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2021

Manuscript accepted in Government Information Quarterly, 2021.
https://doi.org/10.1016/j.giq.2020.101562

Addressing territorial digital divides through ICT strategies: Are investment decisions consistent with local needs?

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Abstract
Governments around the world are investing a great amount of resources on the development of an information society. These investments are particularly important as an attempt to close digital divides among countries and regions within countries. However, there is no clear evidence that suggests that current Information and Communication Technology (ICT) policies are helping align investments with the actual needs of the local contexts. Based on data about the allocation of 2014-2020 EU Funds, this paper analyzes the relationship between local needs and investment decisions aiming at bridging territorial digital divides. The results identify four different regional strategies developed around four policy goals: broadband, digital inclusion, digital government services, and the use of ICTs in enterprises. The results also show that unlike the past 2007-13 period, the allocations to these goals appear to be consistent with the ICT local context, i.e. funding for a given goal is higher in the regions that need it the most. Therefore, our main recommendation for the European Commission and Member States is to keep existing requirements for developing evidence-informed "Digital Growth" strategies for the next 2021-27 period. We also suggest to strengthen existing support tools for regional governments.

Keywords*: Digital divide, Broadband, Technology Policy, Smart City, European Policy, Regional Planning, European Funds.*

1 Introduction

Governments around the world are using Information and Communication Technology (ICT) policies to foster the development of an information society (Castells, 2011). These ICT policies[1] focus on different targets, i.e. the private sector, public sector, or individual citizens, each considered as a producer or a user of technology. More specifically, ICT policy goals usually include the development of digital government applications and services, incentives for the introduction of ICT technologies in Small- and Medium-Sized Enterprises (SMEs), Smart City projects at the local level, improved access to broadband connectivity or the implementation of policies for addressing digital divides among citizens and enterprises (Norris, 2001; Van Dijk, 2005). For example, the United Nations considers the ICTs as powerful tools to achieve their Sustainable Development Goals (SDGs) (Janowski, 2016; Tjoa & Tjoa, 2016). The International Telecommunication Union, a specialized agency of the United Nations, has identified key ICT contributions to all SDGs, including telemedicine, digital infrastructures such as the 5G systems, ICT for education, and Internet access to reduce inequalities, as specific action lines have been developed and discussed during international meetings such as the World Summit on the Information Society Forum (International Telecommunication Union, 2019). The importance of ICT development, especially in terms of broadband availability and digital transformation of the public services, has also been highlighted by the 2020 health crisis, making the need to bridge existing digital divides even more pressing (Moon, 2020).

Strategic use of available public funding is crucial for ICT policies, as money allocated during the programming phase of the policy cycle represents the main input for subsequent implementation (Misuraca et al., 2013). The financial input is usually very relevant since ICT policies require significant investments for acquiring equipment and recruiting and training staff, among other costs (Gascó, 2005). Issues related to the availability of financial resources are found at both state and local levels, and are even more urgent in low development areas (Edmiston, 2003; Ganapati & Reddick, 2014). In this context, the allocation of the available ICT budget to different policy goals is based on the strategic approach that policy makers decide to adopt. In turn, strategic decisions are informed by a wide array of inputs including political inputs, values, organizational factors, and the use of available evidence in terms of statistical data and indicators, as well as codified knowledge included in scientific or policy reports (Mele et al., 2014).

In particular, these strategies should be based on the analysis of existing local ICT needs. Existing efforts to measure the current state of development of Information Society can help policy makers assess existing gaps and plan public interventions accordingly (Huggins, 2010; Rorissa et al., 2011). In the European context, for example, the Digital Economy and Society Index (DESI) evidences wide and persistent gaps across European countries by considering five dimensions: broadband connectivity, human capital, use of Internet services, integration of digital technology, and digital public services (European Commission, 2020). Policy makers, once having access to available data on the local ICT context, could also consider other relevant contextual conditions that are key to the effective introduction of technology, such as digital

[1] The term "ICT policy" is closely related to "Information Society policy", which is also employed in the literature (Mansell & Steinmueller, 2000; Menou & Taylor, 2006; Misuraca et al., 2012; Misuraca et al., 2013). Other scholars use the term "Technology policy" to refer to government policies specifically focused on affecting the evolutionary trajectories of innovation in the private sector (Foray, 2009; Freeman, 1987).

skills, institutional arrangements, and socio-economic conditions (Fountain, 2001; Gil-Garcia, 2012; Heeks, 2005).

Nevertheless, so far, only a few studies have focused on the strategic choices for resource allocation to different ICT policies, while even fewer have analyzed whether this funding allocation is based on or at least consistent with actual context, i.e. that policy decisions are aligned to the most important need of each region (Kleibrink et al., 2015; Reggi & Scicchitano, 2014).

In the European Union, a budget of 21.4 billion euros has been assigned to ICT policies by the national and sub-national governments in the current EU 2014-2020 programming period.[2] This budget is concentrated in the less developed areas of Europe, where it represents a crucial source of funding for addressing current digital divides (Reggi & Scicchitano, 2012). Also, it can cover several kinds of specific ICT policy goals, with national and regional governments having the chance to decide how much money to allocate to each specific goal based on the recommendations and a set of legal requirements from the European Commission.

While most of the literature considers each ICT policy goal as a separate research topic, such as digital government or broadband policies, this context gives us the chance to offer a holistic view of how different ICT policy goals become part of broader strategies, and what factors may influence these strategic decisions. Therefore, the goal of this paper is to respond to the following research questions: (RQ1) What strategies drive the allocation of public funding and which policy goals mainly characterize each strategy? And (RQ2) Are financial allocations to these main policy goals consistent with the local context, in terms of existing digital divides to be addressed?

