hypothesis has been studied in relation to ICT adoption in the business sector and its economic performance (Matteucci et al, 2005; Donati and Sarno, 2013; Millán et al., 2021). Besides this, another large stream of literature on "e-government" has studied the heterogeneous paths and internal benefits stemming from ICT diffusion in the public sector, which enables the provision of digital public services (or "e-services"). Various studies show that ICT adoption and the provision of digital public services by the Public Administration (PA) present large spatial heterogeneity, across both EU countries and regions (Torres et al., 2005; Warf, 2018), and cities (Cepparulo and Zanfei, 2021). Generally, the PA is expected to earn substantial internal benefits by digitalizing administrative operations (Twizeyimana and Andersson, 2019)—including the improvement of the management and collaboration of its own employees and other branches of the PA (Panayiotou and Stavrou, 2021).

Moreover, ICT adoption by the PA is supposed to exert appreciable external effects, by improving its transparency, the participation and collaboration of external stakeholders—such as citizens and the business sector—and the quality of the digital public services supplied to them. In particular, businesses need to perform frequent operations with the PA (e.g., firm registration and authorizations, fiscal and custom duties, public procurement, other information provision), so that the digitalization of the PA, by automatizing most of these bureaucratic operations, cuts the operative and transaction costs of firms and better circulates business-relevant information at large. Disappointingly, while the "e-government" literature has extensively explored the adoption and impact of public e-services on citizens, it has made little progress in verifying the stated hypotheses about their effects on businesses (Lee et al. 2011; Arduini and Zanfei, 2014; Panayiotou and Stavrou, 2021). Most of the works featured in the G2B (government to businesses) literature deal with issues of strategy, design, implementation, communication and evaluation of the maturity of the public e-services supplied (Panayiotou and Stavrou, 2021, p. 8), but none have carried out an empirical evaluation of the external effects on business performance. Concerning the latter, to the best of our knowledge there are two exceptions. Thompson et al. (2005) analyze a US business sample and find that firms using e-government for retrieving information boost their profitability. Badri and Alshare (2008) find similar results for transaction-oriented e-government, generating cost reductions by streamlined paperless procedures.

Among the hypotheses put forward on the external effects of the PA's ICT adoption, the conceptual framework of Friesenbichler et al. (2014) conjectures an impact on business demography. These authors work on EU countries and explore the institutional channels linking the digitalization and the efficiency of the PA with firm growth. Their conceptual framework looks promising, especially once its cross-country nature is adapted and operationalized at the regional and local levels, to capture the day-to-day interactions that firms maintain with the different bodies of the PA.

So far, no study has investigated such a relation between ICT diffusion in the PA and business demography at the regional and local level, in an explicit and causal way. We contribute to exploring the relation between ICT diffusion in the PA and business demography by estimating a cross-sectional model on 5765 Italian municipalities referred to the year 2011. Indeed, the 2011 Italian census first supplied original variables on the diffusion of ICT at the local level of

the PA, distinguishing among types of technologies. We analyze the effects of the diffusion of ICT in the PA on the birth, death and turnover of firms, under the hypothesis that their presence generates a series of positive effects (efficiency and effectiveness) that can be appropriated by the business sector. These effects spill over the internal administrative operations and benefit the external stakeholders (*in primis* businesses) with network effects and externalities, stemming from the "general purpose" nature of ICT. Henceforth, our work is a first attempt to fill the literature gap by empirically verifying the presence of external effects associated to the PA's investment in ICT, with specific reference to the business sector dynamics.

Italy constitutes a remarkable context for such an empirical analysis, especially at the beginning of the 2010s, for several reasons. First, Italian municipalities are entrusted with many important administrative functions, and most of them were affected by the reforms issued during the 2000s to digitalize the PA (Digital Administration Act, see Sorrentino et al., 2017) and to streamline the bureaucratic processes for the business sector (the One-Stop-Shop reform, see Castelnovo et al., 2016; Castelnovo and Sorrentino, 2018). Second, abiding by the EU model of multilevel governance (Piattoni, 2010), Italian municipalities and regions share the function of implementing locally the national and supranational policies for the ICT diffusion and the digitalization of the PA (such as the Digital Agenda for Europe; EC, 2010).

The PA's ICT investment is a necessary but not sufficient condition for the external stakeholders to reap the full benefits of e-government and other public e-services. Some scholars have argued that past reforms of the Italian PA placed main emphasis on passing norms, rather than on their actual and prompt implementation (Gualmini, 2008), with most reforms remaining "on paper" for a great length of time (Mele and Ongaro, 2014): this problem concerned particularly the measures introduced to digitalize the PA (Sorrentino et al., 2017). These implementation failures have been attributed to country-level features, such as country specificities, its normative stratification and the legalistic culture of the Italian PA (Capano, 2003). E-services contributions point to the high territorial heterogeneity of the ICT diffusion across the PA (Torres et al., 2005; Arduini et al., 2010; Cepparulo and Zanfei, 2021): in this case, explanations point to idiosyncratic factors, such as the complexity of technology and other enabling factors, like broadband infrastructure (Seri et al., 2014), or the regional and local institutional quality (Matteucci, 2019; 2020). Therefore, the external benefits of the PA's ICT diffusion may not mature or may fail to reach the entire business sector and all citizens, so that our disaggregated empirical test is more than warranted.

Our cross-sectional model employs the instrumental variable approach in order to account for possible endogeneity problems. We use as external instrumental variables the voter turnout and the share of yes-votes in the referendum which took place in Italy on 12–13 June 2011. Local elected representatives come under pressure from citizens to adopt e-services through high electoral participation in local elections (Henriksen, 2004) and referendums on local issues.

Our estimation results show that the diffusion of various types of ICT in the PA plays a significant role in the reduction of firm death rate, although we find that the impact is small (about 5 firms for every 100,000 inhabitants). The effect on firm birth, although positive and small, is not statistically significant. The results remain unchanged when other instrumental variables are adopted in the 2SLS regression analysis. Our findings are important since they clarify the extent to which ICT and e-government (both information and transaction-oriented) may impact on business activity—*in primis* the decision to enter and remain on the market. The positive but not significant effect on firm entry can be explained by the fact that, according to the established literature on the entrepreneurship drivers, entry requires solid internal resources and external conditions. Presumably, the impact of the ICT externalities from the PA has not yet been sufficiently strong for most firms of the Italian universe to stand out as a significant cause of their

entry, while it is shown to be effective for reducing the likelihood of exit. These results, in part, may be specific to Italy, because of its lengthy, burdensome and partly ineffective process of institutional reforms for the digitalization of the PA. Henceforth, similar empirical tests are needed for other European countries, where the Digital Agenda for Europe might have had different effects.

The rest of the paper is articulated as follows. Section 2 illustrates the literature background and theoretical framework. Section 3 describes the institutional context and ICT diffusion in the Italian PA. In Section 4, the empirical model and estimation methodology are illustrated. Section 5 describes data and variables. In Section 6, results are presented and discussed, and further robustness checks are provided. Section 7 provides concluding remarks and policy recommendations.

2 | LITERATURE BACKGROUND AND THEORETICAL FRAMEWORK

A large body of literature has investigated the drivers of entrepreneurship and business dynamics, although regional level studies appeared more recently (for a survey, see Bosma et al., 2008). Disappointingly, no municipality-level studies of the determinants of business dynamics are available for developed countries.

Concerning the determinants, technology and innovation activities were found to be robust explanatory factors of regional business entry and performance (e.g., productivity or profitability)—especially in high-tech sectors. Empirically, most of this literature measured the technological level and knowledge flows through patents; for Italy, a recent example is Colombelli et al. (2021). Patents possess many valuable properties, but also present severe limitations. A main one is that primary and most tertiary sectors get fewer opportunities for applying for a patent than manufacturing ones.

ICT, which consist of GPT,[1] provide an alternative measure of knowledge and innovation. Worldwide, many industries gradually adopted ICT, because this kind of fixed capital has become indispensable to deal with consumers, suppliers and the PA (e.g., e-commerce, administrative authorizations and fiscal compliance, digital invoicing, etc.).

The impact of ICT diffusion was mostly studied with reference to the digital investment made by the business sector.[2] Yet, the ICT investment made by other subjects may also prove relevant for firm performance and business dynamics. In fact, key subjects such as the PA do intensively invest in ICT: according to the GPT conceptualization, this investment concurs in generating the critical mass of increasing returns-to-scale and network externalities for the business sector and society at large. Henceforth, we posit that newly developed ICT indicators could provide a promising alternative to patents to measure the knowledge and innovation activities of the rich web of actors external to the firm, so far largely unexplored. These innovative activities could significantly

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[1] According to Bresnahan and Trajtenberg (1995), one key technological component (such as semiconductors for ICT) drives each technological era. By generating increasing returns-to-scale and pervasive diffusion, GPT are engines of economic growth. For a recent reappraisal of the debate on GPT, see Bekar et al. (2018).

[2] For example, Matteucci et al. (2005) showed the positive impact of private ICT investment on firm productivity in a set of EU countries. Donati and Sarno (2013), by focusing on a panel of Italian manufacturing firms in the period 2001–2006 find that, while ICT investment alone does not significantly boost labour productivity, it increases efficiency when complemented by training programmes and organizational innovation. Millán et al. (2021) employ a dataset on small entrepreneurs in 35 European countries in 2010 and 2015 and prove the causal impact of ICT usage on earnings.

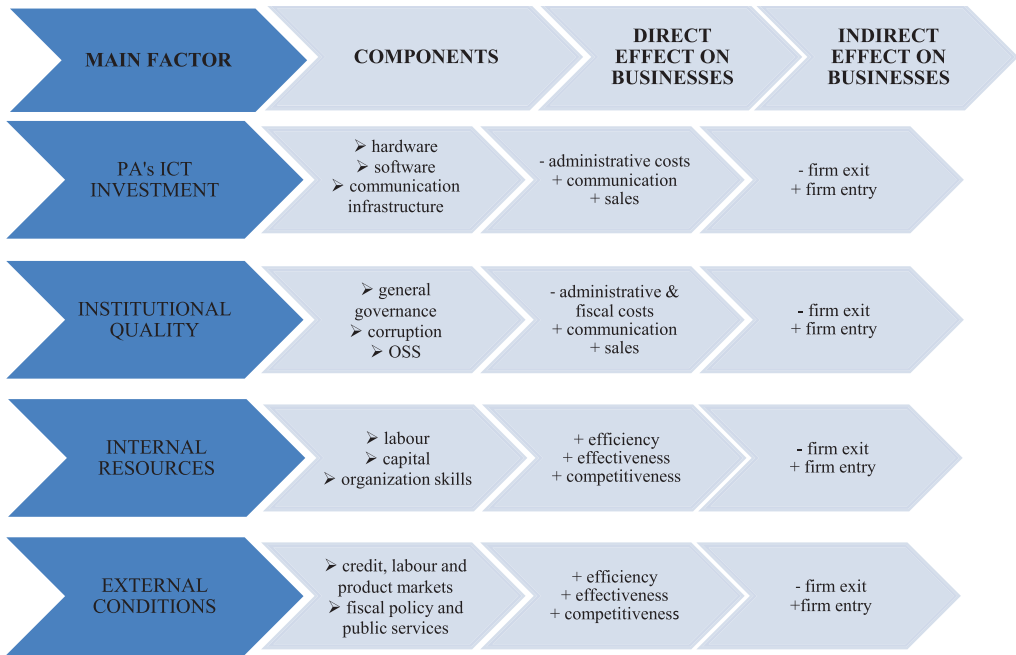impact on business performance, especially in non-manufacturing samples of firms, which hardly patent.

The large literature on e-government and other public e-services investigated not only the drivers and the diffusion paths, but also the effects of the ICT investment made to digitalize governments and the PA. Recent and comprehensive reviews are those provided by Arduini and Zanfei (2014), Twizeyimana and Andersson (2019) and Panayiotou and Stavrou (2021). The bulk of this literature is focused on e-service "inputs" (such as ICT investment), because "output" indicators present higher measurement difficulties (service quality, data availability, etc.).