The paper is organized in seven sections, including the foregoing introduction. Section two reviews the extant literature on context-aware ICT policies, territorial digital divides, and other contextual factors. After a presentation of data and methods, the results section shows some descriptive statistics and outcomes of a two-step quantitative analysis, which is discussed in the subsequent section. Finally, the conclusions are drawn, including policy recommendations and possible avenues for future research.

2 Assessing digital divides in local contexts

The analysis of local context is widely seen as a crucial component of ex-ante evaluation of ICT policies (Castelnovo & Sorrentino, 2018; Heeks, 2002, 2005). According to the socio-technical view of the relations between technology and organizations, the context in which technology is employed plays a major role in determining the success or failure of a digital program (Orlikowski, 1992, 2010; Orlikowski & Scott, 2008). Several authors, in fact, highlight the importance of social, institutional, and organizational contexts when introducing new technologies (Fountain, 2001; Heeks, 2005).

Context-aware ICT policies consider not only specific local needs in terms of ICT development - which can be directly targeted by these policies - but also other contextual factors that can indirectly affect their results. In particular, policy makers are expected to assess the relative performance of a set of territorial indicators regarding their specific context, compared to those

[2] The total amount is reported in the European Commission's "ICT monitoring" website: https://s3platform.jrc.ec.europa.eu/ict-monitoring

of other comparable areas, assuming that local governments can learn from the methods based on the territorial comparison and systematic measurement of progress over time (Codagnone et al., 2015; Huggins, 2010; Maheshwari & Janssen, 2013; Rorissa et al., 2011).

2.1 Territorial digital divides

The first type of contextual factors deals with the state of the ICT context that policies aim to address. These factors vary significantly by geographical areas, thus creating digital divides in the development of Information Society between more and less advanced areas (Van Dijk, 2005). National and sub-national disparities in ICT diffusion are reported by international statistics in both developed and developing countries, such as the United Nations e-government index or the ITU report on the development of Information Society. This is what Norris (2001) calls "global digital divide" (p. 4).

Melody (1996) identifies two main components of the Information Society. The first, "Information infrastructures" represent physical systems (e.g. networks) or services. The second, "applications", take advantage of digital infrastructures to deliver products and services. Businesses, governments, and, to a lesser extent, individual citizens, can be both users and producers of such innovations. Although the "supply-side" of digital applications typically includes products and services produced by the ICT and media industry (Misuraca et al., 2013; OECD, 2011), private sector organizations are also users of existing ICTs, with goals such as innovating production processes or better communicating with other actors in digital ecosystems. The same logic also applies to public sector organizations, which deliver digital government services to citizens and enterprises, and also use ICTs in crucial activities such as information management, procurement, and policy making.

The state of digital infrastructures is considered an enabling condition for many ICT interventions, as the Internet connectivity is believed to be capable of closing digital gaps among governments, citizens and enterprises, and stimulate economic growth (Fernández-i-Marín, 2011). According to Seri et al. (2014), "ICT infrastructure (as measured, in primis, by broadband penetration) is the main "hard" driver of the national diffusion of public eServices, both for availability, usage and their gap; equally, its importance holds for both services aimed at citizens and enterprises" (p. 508). Ferro et al. (2008) found that access to the Internet via broadband networks increases Internet use for different purposes. For example, access to high-speed networks enables the provision of advanced services such as telemedicine, or it can transform the internal production processes of SMEs thanks to technologies such as Artificial Intelligence or the Internet of Things. Although broadband policies are actively promoted in both developed and developing countries, the differences in broadband penetration across the world are very high (Belloc et al., 2012). Geographical factors such as the presence of hills and mountains in the area often negatively affect broadband penetration due to increased deployment costs. Other factors include low demand of broadband access in dispersed or rural areas (Ferguson, 2004) and the level of institutional capacity (Matteucci, 2020).

On the applications side, key providers of digital services are targeted by ICT policies in both the private and public sectors to promote innovation, efficiency and effectiveness. While the ICT industry has been leading the development of ICT innovations in all fields, governments all around the world have contributed to the funding of research on key technologies (Mazzucato, 2015), while also aiming to use ICTs to improve service delivery, transparency and citizen participation. For example, digital government service provision has been widely studied in

terms of website functionalities and open government datasets available. Sub-national divides have been considered in specific countries based on the collection of data at the local level (Arduini et al., 2013; Gil-Garcia, 2012), or thanks to the availability of comparable data at the sub-national level produced by super-national government statistical organizations such as Eurostat (Reggi & Scicchitano, 2014). Sandoval-Almazan and Gil-Garcia (2012) found that differences in capabilities, ICT skills and access to financial resources can explain the existing divides in the provision of digital government services in Mexican municipalities. Specific policies have been implemented to address this "digital government divide" in the peripheral areas by strengthening collaboration among local governments (Ferro & Sorrentino, 2010). Other scholars have focused on the unique characteristics of particular territorial domains such as the "megacities", which give them several advantages compared to the surrounding areas in terms of digital government development (Gil-Garcia et al., 2019).

While the concept of digital divide is more traditionally related to the development of digital infrastructures and applications, it has also been applied to the importance of use, as specific policies target governments, citizens and enterprises, in particular SMEs, as users of ICTs. In particular, the literature focuses on access, skills, and capacity to reap the benefits of information society initiatives. Scholars have highlighted the differences between countries in the use of ICTs in government, developing the concept of "e-government divide" across the World (Gascó, 2005). Digital inclusion policies target specific categories of citizens, as digital divides are influenced by multiple dimensions and perspectives such as gender, age, ethnicity, values, believes, and education, among others (Andreasson, 2015; Ferro et al., 2011; Gil-Garcia et al., 2013; Helbig et al., 2009). This "usage gap" is also highlighted in several studies exploring the factors that influence the take-up of digital government services (Nam, 2014; Van Deursen et al., 2006).

Access to technology and capacity to effectively use it has also been highlighted in the case of managers and employees in SMEs (Arendt, 2008), along with other characteristics such dimension and economic sector. In particular, the digital divide literature often identifies location as an important predictor of access to digital infrastructures and digital literacy (Ferro et al., 2011; Hennessy et al., 2016), since the difference between cities and rural or mountain areas reflects the differences in basic public services availability. Some scholar have focused on within-country digital divide, highlighting significant sub-national variations between metropolitan areas such as capital regions and less developed areas, which reflect the divides in economic development (Vicente & López, 2011). Ruiz-Rodríguez et al. (2018), focusing on the case of Spain, show how the digital divide in SMEs has also an important regional dimension.

2.2 Socio-economic and institutional environment

A second type of contextual factors includes economic, political and institutional elements. First, the level of economic development heavily influences the levels of input of ICT policies in terms of financial resources available, as well as technical and organizational capacities for policy implementation (Gascó, 2005). The wealth of an area also influences the chances for citizens to access to ICTs and use them effectively, since income is a powerful predictor of digital exclusion (Ferro et al., 2011).

Second, political and institutional factors greatly shape, in particular, the implementation of digital government policies. Political culture and changes in political decisions over time are important factors, especially for the implementation of multi-annual ICT programs (Gil-García &

Pardo, 2005). In particular, "institutional arrangements" such as laws and regulations of the local context play a major role (Fountain, 2001). The quality of local institutions has been defined in terms of impartiality, low corruption, efficiency and effectiveness (Rothstein & Teorell, 2008). In this literature, the concept of impartiality has been connected to the idea of "all citizens treated equally" by government institutions, while the rule of law and the fight against corruption represent practical tools to achieve it (Rothstein & Teorell, 2012). Good institutions are expected to positively influence the enactment of newly introduced technologies, especially when technology is introduced in complex organizational environments such as the public sector (De Vries et al., 2016; Fountain, 2001; Gil-Garcia, 2012).

The institutional culture in which ICT policies are embedded also play a role (Guy Peters, 2008; Loughlin, 1997). While there are empirical studies showing that national culture matters in digital government development (Khalil, 2011), some authors have hypothesized that administrative culture and state traditions can affect digital government development (De Vries et al., 2016; Schuppan, 2009) and online transparency (Cucciniello et al., 2017; Rodríguez Bolívar et al., 2015).

3 Data and methods

This article employs data on the financial allocations of European Regional Policy, the main development policy in the EU. This policy targets all EU Regions and Countries and support the implementation of several goals included in the European Digital Agenda strategy (European Commission, 2010). Based on the budget negotiated at the regional and national levels, policy makers decide how to allocate this money to different policy goals related to ICT development such as digital government, broadband development, and digital inclusion (see the full list of "intervention fields" in Table 1). All policy goals are coded and descripted in the common EU regulation (Commission Implementing Regulation No. 215/2014 of 7 March 2014). We merged data on financial allocations from the European Commission – Joint Research Centre with data from Eurostat on the ICT context and the Quality of Government Institute to construct a cross-sectional dataset composed of 108 European lagging regions (sub-national governments)[3].

3.1 Data on funding allocations

For each region, financial allocations to 14 "intervention fields" related to ICT policies are included as a percentage of the total budget for ICT development available. Intervention fields are administrative classification items that are used by Regional and National governments to report on their financial allocation decisions to all different policies financed by European

[3] Regions are considered here at the NUTS2 geographical level, with the exception of Germany and the UK where the geographical units considered is NUTS1 (further aggregation of NUT2-level regions) and smaller countries like Croatia, Cyprus, Estonia, Latvia, Lithuania, and Slovenia, where the national level is considered. Geographical levels refer to the Nomenclature of Territorial Units for Statistics (NUTS), a statistical classification standard created by Eurostat in 2003. NUTS0 is the code for the whole country.
Data on funding allocations were downloaded from the website of the European Commission's Joint Research Center at https://s3platform.jrc.ec.europa.eu/ict-monitoring. Data on the quality of government are from the Quality of Government Institute's website at https://qog.pol.gu.se/data. Contextual ICT indicators are retrieved from the Eurostat website (ec.europa.eu/eurostat).

Regional Policy. The data refer to funding allocations made in 2013 or the beginning of 2014 for the 2014-2020 programming period and were retrieved in 2017.

As showed in Table 1, we aggregated financial allocations to similar intervention fields when information was redundant. Therefore, the 10 ICT "policy goals" are developed by us for analysis purposes in this study. In particular, the "Broadband" policy goal derives from the aggregation of three intervention fields corresponding to three different types of broadband networks. The Digital Inclusion ("eInclusion") policy goals derives from the sum of the allocations to two intervention fields, one used when the money comes from the European Social Fund (ESF), and the second when the European Regional Development Fund (ERDF) is employed. The ICT in SMEs policy goals includes two separate interventions fields, one more specifically related to the cooperation between large enterprises and SMEs, and the other digital services that have SMEs as their main target. The goal named "ICT_Agri" refers to ICT investments in rural areas financed by the European Agricultural Fund for Rural Development, mainly regarding the competitiveness of rural businesses.