As such, theoretically two main potential effects of public e-services were disentangled: (a) the effects "internal" to the PA (affecting its employees and the other PA bodies), and (b) the effects "external" to the PA—affecting citizens and businesses. A main claim is that ICT entail a high degree of automation of the bureaucratic work, whose labour contribution is reduced and substituted with ICT capital, so-called "e-administration" (Twizeyimana and Andersson, 2019). Henceforth, this transformation may increase the internal efficiency and effectiveness of the functioning of public institutions, via a series of mechanisms: by cutting operative and transaction costs (in the meaning of Williamson, 2000), reducing the bureaucratic "red tape", improving the information flows and coordination among employees and PA bodies, enhancing public procurement and reusing PA's data (Arduini and Zanfei, 2014; Panayiotou and Stavrou, 2021). Furthermore, most of these internal effects are also believed to exert an impact on the external stakeholders of the PA (citizens, firms and society at large): in fact, the deployment of ICT innovations, besides reducing the costs for the PA, also increases the quality of the public services provided. In turn, the provision of higher quality public e-services does impact positively on the company's balance sheet. For instance, the theoretical review of Panayiotou and Stavrou (2021, p. 6) reports that G2B e-services may benefit firms by reducing their administrative burden, by increasing competitiveness, and by enhancing the data management and the monitoring of production processes.

Disappointingly, when looking at the main reviews (Lee et al. 2011; Arduini and Zanfei, 2014; Twizeyimana and Andersson, 2019; Panayiotou and Stavrou, 2021), it emerges that the bulk of the literature considering the effects of public e-services has a theoretical/conceptual nature, while empirical and econometric contributions remain scarce. Moreover, whereas the effects of e-services were seldom studied when concerning the PA (and, to a lesser extent, citizens), the business sector was mostly ignored.

Among the very few studies that estimated the "external" effects for the business sector, Thompson et al. (2005) focus on profitability. They study a sample of 100 small firms from three US states and classify e-government services that have search-oriented and transaction-oriented uses. It is found that the firm's digital capability drives the extent to which firms use e-government for search-oriented uses, which in turn increase profitability; instead, a similar effect is not found for transaction-oriented e-government. By using the same conceptual framework, Badri and Alshare (2008) study a larger sample of 1859 firms in Dubai. The basic results of Thompson et al. (2005) are confirmed, and a positive significant effect on profitability is also found for transaction-oriented e-government, via time savings related to paperless procedures. Henceforth, they confirm the literature hypotheses that the PA's ICT investment may reduce the information costs and the administrative burden for businesses, thereby raising profits.

Other external positive effects on businesses are possible. An efficient and effective PA (as transformed by ICT adoption), by reducing the administrative burden, improving the communication of business-relevant information and stimulating their sales, could help existing firms not to exit (especially during crises); in a more optimistic scenario (or during expansionary cycles), such a

MAIN FACTOR	COMPONENTS	DIRECT EFFECT ON BUSINESSES	INDIRECT EFFECT ON BUSINESSES
PA's ICT INVESTMENT	➢ hardware ➢ software ➢ communication infrastructure	- administrative costs + communication + sales	- firm exit + firm entry
INSTITUTIONAL QUALITY	➢ general governance ➢ corruption ➢ OSS	- administrative & fiscal costs + communication + sales	- firm exit + firm entry
INTERNAL RESOURCES	➢ labour ➢ capital ➢ organization skills	+ efficiency + effectiveness + competitiveness	- firm exit + firm entry
EXTERNAL CONDITIONS	➢ credit, labour and product markets ➢ fiscal policy and public services	+ efficiency + effectiveness + competitiveness	- firm exit +firm entry

FIGURE 1 **Theoretical framework on the territorial drivers of business dynamics**. Source: Authors' elaboration [Colour figure can be viewed at wileyonlinelibrary.com]

pro-business PA could even encourage new firms to enter the market, *ceteris paribus*. So far similar hypotheses were conceptually sketched at the cross-country level by Friesenbichler et al. (2014), but no empirical analysis was proposed at the regional or lower levels, where the heterogeneity of ICT investment is higher and such effects could be more detectable. In detail, Friesenbichler et al. (2014, ch. 1) explore at the state level, from an EU perspective, the institutional channels linking the efficiency of the PA with firm's growth. Such a conceptual framework explicitly connects the quality of the government and PA (together with their ICT efforts) with the business demography, via "domains" and "profiles". Three general domains are conceptualized: "general governance" (or institutional quality), "e-government" (summarizing the PA's ICT instruments) and "corruption and fraud".[3] We notice that these domains correspond to institutional characters and competences that the EU system of multi-level governance (Piattoni, 2010) attributes to the regional and municipality governments. Moreover, the institutional profile "starting a business" fits one recent international reform—the One-Stop-Shop (OSS)—that simplified the bureaucracy needed for starting a business. Finally, as verified by Braunerhjelm and Eklund (2014) on a panel of 118 countries, similar entry-boosting effects are also generated by PA reforms reducing the tax administrative burden.

To sum up, given the hypotheses on the external benefits for the business sector found in the public e-services literature, and by extending the conceptual contribution of Friesenbichler et al. (2014, ch. 1), we formulate our theoretical framework, as in Figure 1. It motivates an original

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[3] Furthermore, four specific profiles are identified, to measure further dimensions where public institutions interact and shape business growth: "starting a business", "public payment morale", "tax compliance" and "efficiency of the civil justice".

empirical test of the impact of the PA's ICT investment on business demography, that appears promising when conducted at the disaggregated level.

In detail, Figure 1 posits that the PA's ICT investment is the key input and the main driver of change connected to the provision of new public e-services. In turn, public e-services help firms to stay alive, by reducing their administrative costs, improving business-relevant communication and stimulating firm sales (thereby, they reduce the exit rate). Potentially, when e-services attain certain quantity and quality thresholds, the PA's ICT investment may even motivate new firms to enter. Therefore, we state the two key hypotheses of our paper, H_1 and H_2:

> H_1: *The PA's ICT investment reduces the firm exit rate.*
> H_2 : *The PA's ICT investment increases the firm entry rate.*

Then, in analogy with the e-services literature and Friesenbichler et al. (2014), we consider the complementary role of institutional factors, such as good governance (or rule of law), absence of corruption, and specific reforms reducing the "red tape" (such as the OSS); as surveyed by Djankov (2009) and confirmed by Amici et al. (2016) for Italy, good institutions and reforms easing business entry should promote entrepreneurship.

Finally, entrepreneurship—in particular, firm entry—also requires resources internal to the firm (e.g., workforce, capital and organizational skills), and favourable external conditions (on the input and output markets, wealth and fiscal and economic policy), that drive the overall firm efficiency and effectiveness (thereby, competitiveness). These resources and conditions have been examined by the large body of literature on business demography, and will be expressed as controls in the following econometric analysis (as detailed in Section 5).

3 | ICT DIFFUSION IN ITALIAN PUBLIC ADMINISTRATIONS

During the past decade, the Italian PA ranked below the EU-28 average for its overall status of digitalization; the enduring laggardness is confirmed by the sub-component "Digital Public Services" of the DESI index,[4] which is a multidimensional composite indicator measuring the progress of ICT diffusion and usage across EU member states.

Since the early 1990s Italy has passed many reforms for the digitalization of the PA and the introduction of public e-services, with meagre results. In particular, major modernization efforts were made during the 2000 and 2010 decades, but most of them focused on drafting and passing the new norms; instead, the crucial implementation phase (where ICT investment occurs and the front-office and back-office of the PA are transformed—see Arduini and Zanfei, 2014) was often delayed (Natalini and Stolfi, 2012; Castelnovo and Sorrentino, 2018; Sorrentino et al., 2017). A striking example is the Digital Administration Act (henceforth, DAA), a crucial normative text that frames the fundamental principles for the digitization of the PA, concerning the availability, management, access, transmission, storage and usability of information. The initial Act dates to Legislative Decree No. 82 of 7 March 2005, which was followed by 29 changes of the DAA text.

Another example of delayed and partial implementation of PA reforms is the introduction of the One-Stop-Shop (OSS) in Italy. The OSS founding Act, Legislative Decree No. 112 of 3 March 1998, was aimed at introducing a "single point of contact", where any entrepreneur can find all

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[4] Available at: https://digital-agenda-data.eu. The DESI index is available starting from the year 2014.

the information needed and administratively start their new business, irrespective of the number of procedures and public administrations involved. The OSS reform was delayed and 10 years later, by December 2007, only 70.6% of Italian municipalities had implemented an OSS (Castelnovo et al., 2016). With further norms (e.g., Law 160/2010), municipalities were submitted to more stringent obligations and deadlines for implementing an OSS (Castelnovo and Sorrentino, 2018). Consequently, the formal availability of OSS touched 89% of Italian municipalities by 2012, reaching 100% by the end of 2014. Although the reform has not reduced the administrative fees, it has simplified the procedures and reduced the days needed to start a business—in other words, the "red tape" (Amici et al., 2016).

The causes of reform failures are manifold. On the one hand, scholars of administrative law and public governance point to institutional country-wide obstacles. Capano (2003) sees the Italian public sector dominated by a legalistic administrative paradigm, which requires every PA reform to be codified through formal (legal) norms and paper-based processes (Mele and Ongaro, 2014). Disappointingly, legalism focuses on passing new norms, while it tends to disregard their actual implementation (Gualmini, 2008).

On the other hand, ICT diffusion in the PA and e-services deployment show a relevant territorial heterogeneity, especially in Italy: Cepparulo and Zanfei (2021) find that the within-country municipal heterogeneity of Italy is one of the highest among all EU15 countries. A main case is the Public Connectivity System, presented below, which enables the PA units and their stakeholders to be interoperable. Moreover, many e-services are systemic and, in order to work effectively, require the usage of multiple hardware and software devices, and communication technologies, located both in the "back" and "front-office" of the PA (Panayiotou and Stavrou, 2021); a peculiar example is broadband infrastructure (Seri et al., 2014). Furthermore, most ICT innovations do require organizational and institutional innovations (Arduini and Zanfei, 2014), in both the supply and usage phases: without these innovations, ICT investment may not unleash its full benefits on external business stakeholders. Henceforth, the materialization of the external benefits from the PA's ICT investment also depends on the administrative capacity of the PA, for which some Italian regions—concentrated in the south of the country—are laggards (Milio, 2007; Matteucci, 2020). Hence, besides country-wide obstacles, there could be differentiated dynamics as well as territorial drivers going on at the level of technology and institutional quality (the latter being composed of government quality and administrative capacity).

Table 1 is drawn from the triennial survey on the ICT deployed in Italian local public administrations (LPA); the survey is run by ISTAT (2010, 2013, 2017 and 2020), and it is publicly available only at the aggregate level. It shows that some types of ICT hardware, such as desktop PC per 100 employees, by 2012 had reached mass diffusion (84.4%); instead, mobile technologies were much less widespread (3.2%). According to the theory of diffusion of innovations (e.g., Rogers, 1995), we expect that the spread of the various types of ICT varies by their specific complexity and technological maturity. This fact is confirmed by focusing on two ICT that we later employ as explanatory factors for entrepreneurship. First, social media: as in 2012 this was a novel communication platform for the PA, it was used only by 16.6% of LPA. Instead, open source software[5] in 2012 was mature and present in the majority of Italian LPA (55.2%).

Finally, Figure 2 shows the municipality level distribution of two key types of ICT across the LPA by 2011: open source (left-hand side) and Public Connectivity System (PCS, right-hand side). The PCS is a complex ICT resource (or "platform") consisting of an interoperable architecture

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[5] Open source can be more flexible and innovative compared to pre-packaged software, especially when customized for manufacturing applications.