ICT policy goal	**"Intervention fields" as listed in the EU common Regulation for 2014-2020**
Broadband	• ICT: Backbone/backhaul network • ICT: High-Speed broadband network (access/local loop; >/= 30 Mbps) • ICT: Very high-speed broadband network (access/local loop; >/= 100 Mbps)
ICT_Infr	• ICT: Other types of ICT infrastructure/large-scale computer resources/equipment (including e-infrastructure, data centres and sensors; also where embedded in other infrastructure such as research facilities, environmental and social infrastructure)
eGov	• e-Government services and applications (including e-Procurement, ICT measures supporting the reform of public administration, cyber-security, trust and privacy measures, e-Justice and e-Democracy)
ehealth	• ICT solutions addressing the healthy active ageing challenge and e-Health services and applications (including e-Care and ambient assisted living)
PSI	• Access to Public Sector Information (including open data e-Culture, digital libraries, e-Content and e-Tourism)
SmartTransp	• Intelligent transport systems (including the introduction of demand management, tolling systems, IT monitoring, control and information systems)
SmartEnergy	• Intelligent Energy Distribution Systems at medium and low voltage levels (including smart grids and ICT systems)
eInclusion	• ESF - Enhancing the accessibility, use and quality of information through the development of digital literacy, investment in e-inclusion, e-skills and related entrepreneurial skills • ERDF - e-Inclusion, e-Accessibility, e-Learning and e-Education services and applications, digital literacy
ICT_SMEs	• Productive investment linked to the cooperation between large enterprises and SMEs for developing information and communication technology ('ICT') products and services, e-commerce and enhancing demand for ICT • ICT Services and applications for SMEs (including e-Commerce, e-Business and networked business processes), living labs, web entrepreneurs and ICT start-ups)
ICT_Agri	• ICT in rural funds (mainly funds to rural businesses)

Source: Commission Implementing Regulation (EU) No 215/2014 of 7 March 2014

Table 1 - Policy goals for funding allocations considered

One hundred regions classified by the EU Commission as "more developed" are excluded from the analysis[4].

3.2 Data on the regional context

Data on the context all refer to year 2013, when the allocation decisions were made. We selected 4 indicators, one for each ICT contextual factor, based on the availability of data from official sources, as reported in Table 2. Selected indicators reflect the different facets of territorial digital divides, considering infrastructural gaps as well as use gaps among citizens and enterprises.

ICT contextual factor	Indicator	Notes
Digital infrastructures	Percentage of households having access to New Generation Network (NGN) broadband	Households living in areas served by NGA, which includes the following technologies: FTTH, FTTB, Cable Docsis 3.0, VDSL and other superfast broadband (at least 30 Mbps download). Available at the NUTS0 level.
Digital government	Percentage of Individuals who used the Internet for interaction with public authorities	Individuals aged 16 to 74. Available at the NUTS2 level.
Digital divide among citizens	Percentage of individuals who have never used the Internet	Individuals aged 16 to 74. Available at the NUTS2 level.
Use of ICTs in enterprises	Percentage of enterprises sharing electronic information on the supply chain	Enterprises sending/receiving all type of information on the supply chain (e.g. inventory levels, production plans, forecasts, progress of delivery) via computer networks or via websites, but excluding manually typed e-mail messages. Enterprises with 10 or more persons employed are included. Available at the NUTS1 level.

Table 2 - Descriptive statistics on the variables employed

As for the other contextual characteristics, a measure of quality of institutions is used, namely the "European Quality of Government Index", developed by the University of Gothenburg, Sweden. The index reflects the perceptions and experiences of a large sample of European citizens on the quality of local institutions in 2013.

3.3 Methods

We use a two-step approach in order to address the two research questions. In the first step, the data on funding allocations are explored through a multivariate analysis to (a) identify relevant groups of EU regions following similar strategies and (b) find out which specific policy goals mainly characterize each strategy. The unit of analysis is the European Region, as defined

[4] "More developed" regions are those whose GDP per capita is above 90% of the average GDP of the EU-27. They receive only the 23.4% of total amount of ICT funding, while the remaining 76.6% is concentrated in 108 regions classified as "less developed" (where GDP per capita is less than 70% of the EU average) and "in transition" (GDP per capita between 75% and 90%). In these regions, the budget available for ICT policies represents a very high proportion of the total ICT investments including other sources of funding such as national or regional funds (Reggi & Scicchitano, 2014). Therefore, focusing on the "less developed" and "in transition" regions minimizes the risk that other sources of funding is used that are not considered in this analysis, as it usually happens in the "more developed" areas (Reggi & Scicchitano, 2014).

above. In particular, a Principal Component Analysis (PCA) is applied to the financial allocations to the ten policy goals in Table 1 with the aim of reducing the total number of variables for the subsequent Cluster Analysis. An agglomerative hierarchical Cluster Analysis (CA) based on the "Agnes" procedure is applied to the principal components resulting from the PCA and accounting for more than 50% of the total variance (Kaufman & Rousseeuw, 2009). Each identified cluster corresponds to an ICT strategy. A "v test" is performed to assess the association of each ICT goal to each identified strategy. The "v test" lets us identify which policy goals mainly characterize the strategies by comparing the mean of each group with the mean of all observations. If the mean of the allocations for a policy goal (in percentage) is higher than the overall mean and it is statistically significant, the goal can be associated with the strategy (Lebart et al., 1995). The analysis is carried out by using the *FactoMineR* package in R.

In the second step, we focus on the allocations to the "core" policy goals that mainly characterize each strategy, as revealed in the first step. Eight cross-sectional linear regression analyses (OLS models) are carried out to explore the links between the financial allocations to each "core" policy goal (dependent variables) and all the different contextual factors (independent variables). The OLS method is chosen based on the characteristics of the dependent variables, which are continuous, consistent with the OLS requirements (Wooldridge, 2010). We then look at the signs of the coefficients of the independent variables to find out whether each contextual factor had a positive or negative influence on the decision to invest public money on each ICT "core" goal.

4 Analysis and Results

This section presents the main results of our analysis. It starts with a description of the data employed, followed by a presentation of the result of the CA, aimed at revealing the prevailing strategies for financial allocations to the different ICT policy goals. The results of the OLS models are presented in the final sub-section.