TABLE 1 Diffusion of ICT and supply of e-government services in Italian LPA (%)

Diffusion of hardware technologies	2009	2012	2015	2018
Desktop PC for 100 employees	89.0	84.4	90.3	94.5
Laptops for 100 employees		7.2	7.7	8.3
Other mobile devices for 100 employees		3.2	8.1	10.8
Diffusion of software technologies (% tot)	**2009**	**2012**	**2015**	**2018**
LPA that use opensource	48.9	55.2	54.1	50.9
LPA that use social media	n.a.	16.6	30.9	n.a.
Supply of e-government services (% tot)	**2009**	**2012**	**2015**	**2018**
Visualization and/or acquisition of information	89.8	90.5	93.5	98.5
Acquisition (download) of forms	67.8	75.9	85	92.8
Online submission of forms	15.6	36.7	58.3	68.3
Telematic initiation and conclusion of the entire process relating to the requested service	7.6	19.1	33.8	47.8

Notes: LPA = Local Public Administrations. n.a. = not available

Source: Authors' elaboration on ISTAT (2010, 2013, 2017, 2020), *Survey on ICT in LPA*.
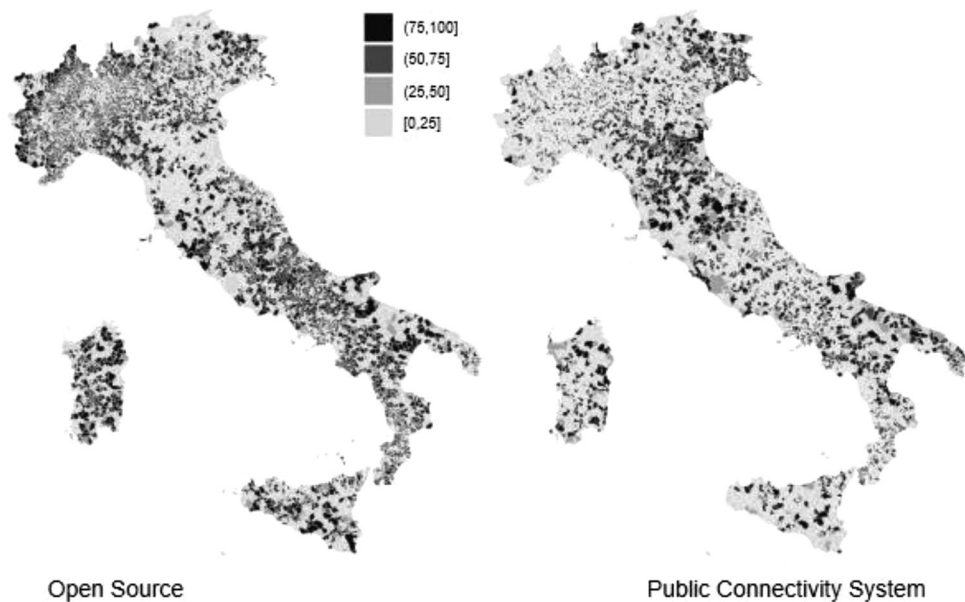
FIGURE 2 **Municipal diffusion of open source and PCS in Italy, 2011 (% of cases)**. Source: Authors' elaboration on ISTAT data, 2011 Industry and Services Census

of networks, devices and codes specifically designed and engineered to serve as an informative system for the PA, across its various levels (AGID, 2013).

The territorial distribution shows high heterogeneity, with some areas being heavy adopters and others where both technologies register very limited diffusion. Comparatively, open source is more diffused than PCS. Concerning PCS, municipal leaders tend to concentrate in four regions of the North-Centre: Friuli-Venezia-Giulia, Emilia-Romagna and Tuscany, and one of the South (Apulia). Although open source in 2011 included a heterogeneous variety of packages and

applications (from simple web browsers to personalized office automation programs), in the same year the development of PCS signalled the attainment of a superior level of technological complexity in the process of PA digitalization.

4 | EMPIRICAL MODEL AND ESTIMATION METHODOLOGY

We are interested in investigating the impact of ICT diffusion in the Italian PA on business demography. We contribute to expanding the research frontier by using innovative, previously unexploited municipal data referring to the PA: in fact, our study is one of the first examples uncovering the huge heuristic potential stemming from granular government data (Rahal, 2018). Municipal-level analyses, besides accounting for a tiny fraction of the existing literature on the determinant of business dynamics, are particularly insightful for topics like ours: in fact, most of the interactions that firms have with the PA during their life unfold at the municipal level. To the best of our knowledge, for the EU and Italy the only municipal-level analysis is that of Amici et al. (2016), while other contributions exploited provincial data, at the most (e.g., Gagliardi, 2009; Agostino et al., 2019; Colombelli et al., 2021). Moreover, since ICT are GPT (Bresnahan and Trajtenberg, 1995; Bekar et al., 2018), which may present long diffusion lags and large territorial gaps, the municipality level of enquiry enables us to measure both the intensive and the extensive margin of diffusion across all units composing the PA. As shown in Section 2, the regional and local relationship between e-services and business dynamics has been neglected, with the few existing contributions mostly considering the country level.

Methodologically, we conduct a regression analysis with cross-sectional data. We estimated model (1), where the dependent variable BD_i measures the following three dimensions of business dynamics in the ith municipality: the firm birth rate; the firm death rate; and the turnover rate, as the difference between the previous two indicators. Therefore, we estimate three models, one for each of the three dependent variables. The BD_i rate is measured in the census year 2011 since municipal data on the ICT of Italian PA are available only for that year.

$$BD_i = \alpha + \beta ICT_i + \gamma X_i + \varepsilon_i \qquad (1)$$

On the right side of Equation (1), the variable ICT corresponds to the ratio of public institutions (PI) using a given ICT type to provide digital public services, on the total number of PI present in the ith municipality. It captures how widespread the use of ICT is in both central and local public institutions. We stress that those ICT-using PI may belong to any type of PA bodies (central, regional or local governments, and all the other public institutions). Henceforth, this variable provides a comprehensive measure of all e-government deployments present throughout the country, contrary to other official surveys that are focused only on the local PA (i.e., municipal governments—for example, ISTAT, 2010–2020). We use four different indicators of ICT in the PA in model (1). They are introduced one at a time in each of the three models to avoid problems of multi-collinearity (Wooldridge, 2002) due to high correlation across them. The indicators are illustrated in greater detail in the next section.

The cross-sectional analysis may suffer from the omitted variable problem caused by the unavailability of data on explanatory variables that cannot be included among the regressors. The potential correlation between the explanatory variable and the omitted one makes the former endogenous, making the ordinary least squares (OLS) estimation method inconsistent (Wooldridge, 2002). To minimize the risk of endogeneity due to omitted variables, we use a rich set

of controls X, which includes socio-economic characteristics, demographic, territorial and institutional variables; where possible, controls refer to the municipal level, or to NUTS-3 at the most (corresponding to provinces in Italy).

ICT endowments of the PA may be endogenous for reverse causality problems due to the simultaneous relationship between business demography and the share of public institutions using ICT to offer public e-services. The key regressor *ICT* is assumed to be partially determined by the dependent variable, causing a correlation between *ICT* and the error term. The correlation makes inconsistent the OLS estimate of the parameters of model (1), calling to other estimation methods to solve the reverse causality problem. We employ a two-stage least squares (2SLS) methodology to address this issue. This method is commonly used in the literature to solve estimation problems due to an endogenous explanatory variable (Wooldridge, 2002). The 2SLS method uses exogenous observable variables as valid instruments for endogenous regressors. The instruments should be uncorrelated with the error term and correlated with the endogenous variable (Wooldridge, 2002). This method is based on two stages of regression: in the first stage, the endogenous variable (in our case, *ICT*) is regressed on the set of instrumental and explanatory variables (X); in the second stage, the OLS estimator is performed by regressing the dependent variable (*BD*) on the set of explanatory variables and the fitted value of the endogenous variable obtained from the first-stage regression.

The ICT endowments of the PA are instrumented with electoral variables. Specifically, we use two instrumental variables related to the voter turnout and the share of yes-votes in the referendum which took place in Italy on 12–13 June 2011. The two variables are calculated on the referendum question 1 (q_1) concerning the awarding of local public services of high social and economic importance (such as water, electricity and gas), and the role of "mixed" (ownership) enterprises: these issues attracted much debate in the public arena, and their norms had undergone several reforms in the previous two decades (Bognetti and Robotti, 2007).[6] Specifically, we calculated the voter turnout as the ratio between the number of those who voted in this referendum question over the total number of eligible voters. The second indicator is calculated as the share of yes-votes over the total number of actual voters on this referendum question. Both indicators measure civic engagement and political involvement in public interest issues. In fact, also in Italy, individuals participate in the referendum vote to mandate specific legislative changes and put political pressures on elected representatives,[7] thereby catering for the public interest. The adoption of ICT enables the PA to provide public services that make life easier for citizens, which is a key public interest. According to Henriksen (2004), elected representatives are put under pressure by citizens through electoral participation to adopt e-services that improve and simplify their lives. Henriksen (2004) predicts that municipalities with high voter turnout tend to adopt more e-services. She tested this hypothesis on Danish municipalities without finding a statistically significant relationship between the adoption of e-services and voter turnout in local elections. A higher voter turnout in a referendum on local issues also creates strong pressures on local elected representatives. They may feel greater insecurity about the probability of their re-election in office, which could lead them to point towards new programmes popular with the public (Berry and Berry, 2018). The adoption of ICT in the PA to provide e-services to citizens is part of the new

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[6] Citizens were called to the polls to vote for four referendum questions including the one related to the abolition of Article 23-bis of Law Decree no. 112/2008, converted in Law no. 133/2008. This Law established that the provision of these local public services could be awarded only to undertakings featuring specific ownership schemes, which could be either private or mixed (public-private).

[7] In Italy the referendum is only revocatory, and voting is not compulsory, contrary to political elections.

programmes that elected representatives can engage to obtain greater voter support. Even a high level of yes/no in the referendum can put great pressure on the elected representatives who will be more inclined to please voters by introducing popular policies like ICT policies. Therefore, a positive correlation is assumed between ICT in the PA and the voter turnout (share of yes-votes) in the referendum. The two electoral variables do not display theoretical relationships with the dependent variable *BD*. Moreover, they are correlated to each other only at 0.192. Thus, they can be used together in the first-stage regression analysis as they are exogenous and not subject to multicollinearity problems.

5 | DATA AND VARIABLES

The empirical analysis was conducted on a sample of 5765 Italian municipalities, referring to the year 2011, when similar census surveys were conducted across EU member states. We considered only those municipalities belonging to the regions with ordinary statute, whose normative and administrative powers differ substantially from those of special statute regions.

Concerning firm dynamics, we used the official annual data on business demography registered at the municipal level, which come from the Register of Companies of Infocamere, the statistical office of the network of the Italian Chambers of Commerce: by law, enrolment and cancellation (upon exit) from the Register is compulsory. We use them to calculate the firm birth rate, the firm death rate and the turnover rate. In analogy with previous studies, we calculate the birth rate by standardizing the total number of firms born in a given period (in our case, in the year 2011) to the municipality inhabitants. In fact, as recalled by Audretsch and Vivarelli (1996), geographical areas (provinces, municipalities) comprising more people or potential entrepreneurs are expected to generate more firms. Across the three macro-sectors of the economy included in our study (agriculture, manufacturing and services), the resident population provides the most uniform and correct proxy of the number of potential entrepreneurs.[8] Similarly, the firm death rate is the ratio of the total number of exiting firms (during 2011) to the demographic population of the municipality. The difference between the two variables provides the third indicator, the turnover rate.

Based on the suggestions coming from converging streams of literature (discussed in Section 2 and summarized in Figure 1), we assume that ICT diffusion in the PA can gradually transform both the front and back office of administrative processes, and their efficiency and effectiveness gains may arrive to impact on business demography. To this end, we need an informative variable of ICT adoption valid for all the units of the PA with which firms have frequent interactions. We exploit original information on ICT diffusion, coming from the 2011 census, which is richer than other ICT surveys (e.g., ISTAT, 2010–2020), since it provides data for all the local units of the central, regional and local PA—not just regional councils and municipalities: we called them PI, or public institutions.[9]

In 2011, all Italian PI were surveyed with a questionnaire asking about the presence of selected ICT resources, which belong to the traditional classes of hardware, software and communication

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[8] Furthermore, this choice is also motivated by the wide territorial heterogeneity existing in the stock of active firms in Italy: the less developed southern regions exhibit a much lower business base than the northern and central ones. Using the stock of active firms as numeraire would overestimate the southern birth rate.

[9] In detail, it surveys the offices of the urban police, fire brigade, tribunals, national health system, social welfare system, environmental agencies, and so on, whose activities impact on the daily operations of firms.

services, employed in the business sector taxonomies (e.g., Matteucci et al., 2005). In particular, we built the following indicators of ICT in the PA: the percentage of PI that use mobile technologies (on the total number of PI present in that municipality); the percentage of PI that use open source software; the percentage of PI that use social media to communicate with the public; and, finally, the percentage of PI that use the PCS. As discussed in Section 3, these technologies present heterogeneous levels of complexity and potential benefits for the external stakeholders. The PCS is the most ambitious and systemic type of ICT among those surveyed, and its importance can hardly be overstated, since it acts as the "nervous system" of the PA: by connecting its branches, it boosts the systemic intelligence of administrative activities, and can reduce overlapping or conflicting functions. In other words, among the ICT covariates, the PCS is the one that better registers the network externalities generated by the PA digitalization. We point out that the types of ICT surveyed in this study are common and standardized across most EU and OECD countries, which also adopted similar policies for the digitalization of the PA: therefore, our study is highly replicable for these countries, for similar technologies and periods.

For all ICT covariates, the impact of using digital resources by PI is expected to be positively related with the firm birth rate, negatively with the death rate, and positively with the turnover rate. As discussed in Section 2, our expectation is partly formed by analogy with the literature which studies the benefits obtained by the PA internally, and those accruing to citizens using e-services. Furthermore, a few empirical papers (Thompson et al., 2005; Badri and Alshare, 2008) found a positive relation between the firms' rate of e-government usage and their profitability. Finally, a conceptual paper (Friesenbichler et al., 2014) conjectured that, at the cross-country level, the PA's ICT investment may spur business entry and growth. We expect that such a relation may be better captured at the regional and local level, offering many more interactions between the PA and businesses. Here, ICT can ensure better accessibility of the PA services to businesses, increase the wide diffusion of business-relevant information, improve the quality of the public services offered, and help the PA to simplify and speed up procedures relevant for business activities. Concerning the latter point, an identification problem may arise and will need to be dealt with. We need to distinguish the simplifying effect played by ICT resources by controlling for other institutional and organizational factors which jointly contribute to reducing the administrative burden for businesses, such as the institutional reform introducing the OSS. Since the OSS is a unit of the local PA that handles in a centralized manner the bureaucratic procedures related to entry, following Ciccone and Papaioannou (2007) and Djankov (2009), we posit that this administrative reform should reduce "red tape" and transaction costs, and thereby promote entry. Therefore, we exploit a municipal-level variable measuring OSS implementation, which is retrieved from the ISTAT census and is updated at 2011. Finally, according to the "threshold" rationale found in the ICT and e-services literatures, it is more likely that a positive effect of the ICT PA is found in terms of reduction of exit, than the promotion of new entry—especially in periods of crisis.

Besides the key ICT covariates, we employed a battery of controls to check for socio-demographic, economic, institutional quality and territorial determinants of business demography. It is important to recall that, in the literature on the determinants of entrepreneurship, some covariates (such as economic growth, unemployment, input costs, etc.) can assume both signs, across different studies. A main taxonomy is the one distinguishing between "pull" and "push" motivations, which partly overlaps with that of, respectively, "opportunity" and "necessity" entrepreneurship (van der Zwan et al., 2016). Pull factors are generally meant as positive drivers of entrepreneurship, correlated to the desire to exploit business opportunities (industry profits, barriers to entry, positive business cycle, but also individual motivations of personal

achievement); push factors are understood as negative drivers (such as unemployment, family pressure or personal job dissatisfaction), that force people into becoming entrepreneurs.

In the first group of controls (socio-demographic) we include education, which is measured by the ratio between the total number of university graduates and the population. Education builds the human capital which, together with the financial capital, is a main input for self-employment and entrepreneurship: henceforth, education is expected to exert a positive influence on firm creation (e.g., Storey, 1994; Delmar and Davidsson, 2000; Audretsch et al.., 2002; Dilli and Westerhuis, 2018). For immigration we considered the percentage of foreigners on the total population. This control is expected to show a positive correlation with the firm birth rate; at the same time, ethnic ventures face higher failure rates and register shorter ownership duration (OECD, 2010; Bettin et al. 2018; Ostrovsky and Picot, 2018).

Coming to the second group, the unemployment rate is calculated as the percentage of unemployed people on the total labour force. The relationship between unemployment and entrepreneurship is multi-faced, and can assume in principle both signs, positive or negative (Audretsch and Fritsch, 1994; Storey 1991, 1994; Reynolds et al., 1994; Santarelli and Vivarelli, 2007). Then, we consider the degree of economic openness and the economic size (or wealth) of the local area. Both refer to the provincial level, not only because similar data are lacking at the municipal level, but also because the provincial level is the most appropriate for detecting business activation effects stemming from production and trade activities, especially in Italy.[10] Openness is calculated "gross", as the ratio between the sum of exports and imports and GDP. The value added of the total economic activities (VAT, measured in thousands of euros, in natural logarithm) proxies the economic size and wealth of the local area. To control for firms' access to capital, we use the ratio between total bank loans and the resident population—all measured at the provincial level. We lack the business loans variable, so we employed the overall loans equivalent, lent to any type of bank customer. Then, the ratio between (local) tax revenues and the total population is used as a proxy for tax burden, in linear and squared form. In fact, the effects of taxation on entrepreneurship are complex to disentangle and may follow non-linear paths. In principle, taxation is expected to be negatively correlated with firm birth rate (Djankov et al., 2010; Da Rin et al., 2011; Kneller and McGowan, 2011 and 2012; Braunerhjelm and Eklund, 2014). Da Rin et al. (2011) and Kneller and McGowan (2012) find a significant concave relationship between the birth of new businesses and the average tax rates. Similarly, a high burden of administrative fiscal compliance can be positively correlated to firm death (Bruce, 2002; Klapper et al., 2006; Gurley-Calvez and Bruce, 2008; Braunerhjelm and Eklund, 2014). Thus, we expect a positive relationship between the overall (local) tax burden and firm death rate.

For the third group (institutional quality), we use the two sub-components of the IQI index of Nifo and Vecchione (2014) accounting for "rule of law" and "corruption", referred to 2011 (provincial level). In principle, these indicators bear opposite meanings: positive for rule of law (the more, the better), negative for corruption. Concerning rule of law, a positive relationship with firm birth rate and a negative one with firm death rate are expected for normative certainty and enforceability of business contracts (similarly to Agostino et al., 2019). Concerning corruption, literature findings vary, according to the prevailing economic and business effects of mis-practice ("grease" or "sand"). Although most macroeconomic and development studies expect negative effects from corruption, Dreher and Gassebner (2013) uncovered positive effects on entry; here, the causal effect is that corruption may soften the administrative and regulatory burden and render entry

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[10] We recall that nearly 70% of Italian municipalities register less than 5000 inhabitants (source: https://www.tuttitalia.it, 2021); hence, a limited scale of activity.

less costly and difficult. At the same time, corruption may induce market exit or death, due to higher transaction costs and inequities generated (for the US case, see Goel and Saunoris, 2020). Concerning institutional reforms (or organizational innovations connected to e-services) directly impacting on business entry, we consider "OSS", calculated as the share between PI that own the One-Stop Shop and the total number of PI, measured by 2011: in fact, because the OSS implementation was delayed, the municipalities that had implemented it by 2011 could be considered best performers. Although OSS streamlines entry bureaucracy, it is not concerned with exit decisions. Therefore, similarly to Amici et al. (2016), we expect OSS to play a positive impact on firm birth, and a non-significant one on firm exit.

Fourth, for territorial characteristics, we control for rurality by means of a dummy variable that assumes value 1 if the municipality is rural, and 0 otherwise. Finally, our dummy North-Centre assumes value 1 for municipalities located in the northern and central areas, and 0 otherwise, to check for broad geographical patterns:[11] in fact, it is dubious whether this dummy captures the broad allocation of administrative capacity (that in Italy mostly accrues to the northern and central regions). Given the policy-specific contents of the latter construct (Milio, 2007; Matteucci, 2020) and its territorial variability, we tend to interpret the macro-area dummy as a more general fixed effect registering multiple institutional factors, in conjunction with the other provincial level institutional controls (IQI).

Variable definitions and data sources are presented in Table 2, and Table 3 displays summary statistics of all variables. A correlation matrix between dependent and explanatory variables is reported in the Appendix section. Table A.1 shows that the degree of correlation between the variables is not high except for the ratio of total bank loans to inhabitants. The ratio is strongly correlated with the share of foreigners (0.45), the value added of the total economic activities (0.67), trade openness (0.42), and the unemployment rate (-0.51). Corruption is also highly correlated with the unemployment rate (-0.64) and trade openness (0.43). The unemployment rate and trade openness are highly negatively correlated with each other (-0.51). The high correlation between such variables could cause a multicollinearity problem in our regression analysis. We check for the presence of multicollinearity using the variance inflation factor (VIF) (Mansfield and Helms, 1982). A rule of thumb that appeared in the literature indicates that the VIF values higher than 5 suggest that multicollinearity is a concern in the linear regression analysis. The VIF values between 1 and 5 indicate a moderate correlation. A value equals to 1 indicates no correlation (Daoud, 2017, Shrestha, 2020). In Table A.2, the VIF values are computed for each explicative variable and are below 5, underlining that multicollinearity should be no longer a problem in our estimates.

6 | RESULTS

In this section, we illustrate the 2SLS estimation results obtained by using different indicators of business demography as the dependent variable of model (1). Specifically, Table 4 displays the results for hypothesis 2 (H_2) by using the indicator of firm birth rate, whereas Table 5 provides those using the firm death rate to verify hypothesis 1 (H_1). Table 6 illustrates the results concerning turnover rate. The estimates are performed by inserting a single indicator of the PI's ICT diffusion

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[11] The ordinary statute regions in the south of Italy are Abruzzo, Molise, Campania, Basilicata, Apulia, Basilicata and Calabria.

TABLE 2   Variable definitions and data sources

Variable	*Definition*	*Data source*
Firm birth rate	Rate between the total number of new firms and the total population (multiplied by 100,000 inhabitants).	Infocamere, data released by Chamber of Commerce
Firm death rate	Rate between the total number of exiting firms and the total population (multiplied by 100,000 inhabitants).	Infocamere, data released by Chamber of Commerce
Turnover rate	Difference between firm birth rate and firm death rate (multiplied by 100,000 inhabitants).	Infocamere, data released by Chamber of Commerce
Mobile tech	Share (%) between PI that use mobile technology, tablets, other mobile devices, and the total number of PI.	Industry and services census 2011, Istat
Open source	Share (%) between PI that use opensource and the total number of PI.	Industry and services census 2011, Istat
Social media	Share (%) between PI that use social media and the total number of PI.	Industry and services census 2011, Istat
PCS	Share (%) between PI that use a Public Connectivity System (PCS) and the total number of PI.	Industry and services census 2011, Istat
Education	Share (%) between the total number of graduates and the total population.	Population and housing census 2011, Istat
Foreigners	Share (%) between the total number of foreigners and the total population.	Population and housing census 2011, Istat
Tax burden	Ratio between municipal tax revenues and the total population (divided by 100).	Ministry of Interior Database on public finance
VAT	The added value of the total economic activities (VAT) is a proxy for size of economy. Measured in thousands of euros (in natural logarithm). Provincial level.	National accounts, Istat
Unemp	Share (%) between the unemployed people and the total labour force. The unemployed are people of working age who are without work, are available for work, and have taken specific steps to find work. The labour force, or currently active population, comprises all persons who fulfil the requirements for inclusion among the employed or the unemployed.	Population and housing census 2011, Istat
Trade openness	Ratio between the sum of imports and exports divided by the added value of the total economic activities (VAT) (divided by 1000). Provincial level.	National accounts, Istat
Loans rate	Ratio between total loans and the total resident population. Provincial level.	Bank of Italy
OSS	Share (%) between PI that own the One-stop shop (OSS) and the total number of PI.	Industry and services census 2011, Istat
Rule of law	Provincial index that summarizes data on crimes against persons or property, trial times, magistrate productivity, tax evasion and shadow economy. Provincial level.	Nifo and Vecchione (2014) https://sites.google.com/site/institutionalqualityindex/home