4.1 Descriptive statistics

Some descriptive statistics of the variables included in the analysis are showed in Table 3.

Type of variable	Variable	Mean	SD
Financial allocations to ICT goals (in %)	eGov	13.2	12.4
	eHealth	4.4	4.9
	ICT_Infr	3.0	5.6
	Broadband	24.2	17.1
	eInclusion	17.4	17.7
	PSI	5.2	5.9
	Smart Transp	10.8	8.1
	Smart Energy	6.7	9.5
	ICT_SMEs	11.6	12.6
	ICT_Agri	3.5	8.7
ICT-specific contextual factors	*Digital infrastructures:* "Percentage of households having access to New Generation Network (NGN) broadband"	55.6	20.1
	Digital government: "Percentage of Individuals who used the Internet for interaction with public authorities"	30.0	13.9
	Use of ICTs in enterprises: "Percentage of enterprises sharing electronic information on the supply chain"	15.8	5.2
	Digital divide among citizens: "Percentage of individuals who have never used the Internet"	30.0	11.6
Socio-economic and institutional factors	Total ICT budget (million euros)	152.6	138.8
	Quality of Government Index	41.5	15.0
	GDP per capita (billion euros)	30.0	34.5

Table 3 - Descriptive statistics on the variables employed

In particular, the mean values of funding allocations to the different ICT policy goals (in percentages) give a preliminary indication on the distribution of the total available budget. The goal with the largest share of funding is broadband, with over 4 billion euros of programmed resources in the EU lagging regions, corresponding to 24.2% of the total budget for ICT policies (16.5 billion euros). The second largest goal is digital inclusion ("eInclusion") with an average allocation of 17.4%, followed by digital government ("eGov", 13.2%). As for the selected ICT context indicators, access to broadband infrastructure is the one with the highest standard deviation (20.1%), showing relevant differences among European regions[5]. With a EU average of 30% and a standard deviation of 13.9%, also the diffusion of digital government, in terms of the use of online government services by citizens, shows the presence of regional variations that are worth exploring.

[5] European regions are sub-national institutional entities directly below the state level. The EU policy employs the statistical units "NUTS2" to refer to European regions (see NUTS definitions in the methods section).

4.2 Step 1 - Exploring regional strategies for funding allocation and identifying "core" policy goals

First, a PCA is conducted with the aim of reducing the number of variables to be used in the subsequent CA. The results of the PCA include a total of 9 dimensions. In particular, the sum of cumulative variance of the first 4 dimensions is 64.1% of the total variance - which is above the recommended 50% threshold (Kaufman & Rousseeuw, 2009). Second, we then use these 4 dimensions as input values for the CA. We also employ the *NbClust* procedure in R, which compares the results of 30 different methods, to find out the optimal number of clusters (Charrad et al., 2012). Thanks to this procedure, four clusters are used to cut the hierarchal tree in the CA.

As a result, we are able to classify each EU region into one of the four identified clusters, each representing a different strategy in allocating the EU funds to the different policy goals. Each strategy is followed by a consistent set of EU regions that have made similar allocation choices. Furthermore, the "v test" helps us identify which ICT policy goals characterize each strategy. Table 4 shows the four revealed strategies and, for each strategy, a) the average value of financial resources allocated to each policy goal (in percentage) and b) the results from the "v test". The higher the percentage of EU funding allocated to each policy goal, the higher is the contribution of the policy goal to the strategy. In addition, when the value of the v test is positive and significant, the policy goal contribution to that strategy is relevant also considering its contribution, on average, to all other strategies. By considering both these indicators, four "core" policy goals are identified as the ones having the most important role in characterizing each strategy. "Core" policy goals are highlighted in grey.

The first strategy is focused on increasing the coverage of the NGN (New Generation Network) broadband networks (41% average investments), while the other three policy goals show only marginal contributions to the characterization of the strategy (low allocation percentages and negative v test values). The focus of the second strategy is digital government, the access to Public Sector Information ("PSI", including Open Government Data) and "eHealth" solutions, with the "eGov" policy goal being the "core" goal with a mean of 25% and the highest v test value. The third strategy aims at reducing the digital divide among enterprises. The "ICT in SMEs" goal is revealed as the core policy goal of this strategy with 29% average investment of the total ICT budget. Other goals are also relevant such as the ICT in rural areas ("ICT_Agri"), which includes financial incentives to farmers and other enterprises, the Intelligent Energy Distribution Systems ("SmartEnergy"), which are mainly developed by enterprises in the energy sector, and digital infrastructures such as cloud computing ("ICT_Infr"). The fourth strategy is mainly focused on the digital needs of the citizens. The main policy goal of this cluster is Digital Inclusion (47%), which appears associated with investments in smart transportation ("SmartTransp").

Strategy	Policy goal	Mean	v test
1 - Broadband	Broadband	41%	7.56 ***
	egov	8%	-2.99 ***
	eInclusion	10%	-3.13 ***
	PSI	2%	-4.60 ***
2 - Digital Government	eGov	25%	7.21 ***
	eHealth	8%	5.92 ***
	PSI	10%	5.42 ***
	Broadband	19%	-2.38 **
	ICT_Agri	0%	-2.70 ***
	SmartTransp	8%	-2.84 ***
	ICT_SMEs	6%	-3.16 ***
3 - ICT in SMEs	ICT_SMEs	29%	6.37 ***
	ICT_Agri	13%	5.13 ***
	SmartEnergy	14%	3.42 ***
	ICT_Infr	7%	3.09 ***
	Broadband	17%	-2.06 **
	eHealth	1%	-2.83 ***
	SmartTransp	6%	-2.89 ***
	eInclusion	4%	-3.52 ***
	egov	2%	-4.06 ***
4 - Digital inclusion	eInclusion	47%	7.58 ***
	SmartTransp	21%	5.70 ***
	eHealth	2%	-2.26 **
	ICT_Infr	0%	-2.27 **
	ICT_SMEs	5%	-2.49 **
	PSI	1%	-2.85 ***
	Broadband	6%	-4.65 ***

**** Significant at 1% level; ** Significant at 5% level;*

Table 4 – Revealed strategies and ICT policy goals characterizing each strategy

In the following step, these "core" policy goals - "Broadband", "eGov", "ICT in SMEs" and "eInclusion" - are used as dependent variables of the OLS models in order to explore the links between funding allocations to these policy goals and the selected contextual variables.