(Continues)

TABLE 2 (Continued)

Variable	Definition	Data source
Corruption	Provincial index that summarizes data on crimes committed against the Public Administration, the number of local administrations overruled by the federal authorities and the Golden-Picci Index. Provincial level.	Nifo and Vecchione (2014)https://sites.google.com/site/institutionalqualityindex/home
Rurality	Dummy variable concerning the rurality degree of a municipality. It assumes value 1 if the municipality is rural, and 0 otherwise. A rural municipality is a municipality having a population density lower than 150 inhabitants per km^2.	Statistical atlas of the municipalities
North-Centre	Dummy variable concerning the regional location of a municipality. It assumes value 1 if the municipality belongs to the North and Centre regions, and 0 otherwise (South regions).	Our elaboration
Voter turnout (q_1)	Ratio between the number of those who voted in the popular referendum over the total number of eligible voters. The referendum date is 12 June 2011. Question 1 of the referendum refers to the procedures for assignment and management of local public services of economic relevance.	Our elaboration on Italian Ministry of Interior database
Yes-votes (q_1)	Share of yes-votes of the popular referendum over the total number of actual voters. The referendum date is 12 June 2011. Question 1 of the referendum refers to the procedures for assignment and management of local public services of economic relevance.	Our elaboration on Italian Ministry of Interior database
Variable	Definition	Data source
Voter turnout (q_2)	Ratio between the number of those who voted in the popular referendum over the total number of eligible voters. The referendum date is 12 June 2011. Question 2 proposes the partial abrogation of the rules for the determination of the tariff for the disbursement of water, involving the remuneration of the capital invested.	Our elaboration on Italian Ministry of Interior database
Yes-votes (q_2)	Share of yes-votes of the popular referendum over the total number of actual voters. The referendum date is 12 June 2011. Question 2 proposes the partial abrogation of the rules for the determination of the tariff for the disbursement of water, involving the remuneration of the capital invested.	Our elaboration on Italian Ministry of Interior database
Margin of victory	The margin of victory is defined as the difference between the vote share of the mayor and the highest vote share of the opponent candidate, as computed in the last available municipal election.	Our elaboration on Italian Ministry of Interior database

Source: Authors' elaboration on the dataset.

among the regressors and an augmented set of control variables to check the robustness of our findings. The standard errors are robust to heteroscedasticity.

As shown by columns (1)–(4) of Table 4, a greater number of PI that use ICT to make life easier for stakeholders by suppling local e-services and communicating rapidly with them create a

TABLE 3   Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Firm birth rate	5765	586.98	297.73	0.00	4938.27
Firm death rate	5765	642.45	323.58	0.00	5000.00
Turnover rate	5765	−0.06	0.35	−3.80	4.94
Mobile tech	5765	15.88	34.58	0.00	100.00
Open source	5765	38.77	46.86	0.00	100.00
Social media	5765	26.01	41.89	0.00	100.00
PCS	5765	28.17	43.30	0.00	100.00
Edu	5765	7.17	2.65	0.00	25.83
Foreigners	5765	6.47	4.20	0.00	27.58
Tax burden	5765	4.60	2.42	0.17	49.19
VAT (log)	5765	9.44	0.88	7.41	11.79
Unemp	5765	9.24	5.40	0.00	42.18
Trade openness	5765	548.10	308.48	24.12	1670.63
Loans rate	5765	64.32	32.69	17.11	182.49
OSS	5765	32.43	45.13	0.00	100.00
Rule of law	5670	0.60	0.19	0.00	1.00
Corruption	5670	0.86	0.15	0.00	1.00
Rurality	5765	0.58	0.49	0.00	1.00
North-Centre	5765	0.76	0.43	0.00	1.00
Voter turnout (q_1)	5765	56.37	7.07	20.93	87.10
Yes-votes (q_1)	5765	93.00	2.71	71.43	100.00
Voter turnout (q_2)	5765	56.38	7.07	20.93	87.10
Yes-votes (q_2)	5765	93.84	2.50	75.86	100
Margin of victory	5765	25.22	24.84	0.02	100

Source: Authors' elaboration on the dataset.

fertile ground for the birth of businesses in the municipal territory. We find that one additional percentage point in the share of PI that adopt ICT produces an increase between 0.7 and 1.4 in new businesses per 100,000 inhabitants, according to the type of the ICT used: hence, the estimated impact of the share of the PI's ICT endowment on firm creation is small. However, such an impact is not statistically significant, and this holds when adding economic and institutional variables among controls—see columns (5)–(8). The insignificance can be explained by at least two reasons. First, by the fact that the PI's ICT adoption is for new born firms just one of their sources of technology, whose impact is limited to a sub-set of all business operations. In other words, the PI's ICT investment creates a positive externality on the business environment, but this effect needs to be sizeable (attaining on average a certain "threshold") and to be further enhanced by firms with the complementary exploitation of internal resources and with sectoral and local competitive advantages. This mechanism is coherent with the GPT approach of systemic network effects stemming from ICT (Bresnahan and Trajtenberg, 1995; Bekar et al., 2018). Second, the cross-sectional nature of our estimates, based on one single year (2011), may fail to capture a statistically significant effect of the PA's ICT on business entry, which would require a longitudinal setting.

TABLE 4 Estimation results of the impact of the PI usage of ICT on firm birth rate

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Mobile tech	1.419							
	(0.88)							
Open source		0.728				1.214		
		(0.75)				(1.02)		
Social media			0.914				1.373	
			(0.86)				(1.02)	
PCS				1.178				1.597
				(0.89)				(1.00)
Edu	8.332***	9.398***	9.062***	10.070***	7.030**	8.227***	7.909***	9.479***
	(2.82)	(4.20)	(3.80)	(5.36)	(2.09)	(3.37)	(2.97)	(4.94)
Foreigners	12.281***	12.339***	12.546***	12.575***	12.484***	12.386***	12.818***	12.857***
	(8.53)	(8.42)	(9.62)	(9.74)	(8.65)	(8.38)	(9.72)	(9.75)
Tax burden	22.496***	23.198***	23.097***	22.797***	21.984***	23.107***	22.829***	22.649***
	(4.98)	(5.25)	(5.24)	(5.04)	(4.85)	(5.24)	(5.20)	(5.00)
Tax burden^2	−0.307**	−0.329**	−0.332**	−0.294*	−0.306**	−0.341**	−0.341**	−0.292*
	(−2.09)	(−2.33)	(−2.39)	(−1.95)	(−2.09)	(−2.49)	(−2.54)	(−1.96)
VAT (log)					20.263***	22.099***	20.002***	22.310***
					(2.94)	(3.00)	(2.95)	(2.94)
Unemp					−3.129**	−3.210**	−3.222**	−2.575*
					(−2.17)	(−2.19)	(−2.20)	(−1.89)
Trade open					−0.032*	−0.033*	−0.029	−0.027
					(−1.75)	(−1.89)	(−1.48)	(−1.27)
Loans rate					−0.890***	−0.877***	−0.844***	−0.795***
					(−2.72)	(−2.83)	(−2.96)	(−3.13)

(Continues)

TABLE 4 (Continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
OSS					0.137	0.091	0.099	0.127
					(1.42)	(0.75)	(0.84)	(1.24)
Rule of law					116.142***	124.698***	112.605***	122.787***
					(4.90)	(5.17)	(4.65)	(5.09)
Corruption					82.617**	89.840**	78.864**	76.568**
					(2.35)	(2.55)	(2.24)	(2.11)
Rurality	39.705**	32.602**	34.119**	26.748***	35.245*	27.211**	28.751**	19.622**
	(2.14)	(2.51)	(2.56)	(3.17)	(1.73)	(2.03)	(1.97)	(2.11)
North-Centre	−98.889***	−94.692***	−95.602***	−84.793***	−125.326***	−124.263***	−123.207***	−107.809***
	(−7.64)	(−7.20)	(−7.41)	(−4.47)	(−6.39)	(−6.42)	(−6.28)	(−4.18)
First-stage results:								
Yes-votes (q_1)	1.116***	1.997***	1.712***	1.359***	0.934***	1.542***	1.362***	1.171***
	(7.25)	(7.44)	(7.87)	(5.36)	(5.75)	(5.43)	(6.02)	(4.34)
Voter turnout (q_1)	0.168**	0.235**	0.248***	0.213**	0.148**	0.256***	0.224***	0.192**
	(2.58)	(2.45)	(3.01)	(2.29)	(2.25)	(2.62)	(2.68)	(2.02)
K-P rk LM p−value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
K-P rk Wald F stat.	35.81	42.02	47.00	22.833	23.40	26.637	29.13	15.78
Hansen J stat.	0.121	0.102	0.116	0.125	0.276	0.282	0.280	0.283
Obs. No.	5,765	5,765	5,765	5,765	5,670	5,670	5,670	5,670

Notes: A constant term is included among the regressors. Standard errors are robust to heteroscedasticity.

*** $p<0.01$,
** $p<0.05$,
* $p<0.1$.

TABLE 5 Estimation results of the impact of the PI usage of ICT on firm death rate

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Mobile tech	−6.198***				−6.258**			
	(−3.02)				(−2.40)			
Open source		−3.658***				−3.743**		
		(−2.94)				(−2.38)		
Social media			−4.080***				−4.249**	
			(−3.11)				(−2.48)	
PCS				−5.039***				−4.946**
				(−3.02)				(−2.41)
Edu	14.020***	9.929***	10.953***	6.418***	13.083***	9.257***	10.259***	5.400**
	(3.90)	(3.89)	(4.02)	(3.05)	(3.09)	(3.21)	(3.27)	(2.51)
Foreigners	12.335***	12.504***	11.219***	11.015***	12.240***	12.509***	11.180***	11.060***
	(6.46)	(6.53)	(6.68)	(6.40)	(6.42)	(6.53)	(6.57)	(6.41)
Tax burden	20.271***	16.807***	17.597***	18.972***	19.546***	16.068***	16.920***	17.476***
	(4.11)	(3.38)	(3.72)	(3.94)	(3.95)	(3.18)	(3.54)	(3.63)
Tax burden^2	−0.104	0.003	0.007	−0.160	−0.085	0.023	0.024	−0.127
	(−0.65)	(0.02)	(0.04)	(−1.03)	(−0.52)	(0.14)	(0.16)	(−0.81)
VAT (log)					−15.101*	−20.696**	−14.238*	−21.389**
					(−1.75)	(−2.25)	(−1.76)	(−2.24)
Unemp					−1.894	−1.673	−1.628	−3.632**
					(−1.05)	(−0.89)	(−0.89)	(−2.18)
Trade open					−0.042	−0.039	−0.051*	−0.057*
					(−1.61)	(−1.53)	(−1.88)	(−1.90)
Loans rate					−0.213	−0.268	−0.365	−0.519
					(−0.48)	(−0.65)	(−0.99)	(−1.55)

(Continues)

TABLE 5 (Continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
OSS					0.101	0.240	0.217	0.131
					(0.81)	(1.55)	(1.50)	(1.02)
Rule of law					−42.402	−68.897**	−31.532	−63.062**
					(−1.38)	(−2.23)	(−1.05)	(−1.99)
Corruption					136.103***	113.710***	147.634***	154.755***
					(2.90)	(2.58)	(3.34)	(3.21)
Rurality	46.229*	72.029***	69.689***	102.995***	27.820	53.515***	48.630***	76.888***
	(1.94)	(4.44)	(4.27)	(9.68)	(1.05)	(3.17)	(2.69)	(6.76)
North-Centre	−41.543***	−60.887***	−55.958***	−102.062***	−53.013***	−56.420**	−59.672***	−107.367***
	(−2.70)	(−4.08)	(−3.87)	(−4.57)	(−2.28)	(−2.43)	(−2.69)	(−3.65)
First-stage results:								
Yes-votes (q_1)	1.116***	1.997***	1.712***	1.359***	0.934***	1.542***	1.362***	1.171***
	(7.25)	(7.44)	(7.87)	(5.36)	(5.75)	(5.43)	(6.02)	(4.34)
Voter turnout (q_1)	0.168**	0.235**	0.248***	0.213**	0.148**	0.256***	0.224***	0.192**
	(2.58)	(2.45)	(3.01)	(2.29)	(2.25)	(2.62)	(2.68)	(2.02)
K-P rk LM p−value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
K-P rk Wald F stat.	35.81	42.02	47.00	22.83	23.40	26.64	29.13	15.78
Hansen J stat.	0.794	0.930	0.815	0.779	0.882	0.863	0.865	0.870
Obs. No.	5,765	5,765	5,765	5,765	5,670	5,670	5,670	5,670

Notes: A constant term is included among the regressors. Standard errors are robust to heteroscedasticity.

*** $p<0.01$,

** $p<0.05$,

* $p<0.1$.

TABLE 6 Estimation results of the impact of the PI usage of ICT on firm turnover rate

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Mobile tech	0.008***				0.008***			
	(3.49)				(2.92)			
Open source		0.004***				0.005***		
		(3.36)				(2.90)		
Social media			0.005***				0.006***	
			(3.57)				(3.03)	
PCS				0.006***				0.007***
				(3.37)				(2.83)
Edu	−0.006	−0.001	−0.002	0.004	−0.006	−0.001	−0.002	0.004
	(−1.52)	(−0.20)	(−0.66)	(1.50)	(−1.35)	(−0.33)	(−0.70)	(1.61)
Foreigners	−0.0001	−0.0002	0.001	0.002	0.000	−0.000	0.002	0.002
	(−0.03)	(−0.08)	(0.72)	(0.82)	(0.11)	(−0.06)	(0.85)	(0.91)
Tax burden	0.002	0.006	0.005	0.004	0.002	0.007	0.006	0.005
	(0.38)	(1.14)	(1.03)	(0.65)	(0.41)	(1.23)	(1.09)	(0.87)
Tax burden^2	−0.0002	−0.0003*	−0.0003*	−0.0001	−0.0002	−0.0004*	−0.0004*	−0.0002*
	(−0.92)	(−1.70)	(−1.91)	(−0.60)	(−1.00)	(−1.86)	(−2.07)	(−0.75)
VAT (log)					0.035***	0.043***	0.034***	0.044***
					(3.47)	(4.04)	(3.62)	(3.87)
Unemp					−0.001	−0.002	−0.002	0.001
					(−0.61)	(−0.73)	(−0.78)	(0.56)
Trade open					0.00001	0.00001	0.00002	0.00003
					(0.35)	(0.21)	(0.73)	(0.88)
Loans rate					−0.001	−0.001	−0.0005	−0.0003
					(−1.38)	(−1.35)	(−1.18)	(−0.72)

(Continues)

TABLE 6 (Continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
OSS					0.00004	−0.00015	−0.0001	−0.000004
					(0.25)	(−0.89)	(−0.75)	(−0.03)
Rule of law					0.159***	0.194***	0.144***	0.186***
					(4.50)	(5.39)	(4.28)	(4.93)
Corruption					−0.053	−0.024	−0.069	−0.078
					(−0.96)	(−0.46)	(−1.34)	(−1.36)
Rurality	−0.007	−0.039**	−0.036**	−0.076***	0.007	−0.026	−0.020	−0.057***
	(−0.25)	(−2.21)	(−1.97)	(−6.04)	(0.25)	(−1.37)	(−0.97)	(−4.16)
North-Centre	−0.057***	−0.034**	−0.040**	0.017	−0.072***	−0.068***	−0.064**	−0.000
	(−3.22)	(−1.99)	(−2.38)	(0.68)	(−2.67)	(−2.60)	(−2.48)	(−0.01)
First-stage results:								
Yes-votes (q_1)	1.116***	1.997***	1.712***	1.359***	0.934***	1.542***	1.362***	1.171***
	(7.25)	(7.44)	(7.87)	(5.36)	(5.75)	(5.43)	(6.02)	(4.34)
Voter turnout (q_1)	0.168***	0.235**	0.248***	0.213**	0.148**	0.256***	0.224***	0.192**
	(2.58)	(2.45)	(3.01)	(2.29)	(2.25)	(2.62)	(2.68)	(2.02)
K-P rk LM p−value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
K-P rk Wald F stat.	35.81	42.02	47.00	22.83	23.40	26.64	29.13	15.78
Hansen *J* stat.	0.330	0.230	0.300	0.369	0.489	0.520	0.501	0.525
Obs. No.	5,765	5,765	5,765	5,765	5,670	5,670	5,670	5,670

Notes: A constant term is included among the regressors. Standard errors are robust to heteroscedasticity.

*** $p<0.01$,
** $p<0.05$,
* $p<0.1$.

Results show that graduates and foreigners resident in the municipal area are a relevant stimulus for firm birth rate. Concerning graduates, it is widely recognized that education and human capital are essential determinants of economic growth through the injection of innovative business ideas and high entrepreneurship (e.g., Storey, 1994; Delmar and Davidsson, 2000; Dilli and Westerhuis, 2018). Concerning foreigners, our test confirms the expected positive effects on entry (Bettin, 2018; Ostrovsky and Picot, 2018).

Among the economic variables, we find that unemployment rate, tax burden, and total bank loans exert a statistically significant impact on firm birth rate in each regression. A greater rate of unemployment comes with a lower rate of new firms. This finding seems to be an Italian peculiarity, already found in various studies (Garofoli, 1994; Reynolds et al., 1994; Santarelli et al., 2009) where the theory of the economy of necessity does not hold because human capital and entrepreneurial skills in deprived areas might be too scarce. VAT (in logs) measures the provincial market and wealth effects, which are positive on entry: this confirms the pull motivations for entrepreneurship. The impact of the tax burden on the birth rate of businesses is non-linear since, for small values of the tax burden, we observe an increase in the number of new businesses per inhabitant, whereas for high values of it there is a decrease in the firm birth rate. The excessive tax burden, therefore, discourages the entry of new companies into the market, impoverishing the local economic fabric. Furthermore, the greater bank loans act as a deterrent to new business; this apparently counter-intuitive result could be attributed to the fact that our variable measures total bank loans, including mortgages and consumer credit, beside business credit.

The institutional quality at the provincial level creates optimal conditions for new businesses activities. A stronger rule of law favours the creation of new firms, as also found by Agostino et al. (2019) in a 2004–12 panel of Italian provinces; here, they uncover that rule of law is crucial for entry in the laggard regions of the south, prior to the financial crisis (2004–2008). Concerning the control for corruption, our results on entry (positive effect) mirror findings from Dreher and Gassebner (2013), which work on a small panel of 43 countries over the triennium 2003–2005 and find that corruption facilitates entry in highly regulated economies.

The introduction of ICT in public entities produces a statistically significant contraction of the number of closed businesses per 100,000 inhabitants, generalized to all types of ICT we consider. Observing the baseline estimates in columns (1)–(4) of Table 5, it can be seen that an increase of one percentage point in the ICT endowment of PI reduces the number of closed businesses per 100,000 inhabitants from −3.7 to −6.2. In other terms, while the adoption of ICT technologies and services by PI plays a role that is not generalized nor sufficient to spur entry (see previous evidence of Table 4), it is effective in containing at least businesses closure. A series of potential channels was identified in Sections 2 and 3, and these channels are confirmed here. Firstly, several ICT (such as mobile phones and social media) allow smarter communication between PI and businesses, improving information dissemination. Secondly, the introduction of unified infrastructure catering for interoperability (such as open source and the PCS) increases the effectiveness and efficiency of the administrative functions, through the transformation of both the front and back office, and also augments the quality of the e-services provided to external stakeholders (see the reviews of Arduini and Zanfei, 2014; Twizeyimana and Andersson, 2019; Panayiotou and Stavrou, 2021); with the jargon of the ICT literature, interoperability is the main engine for network externalities (Bresnahan and Trajtenberg, 1995; Bekar et al., 2018). Thirdly, some types of ICT, such as open source software, present both cost and performance advantages: although the cost advantage enables the public administration to contain the monetary outlays of ICT, the performance advantages stem from the higher flexibility and personalization granted by open source, delivering more tailored public services. Furthermore, the use of mobile technology implies greater

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flexibility in the supply, especially when the PA has multiple locations. More generally, a PA that is more efficient and competent in ICT tends to be better endowed to implement innovative policies and best practices that help companies not to die.

On the side of socio-demographic controls, we find that a higher share of graduates and foreigners in the total population significantly influences entrepreneurship dynamics, encouraging also firm exit. The first result can be explained by the fact that a higher human capital facilitates labour and skills relocation, also directed to new entrepreneurial start-ups—a stylized fact of the literature. Concerning the positive impact of immigrants on exit, our results match the literature findings (OECD, 2010; Ostrovsky and Picot, 2018).

Among the economic controls, the effect of tax burden loses its previous quadratic shape and becomes linear: hence, higher taxes directly encourage the cessation of the economic activity, and this makes sense in the critical period investigated. Moreover, the control for the provincial total value-added (VAT) exerts a negative effect on firm death rate, which means that the size of the home market and its wealth help entrepreneurs to stay alive (e.g., Storey, 1991; Reynolds et al., 1995; Ilmakunnas and Topi, 1999): also here, the result may be partly driven by the harsh conditions of the period. The provincial control on corruption (IQI) verifies that a higher corruption tends to destroy entrepreneurship (or, at least, relocate it elsewhere), according to the "grease the wheels" hypothesis of Goel and Saunoris (2020), who find that in US states over the period 2000–2014 corruption facilitated firm exit.

Concerning the geographical dummy, the south of Italy experiences higher firm mortality, thereby confirming that its business demography, although being more lively (higher entry), tends to be founded on weaker ventures and business opportunities.

In Table 6, we analyze the interplay between the previous results by estimating the impact of the PI's ICT adoption on the turnover rate. Results show that all ICT significantly increase the difference between entry and exit, by reducing the latter. Concerning the other control variables, we find a clear and positive effect of provincial value added and of the rule of law.

The estimated coefficients of the two instrumental variables resulting from the first-stage regression displayed in Tables 4–6 are positively and significantly correlated with the key variables of the PI's ICT endowments. As suggested by Henriksen (2004), high electoral participation in national referendums is a signal that voters are able to change existing norms and exert political pressure on elected representatives to adopt policies in the public interest, including the adoption of ICT equipment for the provision of public e-services. Our instruments should be correlated with the endogenous regressor to avoid biasing IV estimates of coefficients (Hahn and Hausman, 2002). Moreover, the correlation should be strong between them (Baum et al., 2007). Thus, we perform two *rk* test statistics (Kleibergen and Paap, 2006) to verify that our instruments are strongly correlated with the endogenous regressor. The Kleibergen-Paap (K-P) *rk* LM statistic allows to test that the correlation between instruments and the endogenous variable is different from zero. The Kleibergen-Paap *rk* Wald statistic is used to test the presence of strong correlation between them. The results of both tests displayed in Tables 4–6 reveal that our instrumental variables are strongly correlated with our key variables related to the PI's ICT endowment. The p−value of the K-P *rk* LM statistic rejects the null hypothesis of under-identification at the 1% level. Furthermore, the K-P *rk* Wald statistic assumes values greater than the critical value 10, below which a weak identification should be considered a serious problem (Staiger and Stock, 1997). Both the K-P *rk* tests are robust to heteroscedasticity, autocorrelation and clustering in the error term structure (Baum et al., 2007). The validity of the full set of instruments is also tested by the Hansen (1982) *J*−test for over-identifying restrictions. In each regression of Tables 4–6, the Hansen *J*−test accepts the

null-hypothesis of over-identification, pointing out the validity of the set of the instrumental variables used in the first-stage regressions.