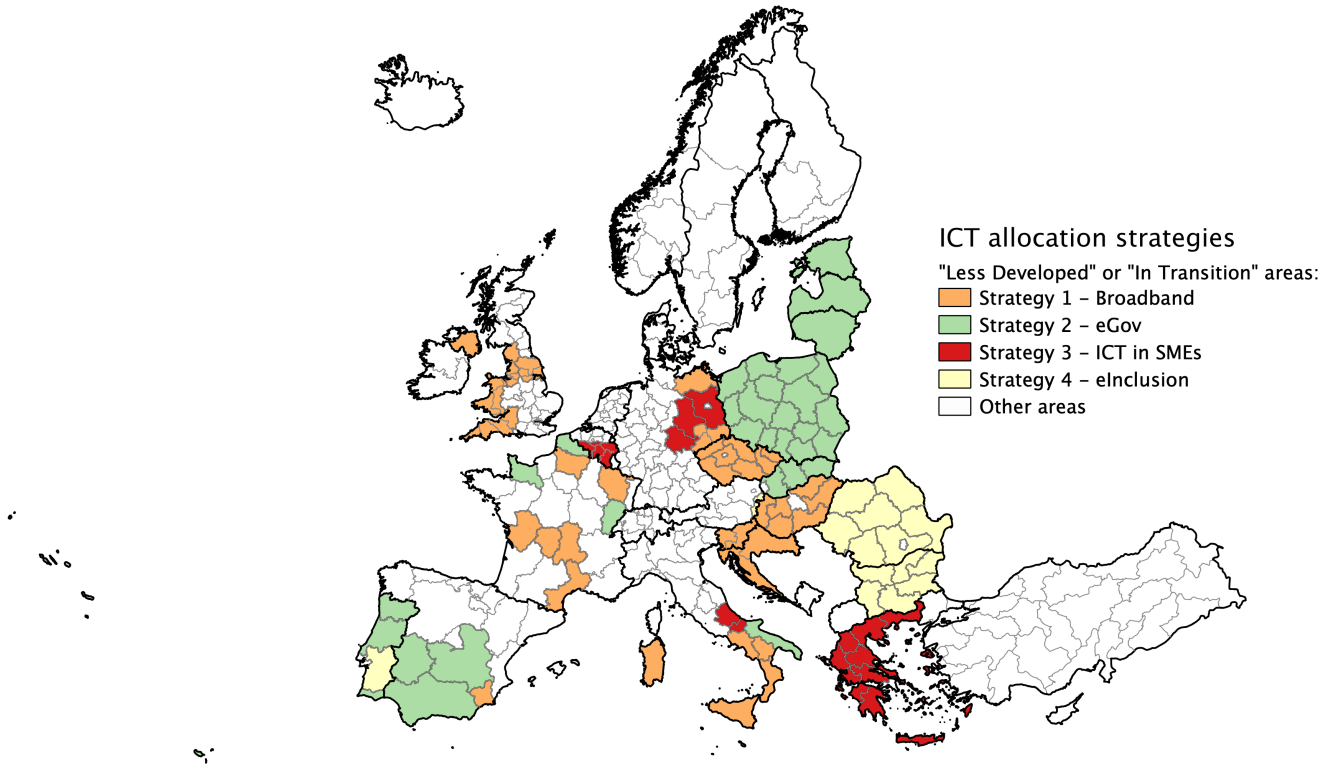

Figure 1 - ICT strategies in "Less developed" or "In Transition" areas of the EU

Figure 1 provides a representation of which EU sub-national areas follows which strategic approach. The first strategy - focused on the development of digital infrastructures - and the second strategy - focused on the "eGov", "eHealth" and "PSI" policy goals - are the two main strategies in terms of number of EU regions (37 and 36, respectively) and population living in those regions (80 million people and 80.5 million people). The third and the fourth strategies are implemented in 18 and 17 regions, where 19 and 26 million individuals live, respectively.

The map shows a strong "country effect", especially in Eastern Europe, where sub-national governments in the same country share the same strategy. The same effect can be observed also in the less developed areas of the UK and Belgium, while the remaining countries show some regional variations.

4.3 Step 2 - Comparing funding allocations to "core" policy goals with the regional context

As a second step of the analysis, we compare the funding allocations to the four core ICT policy goals characterizing each strategy (dependent variables) with the different contextual conditions (independent variables). The results of the OLS models are summarized in Table 5**Error! Reference source not found.**[6]. A negative sign of the coefficients indicates a negative relationship between each contextual factor and the financial allocations, which implies that

[6] 101 out of the 108 regions are included in the models due to the presence of missing values in the Eurostat data on ICT context.

investments seem to be focused on redressing existing imbalances or limitations. In the case of the indicator "Individuals who have never used the Internet", the opposite is true.