6.1 | Robustness checks

In this section, we provide robustness checks to verify if our results are sensitive to the set of instrumental variables used in the cross-sectional analysis. The first check is carried out by performing the estimates with the use of instruments based on the *voter turnout* (q_2) and the share of *yes-votes* (q_2) on question 2 of the 2011 referendum.[12] Question 2 proposes the partial abrogation of the rules for the determination of the tariff for the disbursement of water, involving the remuneration of the capital invested. This question was very important to the Italian voters as it had the intention of preventing profits being made on the local public water supply service. The yes-vote for the abrogation of part of the legislation was based on the sentiment that water is an essential good that belongs to all individuals and that no one can appropriate it or make a profit. Therefore, this referendum question had aroused strong political pressures on local elected officials who are directly involved in the territorial management of the water service.

Estimation results with the new set of instruments are displayed inTable A.1, A.2, A.3 in the Appendix section. The table confirms the estimation results obtained with the instruments based on referendum question 1. In brief, an increase in the share of public institutions that adopt ICT significantly reduces business mortality. Although the results are not statistically significant, we observe in columns (1)–(4) that increasing ICT in the PA fosters the firm birth rate in line with our theoretical hypothesis. The turnover rate increases significantly at the 1% level when the ICT in the PA increases. This result depends on the reduction in the business mortality rate due to the changes in the adoption of ICT in the PA. The first-stage results displayed in Table A.3 show a positive and significant impact of both instrumental variables on ICT in the PA for each model of business demography estimated. The Kleibergen-Paap *rk* tests point out that the instruments are strongly correlated with the endogenous variable. The Hansen $J-$test confirms the validity of the two instruments used in the 2SLS regression analysis.

As a second robustness check, we use a new external instrumental variable and the share of *yes-votes* (q_2) on question 2 of the 2011 referendum. The new external instrument is the *margin of victory* in the last available municipal election. The variable is obtained as the difference between the vote share of the mayor and the highest vote share of the opponent candidate.[13] Theoretical literature dictates that elected officials are influenced by public opinion when they have to adopt a new policy in their jurisdiction, especially during the electoral campaign. The more insecure they feel about being re-elected, the more likely they are to adopt innovative policies that please voters (Berry and Berry, 2018). As Walker (1969) noted, in contested elections, elected representatives are more prone to adopt new programmes encouraging the diffusion of innovations. Thus, a greater inter-party electoral competition may favour the diffusion of innovation in local governments, suggesting a negative correlation between the margin of victory and the adoption of ICT in the public administration.

The 2SLS estimation results with the use of the new instrumental variable are displayed in Table A.4. Also in this case, the results obtained are confirmed with a significant reduction in the

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[12] Both instruments are computed in the same way as those based on question 1 of referendum. They are correlated to each other at 0.190.

[13] The share of yes-votes on question 2 and the margin of victory are correlated to each other at −0.158.

business mortality rate due to ICT in the PA, which turns out into an increase in the turnover rate. As expected, in the first-stage regression results, the margin of victory impacts negatively on the *ICT* variables. It is statistically significant for all of them with the exception of the *PCS* variable. The Hansen J−test and the Kleibergen-Paap *rk* tests confirm the validity and strength of the two instruments used in the 2SLS regression analyses.

7 | CONCLUSIONS

Regional economic growth and development have attracted mounting attention in the most recent literature, and two main drivers have been highlighted—technology and institutions. Technology has been intensively studied, mostly with patent-based indicators. New proxies of innovation are requested to capture technical change in those sectors that do not patent, or acquire significant knowledge spillovers and network externalities from external subjects such as the public sector and economy. In particular, GPT are considered technologies that are now present in most economic sectors and public institutions, are diffused in all the branches of the PA thanks to e-government and other public e-services, and are expected to play an even larger role with the incoming era of artificial intelligence, Industry 4.0 and the Internet of Things.

The e-services literature has examined the transformative role of governments and PA in pushing ICT diffusion; surprisingly, so far this literature has dissected the drivers of adoption and diffusion, but has largely neglected the actual effects of PA digitalization—especially those impacting on external stakeholders. In fact, the literature has focused on the "internal" effect of e-government (i.e., automation of the administrative functions, reduction of the labour input, higher coordination between employees and PA units, higher quality of public services). However, the digitalization of the PA may gradually exert further external effects, especially regarding the business sector, which needs to interact almost daily with the PA at the local level for a variety of reasons: from the very start of the firm throughout its entire life, in a number of informative requests, administrative, customs and fiscal applications, and bureaucratic authorizations. Some papers have theorized some of these effects on business performance, but very few tested them empirically (and did so limited to firm profitability). In detail, the empirical impact of the digital transformation of the PA on business dynamics has been completely overlooked.

We contribute to filling this literature gap by proposing an original econometric investigation of the role of ICT diffusion on business entry, exit and turnover, in the universe of all Italian firms in 2011 (census year) belonging to the three main sectors of the economy (primary, secondary and tertiary). To this end, we exploit original government data on the PA's ICT activities, and look at the municipal level of analysis, where most day-to-day interactions between the PA and firms do occur.

Our findings show that a greater ICT diffusion across all the municipal branches of the PA (belonging to the central, regional and local levels of government) generates a higher firm birth rate, but the effect is not significant. Instead, we find that the PA's ICT impact negatively and significantly on the firm death rate, across all the ICT types surveyed: mobile technologies, open source, communication via social media and PCS (a sort of 'nervous system' of the PA). Also, in the case of turnover, the PA's ICT impact proves to be positive and significant. Although the estimated impact is quite small, our results are relevant because they are a first confirmation of the existence of positive network externalities spilling over from the public sector to the business sector, and benefiting the entire economic system. This evidence is fully consistent with the conceptual reasoning sketched in the e-services literature on the presence of external benefits from

e-government, and with that analyzing the network externalities connected to GPT. All in all, our analysis demonstrates that the competitiveness effects stemming from ICT adoption are not limited to the internal benefits enjoyed by the public investor, but stretch to the business sector, contributing to the resilience of the local economy.

Our results bear important policy implications for both the design and management of digital agendas, and for targeting the socio-economic competitiveness of the regional economy. In fact, because the PA's ICT investment and e-services are shown to exert an additional external positive impact on entrepreneurship (albeit defensive), it follows that, in a cost-benefit analysis perspective, the "real" public value of e-services is bigger than that conventionally assumed based on the computation of the traditional "internal" efficiency benefits of ICT for the PA. Two main consequences are that current regional digital agendas in the EU may deserve a larger budget and priority in cohesion policy, and that they need to emphasize the supply of e-services, beside the traditional focus on the investment in broadband infrastructure. Second, if e-government has the further effect of strengthening businesses, its function becomes much more relevant than conventionally held, because it can act as a complementary instrument for the pursuit of regional development policies: in other words, the latter should evolve beyond their current focus on financial aid (subsidies, loans).

We recognize that our empirical analysis presents some limitations. In particular, the use of cross-sectional data, which contextualize the analysis to a particular year, does not allow to estimate the effects due to variations over time of the variables (Hsiao, 2007; Berry and Berry, 2018). Moreover, cross-sectional analysis is less accurate in terms of model parameter inference compared to panel data analysis (Hsiao, 2007) and suffers from the omitted variable problem that causes endogeneity, despite the effort of adding many explanatory variables in the regression analysis (Hsiao, 2007). A panel data investigation would be desirable to solve all these methodological problems, but the census data on ICT in the public administration do not allow it.

Some fruitful lines of research can be developed on the basis of our study. One of these is to analyze whether the diffusion of ICT in the PA has an impact on firm survival in the medium to long term, distinguishing between different sectors of specialization. Our results, in fact, indicate that ICT in the PA cause lower firm mortality, which could turn out into a greater firm survival over time.

The analysis of the PA's ICT investment on business dynamics is still little explored empirically, and other studies are needed for other countries to verify how much the e-services development impacts on the business sector: in this respect, our study based on census data is highly replicable—at least for EU and OECD countries. The digitization of the PA is a pillar of the digital strategy of many countries to provide public services to businesses and citizens more efficiently. In particular, this process will shape the near future of the EU countries, and it is necessary to shed light on its impact on the economy and on the lives of citizens.

DISCLOSURE STATEMENT

We declare that we do not have any material or financial interest that relates to the research described in this paper.

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APPENDIX

TABLE A.1 Correlation matrix

	Firm birth rate	Firm death rate	Turnover rate	Mobile tech	Open source	Social media	PCS	Edu	Foreigners	Tax burden	Tax burden²	VAT (log)	Unemp	Trade open	Loans rate	OSS	Rule of law	Corruption	Rurality	North-Centre
Firm birth rate	1																			
Firm death rate	0.351	1.000																		
Turnover rate	0.519	−0.618	1.000																	
Mobile tech	0.037	0.002	0.029	1																
Open source	0.031	0.017	0.011	0.229	1															
Social media	0.036	−0.011	0.040	0.195	0.172	1														
PCS	−0.010	−0.018	0.008	0.096	0.162	0.093	1.000													
Edu	0.089	0.002	0.073	0.144	0.102	0.119	0.025	1												
Foreigners	0.103	0.048	0.043	0.104	0.096	0.068	−0.007	−0.004	1											
Tax burden	0.116	0.155	−0.044	−0.023	−0.038	−0.024	−0.046	0.010	−0.011	1										
Tax burden²	0.081	0.121	−0.042	−0.016	−0.016	−0.005	−0.041	0.005	−0.004	0.839	1									
VAT (log)	−0.039	−0.142	0.097	0.115	0.086	0.089	−0.014	0.026	0.178	−0.046	−0.016	1								
Unemp	−0.004	−0.021	0.015	−0.041	0.000	0.001	0.055	0.031	−0.382	−0.160	−0.084	−0.183	1							
Trade open	−0.045	−0.043	0.001	0.029	−0.003	−0.015	−0.081	−0.074	0.329	0.030	0.004	0.226	−0.507	1						
Loans rate	−0.041	−0.111	0.068	0.153	0.128	0.115	−0.003	−0.007	0.447	0.016	−0.001	0.669	−0.508	0.417	1					
OSS	0.022	−0.023	0.040	0.047	0.089	0.080	0.040	0.023	0.042	−0.051	−0.029	0.044	0.042	−0.013	0.042	1				
Rule of law	0.065	0.021	0.036	−0.018	−0.050	−0.020	−0.047	−0.047	0.141	0.075	0.039	−0.174	−0.266	0.269	−0.028	−0.046	1			
Corruption	0.013	0.051	−0.035	0.027	−0.006	0.002	−0.043	−0.083	0.376	0.117	0.051	0.005	−0.639	0.426	0.357	−0.055	0.290	1		
Rurality	0.037	0.173	−0.127	−0.199	−0.149	−0.155	−0.011	−0.290	−0.203	0.165	0.093	−0.349	0.126	−0.205	−0.322	−0.082	0.030	−0.036	1	
North-Centre	−0.051	−0.042	−0.004	0.084	0.043	0.038	−0.075	−0.072	0.487	0.120	0.062	0.312	−0.729	0.571	0.601	−0.016	0.261	0.651	−0.256	1

Source: Authors' elaboration on the sample.

TABLE A.2 Variance inflation factor

	VIF			
Mobile tech	1.07			
Open source		1.05		
Social media			1.05	
PCS				1.02
Edu	1.16	1.15	1.15	1.14
Foreigners	1.44	1.45	1.44	1.44
Tax burden	3.68	3.68	3.68	3.68
Tax burden^2	3.48	3.48	3.48	3.48
VAT (log)	2.20	2.20	2.20	2.20
Unemp	2.57	2.57	2.57	2.57
Trade open	1.61	1.05	1.61	1.61
Loans rate	3.06	3.06	3.06	3.04
OSS	1.02	1.02	1.02	1.02
Rule of law	1.23	1.24	1.24	1.24
Corruption	2.15	2.15	2.15	2.15
Rurality	1.43	1.42	1.43	1.42
North-Centre	3.38	3.38	3.38	3.39
Mean VIF	*2.11*	*2.11*	*2.10*	*2.10*

Source: Authors' elaboration on the sample.

TABLE A.3 Robustness estimation results of the impact of the PI usage of ICT on firm dynamic

	Firm birth rate				Firm death rate				Firm turnover rate			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Mobile tech.	2.846				−6.864***				0.010***			
	(1.30)				(−2.59)				(3.06)			
Open source		1.555				−3.908***				0.005***		
		(1.23)				(−2.60)				(3.02)		
Social media			1.775				−4.455***				0.006***	
			(1.24)				(−2.69)				(3.13)	
PCS				2.018				−5.134**				0.007***
				(1.19)				(−2.57)				(2.88)
Education	5.884*	7.805***	7.376***	9.413***	13.902***	9.461***	10.532***	5.430**	−0.008*	−0.002	−0.003	0.004
	(1.74)	(3.34)	(2.88)	(4.95)	(3.26)	(3.40)	(3.45)	(2.51)	(−1.67)	(−0.54)	(−0.94)	(1.54)
Foreigners	12.198***	12.169***	12.718***	12.778***	12.444***	12.614***	11.231***	11.096***	−0.000	−0.000	0.001	0.002
	(8.03)	(7.92)	(9.42)	(9.48)	(6.11)	(6.22)	(6.38)	(6.23)	(−0.10)	(−0.19)	(0.74)	(0.82)
Tax burden	21.869***	23.348***	22.997***	22.753***	19.628***	15.951***	16.834***	17.430***	0.002	0.007	0.006	0.005
	(4.80)	(5.24)	(5.19)	(4.96)	(3.89)	(3.17)	(3.52)	(3.61)	(0.36)	(1.30)	(1.13)	(0.89)
Tax burden^2	−0.302**	−0.348**	−0.349***	−0.286*	−0.087	0.026	0.028	−0.129	−0.000	−0.000*	−0.000**	−0.000
	(−2.05)	(−2.57)	(−2.63)	(−1.91)	(−0.53)	(0.16)	(0.18)	(−0.83)	(−0.95)	(−1.92)	(−2.16)	(−0.70)
VAT (log)	20.860***	23.012***	20.337***	23.220***	−15.528*	−21.137**	−14.410*	−21.796**	0.036***	0.044***	0.035***	0.045***
	(2.90)	(2.96)	(2.92)	(2.89)	(−1.73)	(−2.23)	(−1.74)	(−2.23)	(3.32)	(3.92)	(3.52)	(3.76)
Unemp	−3.380**	−3.399**	−3.423*	−2.584*	−1.715	−1.582	−1.525	−3.627**	−0.002	−0.002	−0.002	0.001
	(−2.22)	(−2.22)	(−2.23)	(−1.87)	(−0.93)	(−0.85)	(−0.83)	(−2.16)	(−0.77)	(−0.84)	(−0.89)	(0.54)
Trade open. (·1000)	−0.028	−0.030*	−0.025	−0.023	−0.045*	−0.040*	−0.053**	−0.059**	0.000	0.000	0.000	0.000
	(−1.48)	(−1.73)	(−1.28)	(−1.08)	(−1.77)	(−1.68)	(−2.09)	(−2.10)	(0.57)	(0.35)	(0.92)	(1.03)
Loans rate	−1.010***	−0.952***	−0.913***	−0.844***	−0.128	−0.232	−0.330	−0.497	−0.001	−0.001	−0.001	−0.000
	(−2.84)	(−2.92)	(−3.05)	(−3.19)	(−0.28)	(−0.58)	(−0.91)	(−1.50)	(−1.61)	(−1.51)	(−1.35)	(−0.85)

(Continues)

TABLE A.3 (Continued)

	Firm birth rate				Firm death rate				Firm turnover rate			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
OSS	0.120	0.067	0.076	0.114	0.113	0.252*	0.229	0.137	0.000	−0.000	−0.000	−0.000
	(1.26)	(0.56)	(0.66)	(1.13)	(0.89)	(1.71)	(1.64)	(1.09)	(0.05)	(−1.09)	(−0.94)	(−0.15)
Rule of law	115.259***	126.522***	110.959***	123.992***	−41.771	−69.778**	−30.688	−63.600**	0.157***	0.196***	0.142***	0.188***
	(4.81)	(5.02)	(4.65)	(4.94)	(−1.33)	(−2.21)	(−1.02)	(−1.97)	(4.20)	(5.25)	(4.09)	(4.77)
Corruption	81.624**	91.215**	77.079**	74.356**	136.813***	113.046**	148.548***	155.744***	−0.055	−0.022	−0.071	−0.081
	(2.26)	(2.52)	(2.19)	(2.03)	(2.83)	(2.49)	(3.37)	(3.24)	(−0.92)	(−0.40)	(−1.35)	(−1.36)
Rurality	43.138*	30.177**	32.291**	20.399**	22.181	52.082***	46.816***	76.540***	0.021	−0.022	−0.015	−0.056***
	(1.90)	(2.08)	(2.04)	(2.11)	(0.82)	(3.18)	(2.65)	(6.68)	(0.62)	(−1.05)	(−0.65)	(−3.84)
North-Centre	−126.450***	−124.709***	−123.362***	−103.885***	−52.210**	−56.204**	−59.593***	−109.121***	−0.074***	−0.069***	−0.064**	0.005
	(−6.26)	(−6.36)	(−6.21)	(−4.07)	(−2.20)	(−2.41)	(−2.66)	(−3.69)	(−2.62)	(−2.57)	(−2.42)	(0.15)
First-stage results:												
Yes-votes (q_2)	0.816***	1.513***	1.326***	1.169***								
	(4.75)	(5.09)	(5.45)	(4.16)								
Voter turnout (q_2)	0.173***	0.278***	0.244***	0.206**								
	(2.61)	(2.87)	(2.93)	(2.18)								
K-P *rk* LM stat.	0.000	0.000	0.000	0.000								
K-P *rk* Wald F stat.	18.91	24.59	25.91	14.81								
Hansen *J* stat	0.413	0.376	0.374	0.369	0.707	0.783	0.779	0.811	0.801	0.694	0.691	0.677
Obs. No.	5,670	5,670	5,670	5,670	5,670	5,670	5,670	5,670	5,670	5,670	5,670	5,670

Notes: A constant term is included among the regressors. Standard errors are robust to heteroscedasticity.

*** $p < 0.01$,
** $p < 0.05$,
* $p < 0.1$.

TABLE A.4 Robustness estimation results of the impact of the PI usage of ICT on firm dynamic

	Firm birth rate				Firm death rate				Firm turnover rate			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Mobile tech.	0.662				−6.326**				0.007**			
	(0.28)				(−2.25)				(2.18)			
Open source		0.609				−3.919**				0.005**		
		(0.42)				(−2.23)				(2.24)		
Social media			0.453				−4.063**				0.005**	
			(0.30)				(−2.29)				(2.22)	
PCS				1.217				−5.404**				0.007**
				(0.60)				(−2.19)				(2.27)
Edu	8.833**	8.975***	9.128***	9.538***	13.174***	9.474***	10.012***	5.472**	−0.004	−0.000	−0.001	0.004
	(2.42)	(3.57)	(3.40)	(5.06)	(2.98)	(3.14)	(3.17)	(2.47)	(−0.93)	(−0.16)	(−0.27)	(1.61)
Foreigners	12.934***	12.770***	13.045***	12.928***	12.263***	12.621***	11.134***	11.146***	0.001	0.000	0.002	0.002
	(8.50)	(8.01)	(9.78)	(9.58)	(6.12)	(6.06)	(6.45)	(6.13)	(0.30)	(0.06)	(1.01)	(0.87)
Tax burden	22.164***	22.682***	22.443***	22.555***	19.555***	15.944***	16.998***	17.363***	0.003	0.007	0.005	0.005
	(4.92)	(5.10)	(5.08)	(5.01)	(3.92)	(3.16)	(3.60)	(3.57)	(0.45)	(1.22)	(1.04)	(0.88)
Tax burden^2	−0.311**	−0.327**	−0.323**	−0.297**	−0.085	0.027	0.021	−0.133	−0.000	−0.000*	−0.000*	−0.000
	(−2.15)	(−2.31)	(−2.28)	(−2.00)	(−0.52)	(0.16)	(0.14)	(−0.84)	(−1.03)	(−1.83)	(−1.93)	(−0.73)
VAT (log)	19.324***	20.484***	19.235***	21.489***	−15.149*	−21.165**	−14.083*	−22.380**	0.034***	0.042***	0.033***	0.044***
	(2.81)	(2.62)	(2.84)	(2.60)	(−1.73)	(−2.17)	(−1.74)	(−2.15)	(3.52)	(3.78)	(3.66)	(3.60)
Unemp	−2.734*	−2.875*	−2.763*	−2.566*	−1.874	−1.576	−1.721	−3.621**	−0.001	−0.001	−0.001	0.001
	(−1.81)	(−1.84)	(−1.80)	(−1.90)	(−1.02)	(−0.81)	(−0.93)	(−2.12)	(−0.43)	(−0.60)	(−0.52)	(0.56)
Trade open. (·1000)	−0.039**	−0.038**	−0.038**	−0.031	−0.043*	−0.040	−0.049*	−0.061*	0.000	0.000	0.000	0.000
	(−2.15)	(−2.14)	(−1.95)	(−1.31)	(−1.65)	(−1.60)	(−1.89)	(−1.95)	(0.13)	(0.10)	(0.39)	(0.82)
Loans rate	−0.702*	−0.743**	−0.687**	−0.751**	−0.203	−0.230	−0.397	−0.465	−0.000	−0.001	−0.000	−0.000
	(−1.90)	(−2.08)	(−2.24)	(−2.57)	(−0.44)	(−0.52)	(−1.07)	(−1.24)	(−0.95)	(−1.01)	(−0.69)	(−0.65)

(Continues)

TABLE A.4 (Continued)

	Firm birth rate				Firm death rate				Firm turnover rate			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
OSS	0.163*	0.134	0.151	0.139	0.102	0.252	0.207	0.145	0.000	−0.000	−0.000	−0.000
	(1.73)	(1.04)	(1.28)	(1.33)	(0.82)	(1.59)	(1.46)	(1.08)	(0.45)	(−0.68)	(−0.36)	(−0.04)
Rule of law	117.531***	121.470***	116.368***	121.701***	−42.331	−69.834**	−32.294	−64.374*	0.160***	0.191***	0.149***	0.186***
	(5.07)	(4.91)	(4.91)	(4.96)	(−1.38)	(−2.20)	(−1.09)	(−1.94)	(4.78)	(5.38)	(4.63)	(4.85)
Corruption	84.179**	87.405**	82.946**	78.561**	136.183***	113.003**	146.807***	157.164***	−0.052	−0.026	−0.064	−0.079
	(2.48)	(2.49)	(2.43)	(2.19)	(2.90)	(2.50)	(3.38)	(3.14)	(−1.01)	(−0.50)	(−1.34)	(−1.35)
Rurality	22.830	21.962	20.657	18.921*	27.190	51.991***	50.270***	76.041***	−0.004	−0.030	−0.030	−0.057***
	(0.96)	(1.43)	(1.30)	(1.95)	(0.97)	(2.90)	(2.78)	(6.35)	(−0.13)	(−1.39)	(−1.37)	(−3.93)
North-Centre	−123.557***	−123.475***	−122.854***	−111.344***	−52.924**	−56.191**	−59.743***	−111.640***	−0.071***	−0.067***	−0.063***	0.000
	(−6.32)	(−6.38)	(−6.34)	(−4.00)	(−2.26)	(−2.40)	(−2.71)	(−3.42)	(−2.74)	(−2.64)	(−2.58)	(0.01)
First-stage results:												
Yes-votes (q_2)	0.960***	1.768***	1.525***	1.388***								
	(5.61)	(6.27)	(6.51)	(5.14)								
Margin of victory	−0.044***	−0.049**	−0.066***	−0.007								
	(−2.93)	(−2.00)	(−3.25)	(−0.30)								
K-P *rk* LM stat.	0.000	0.000	0.000	0.000								
K-P *rk* Wald F stat.	23.56	22.81	28.16	13.32								
Hansen *J* stat	0.322	0.343	0.324	0.414	0.414	0.673	0.422	0.832	0.151	0.291	0.149	0.691
Obs. No.	5,670	5,670	5,670	5,670	5,670	5,670	5,670	5,670	5,670	5,670	5,670	5,670

Notes: A constant term is included among the regressors. Standard errors are robust to heteroscedasticity.

*** $p<0.01$,

** $p<0.05$,

* $p<0.1$.