	Broadband [strategy 1]		**eGov** [strategy 2]		**ICT in SMEs** [strategy 3]		**eInclusion** [strategy 4]	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ICT-specific context								
Digital infrastructures: Households with NGA broadband availability	-0.27 ***	-0.30 ***	-0.02	-0.03	-0.10	-0.10	0.39 ***	0.44 ***
Digital government: Individuals who used the Internet for interaction with public authorities	-0.15 **	-0.15 ***	-0.37 ***	-0.49 ***	0.26	0.22	0.17 **	0.44 **
Use of ICTs in enterprises: Enterprises sharing electronic information on the supply chain	-0.60 **	-0.83 ***	0.61 ***	0.32	-0.46 *	-0.49 *	-0.33	-0.08
Digital divide among citizens: Individuals who have never used the Internet	-0.99	-0.94	-0.34 ***	-0.37 **	0.38 **	0.40 **	0.73 ***	0.59 ***
Total ICT budget *(in million euros)*	0.013	0.024 **	0.024 ***	0.041 ***	-0.014	-0.012	-0.003	-0.001
Socio-economic and institutional environment								
Quality of Government Index		0.33 **		0.32 **		0.05		-0.49 ***
GDP per capita		-0.54		-1.18 ***		-0.45		0.33
Constant	80.01 ***	74.85 ***	2.217 **	20.52 **	8.134	7.105	-26.28	-14.85
Adjusted R-squared	*0.35*	*0.37*	*0.26*	*0.36*	*0.18*	*0.16*	*0.22*	*0.27*
Observations	*101*	*101*	*101*	*101*	*101*	*101*	*101*	*101*

**** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level.*

Table 5 - OLS models. Dependent variables: EU funding allocations to the four core ICT policy goals characterizing each strategy

The effect of each ICT-specific contextual variable on the funding to the directly related ICT "core" goal is highlighted in grey. The first strategy, characterized by the investments in Broadband infrastructures, appears to be consistent with the local ICT context. The coefficient of the "Digital infrastructures" context indicator is negative and highly significant. Therefore, these investments seem to be aimed at filling regional gaps in terms of broadband access. In addition, two other context indicators, namely digital government and use of ICT in enterprises, are negatively correlated with funding allocations to broadband, showing that this kind of investments tends to focus on the weakest regions in terms of overall Information Society Development.

The second strategy, represented here by the percentage of funding allocations to the "eGov" policy goal, seems also to be consistent with the local ICT context in terms of digital government take-up. Similar to what happens for the first strategy, policy makers appear to be willing to allocate money to the digital government goal especially in those regions where digital government services are less used compared to the other regions, as signaled by the negative coefficient. Furthermore, the analysis shows that investments in digital government are associated with relatively low levels of digital divide among citizens. This choice seems also to be rationally conceived, given that the effect of policies towards a better use of public online services is potentially higher if citizens are already familiar with Internet technologies.

This consistency of funding allocations with the ICT context is found also for the other two strategies. A concentration of financial resources in the policy goal "ICT in SMEs" is associated with relatively low levels of ICT use in the private sectors. Likewise, investments in "eInclusion" are higher when the use of the Internet among citizens is lower. The fourth strategy seems to be implemented in relatively more advanced local contexts, i.e. where the levels of digital infrastructures and the diffusion of digital government are already high compared to the other regions.

These results are confirmed when GDP and quality of government variables are introduced (models 2, 4, 6, and 8). The effect of each ICT-specific contextual variable on the funding to the related ICT "core" goal is always statistically significant, with the expected sign. In particular, we find that the Quality of Government index had a positive influence on the financial allocations to digital government and broadband infrastructures, while it had a negative effect on digital inclusion investments. GDP per capita is statistically significant only in model 4, negatively correlated with the dependent variable on digital government allocations.

5 Discussion and Implications

Based on these results, a few points should be discussed. In general, the results confirm the importance of context for ICT policies. There is evidence that, indeed, strategic choices on financial allocations to key aspects of Information Society development vary from place to place and are influenced by several ICT contextual factors (Castelnovo & Sorrentino, 2018; Heeks, 2005). In particular, the first step of the analysis shows that the two prevailing strategies among EU subnational governments are "Broadband" and "Digital Government". The importance of the Broadband strategy could be explained by considering the high installation costs of equipment and cables, especially in the mountain and remote areas, compared to the other policy goals more focused on software development (Ferguson, 2004). As for the "Digital Government" strategy, it can be considered that local policy makers needed to give financial sustainability to interventions that started in the past 2007-2013 period, when ICT technologies for the provision of public digital services were the most funded topic (Pellegrin et al., 2018; Reggi & Scicchitano, 2012; Reggi & Scicchitano, 2014). In addition, the cluster analysis highlights a "country effect" in the distribution of these strategies in some countries, and in particular in Eastern Europe, i.e. the lagging regions in the same country following the same strategy. This effect could be due to the influence of country-level legislation and centralized institutional structure that guided the decisions of regional-level policy makers in the use of EU funding, especially in those countries where the authority of sub-national governments is weak (Dąbrowski, 2014).

Through the second step of the analysis, we obtained two key results that are worth discussing. The first result is that broadband connectivity is the focus of funding allocation in the less developed regional ICT contexts, which provides evidence to the hypothesis that digital infrastructures represent a strategic precondition for all other kinds of ICT interventions (Fernández-i-Marín, 2011; Ferro et al., 2008; Melody, 1996). Broadband investments can be seen, therefore, as a starting point for enabling subsequent actions in the field of ICT development, such as strengthening the use of ICT applications or bridging existing digital divides among users. We can conceptualize this evidence by considering the investments in digital connectivity as "the first step" of Information Society development, followed by different strategic choices based on the different characteristics of the local context.

The second key result is that the allocation of financial resources for the 2014-2020 EU programming period seems to be consistent with the needs of local areas. This evidence suggests that policy makers, at the time of the allocation decisions, might have been aware of the main characteristics of regional contexts and the gaps to be addressed through the use of EU funding.

These results seem to diverge from what Reggi and Scicchitano (2014) found in the previous 2007-13 period. According to those findings, the preferred strategy in 2007-13 was to allocate the funding to the aspects of Information Society for which the region already showed positive results. Instead of aiming at redressing imbalances, policy makers seemed to focus on the traditional strengths of regional ICT development, showing a form of path dependence on previous policy choices (Pierson, 2000). It might not be a coincidence that some early evidence questioned the overall effectiveness of these previous strategies (Kleibrink et al., 2015).

We can identify at least two discontinuity factors that might explain this change in the strategic approach. First, legal requirements introduced in 2014 by the common EU regulation forced each administration to develop a regional "digital growth strategy" that should be based on the analysis of the local context. In particular, a policy ex ante conditionality "mandates that the strategy needs to include information on budgeting and prioritisation actions, an analysis of balancing support for demand and supply of ICT, indicators to measure progress and an assessment of the need to reinforce capacity building in public administrations" (Stancova & Sörvik, 2015, p. 6). This ex ante conditionality implies that access to the EU funding on ICT is possible only if strategies with the required characteristics have been formally approved by the Commission.

Second, in the current period a new set of tools is available for the analysis of local ICT context, which allows for systematic comparison of regional performances in the different aspects of Information Society development (Codagnone et al., 2015; Huggins, 2010; Rorissa et al., 2011). The main example is the "Digital Scoreboard" tool, which includes a wide array of regional ICT indicators comparing the digital performance of each regions with other regions in the same country or in other countries. Additional supporting tools were made available by the Commission, such as the "Digital Agenda Toolbox", a set of guidelines and recommendations for evidence-based analysis, which are also supported by field visits to the regional administrations (Stancova & Sörvik, 2015).

The main policy implication is, therefore, that the current EU requirements for a sound analysis of the ICT context may have worked well and should be considered in the next 2021-2027 programming period. The European Commission proposal for the new EU regulation - currently in the process of negotiation with Member States and the other EU institutions - does include one

"enabling condition" on the development of "Smart Specialisation Strategies" based on the "up-to-date analysis of bottlenecks for innovation diffusion, including digitalisation"[7]. However, this proposal does not require to develop the dedicated ICT strategies anymore. Current multi-level interactions among EU, national and regional institutions should promote the development of regional strategies that are context-aware and encompassing all available funding for ICT development within different policy objectives. In addition, the use of web-based tools and learning opportunities for policy makers about available data and analyses should be further promoted, such as decision support tools (Petrović et al., 2014) or benchmarking tools (Reggi et al., 2014).

6 Conclusions

This paper analyzes the programming phase of ICT policies from a novel perspective. First, it considered funding allocation to specific policy goals as a crucial factor for the existence of effective policies tackling the main components of the Information Society at the local level. Second, based on a quantitative analysis of the planning phase of the 2014-2020 Structural and Investment Funds in the EU lagging areas, the paper compared different types of ICT interventions, providing a holistic view on the policy priorities of the national and local governments, as well as some preliminary indications on the factors influencing them.

As a response to the first research question, the first step of the analysis identified four main ICT strategies, each characterized by one or more policy goals. The first strategy is focused on broadband infrastructures, the second on the use of ICTs in the public sector, the third on the digitalization of SMEs, and the fourth on digital inclusion. The first two strategies are prevalent.

The second research question was addressed through the second step of the investigation. The regression models systematically compared the financial allocations to four policy goals characterizing each strategy with the regional context. The results indicate that, overall, current ICT strategies in the context of the EU funding are consistent with the characteristics of the local environments. Financial resources are concentrated in those ICT policy goals for which contextual indicators suggest that there are significant territorial digital divides to be addressed. In focusing on improving the weaknesses of their area, policy makers seem to have pursued strategies aimed at balancing the different components of Information Society development. In particular, investments in broadband infrastructures are concentrated in EU regions where all ICT contextual characteristics are weaker compared to the other regions, indicating that digital infrastructures are perceived as a precondition for the development of ICT applications.

Finally, the following lines of further research can be suggested based on the main limitations of this paper. First, although ESIFs are the main source of investments in the European lagging regions, they are not the only ones. For example, in several countries such as Portugal, broadband development is also co-funded by the Connecting Europe Broadband Fund (European Investment Bank, 2018). In addition, national and local ICT policies usually play a role. Further research could also consider these different sources, as well as the interplay between EU policies and existing policies at the national and regional level, in terms of potential complementarity or

[7] COM/2018/375 final - 2018/0196 (COD) – Annex IV. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2018%3A375%3AFIN. On the Smart Specialisation Strategies see for example McCann and Ortega-Argilés (2015).

overlap. This could affect not only the development of infrastructure, but also digital skills and citizen use in different regions, which could also be the focus of future research.

Second, the comparison discussed here between the 2007-2013 and 2014-2020 periods could be further investigated by carrying out a comprehensive analysis including financial allocations and available context indicators for both periods. This unitary approach should improve methodological comparability. Furthermore, this exercise could be replicated in the next 2021-2027 programming period, as new allocation data are expected to be available by the end of 2022. A dynamic analysis considering the 3 periods could provide some insights on the possible evolution of strategic patterns, including an in-depth exploration of results of the cluster analysis.

Third, a qualitative analysis conducted through interviews with policy makers could be helpful to identify other relevant variables that affect the process of decision making on funding allocations, such as federal and national policy constraints, values, anecdotal knowledge, institutional rules and routines, and the input from public participation (Mele et al., 2014).

Finally, future research may concentrate on the impact of these investments on regional ICT contexts, in terms of reducing existing digital divides in access and use of digital infrastructure. For example, actual spending data can be retrieved from the same sources at the European Commission as one of the determinants of the change in context indicators during the current programming period.

Funding statement

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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