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The access to broadband services as a strategy to retain population in the depopulated countryside in Spain

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ABSTRACT

The aim of this paper is to analyze at what extent the connectivity of small localities is a determinant of their demography. Specifically, we pay attention to three factors: the evolution of the population; the distance, measured both in kilometres and travel time, to the province capital, the usual city where the largest set of services is available; and finally, the coverage of different kinds of broadband services (from ADSL or 3.5 G to the fastest ones FTTH) in rural areas. An econometric model was estimated where the dependent variable captures the increase of inhabitants along 2017–2020 of the 5955 Spanish municipalities with a population between 101 and 10,000 inhabitants (73.3 % of all municipalities). The results point out to the following facts: digital connectivity of small localities is a determinant of their demography, whatever the technology used, but physical distance remains being a significant factor on the population growth (both if it is measured of physical distance or travelling time) to explain the population growth of each locality.

1. Introduction

The depopulation of rural areas is a growing problem in the world that is reaching practically unstoppable magnitudes. According with World Bank data, between 2000 and 2020 the world population in urban areas has grown by 22 % while in rural areas it has lost >18 %. Since 2007, the rural population not only began to be less than the urban one, but also rapidly distanced itself from it due to the greater attractiveness of the cities and the few opportunities offered by rural areas. In 2020 the rural population only represented 43.88 % of the world population.

More specifically, in rural areas across the EU the population is, on average, ageing more quickly than in urban areas, without any indication that this trend will change in the coming decades. This, added to the lack or weak internet coverage, poor infrastructure, lack of employment opportunities and limited access to services, makes rural areas less attractive to live and work.

The causes behind this process are numerous and have been widely studied from different perspectives: demographic (Bruno et al., 2021; Coleman & Rowthorn, 2011; Copus et al., 2021; European Committee of the Regions, 2017; European Committee of the Regions, 2020), psycho-social (Llorent-Bedmar, Palma, & Navarro-Granados, 2021; Mitchell, 1950; Paniagua, 2002a; Paniagua, 2019; Stockdale, 2002), environmental (Paniagua, 2008; Szymanowski & Latocha, 2021; Willians & Jobes, 1990; Willians, Shaw, & Greenwood, 1989) territorial characteristics (Collantes & Pinilla, 2011; Reynaud, Miccoli, Benassi, Naccarato, & Salvati, 2020; Van Berkel & Verburg, 2011; Alamá-Sabater et al., 2021) and economic (Alamá-Sabater, Budí, García-Álvarez-Coque, & Roig-Tierno, 2019; Boyle, Halfacree, & Robinson, 1998; Commins, 1978; Fielding, 1989; Merino & Prats, 2020; Paniagua, 2002b; Pezzini, 2001).

It is well known that the lack of employment, public services, infrastructure, especially transport and connectivity, and the lack of economic and social prospects in rural areas pushed the population, especially the youngest, to settle in larger cities that offered a quality of life more encouraging and more favourable employment perspectives. All of them had been very powerful factors, and their role cannot be ignored or eliminated due to their status as permanent factors in a depopulation analysis.

However, since the spread of ICT, it is claimed that physical distance will play a smaller (or even negligible) paper in the location where individuals live and develop their jobs since many work activities as well as leisure ones and personal relations can be developed online thanks to

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the spread of internet services and the irruption of working from home tools, video streaming platforms and social networks. If we take into consideration the most recent advances that have made available many other services on line (from banking services to relations with the public administration and even medical assistance), the challenge that ICT generate on the role of physical distance increases.

In this paper, we are especially interested in introducing the new channels that internet connections open in the traditional role that communication has had to promote/deter depopulation in rural areas. This is, we are wondering if easy and fluent communications, as one of the factors that shapes the appeal of one location, should not only make reference to the physical world (breaks) but also to the digital one (bits). Then, the aim of the paper is to analyze whether internet connections may substitute or complement the value that physical communication has as a factor to hold the appeal of locations to live in. There is a vast literature dealing with the impact of physical transport infrastructures on land use (see a review in Kasraian, Maat, Stead, & van Wee, 2016), but at the authors' best knowledge, this is the first attempt to explore the role that both communications channels (physical and digital) have on the depopulation process. It must be noted that this is an important question, not only from the academic perspective, but also for the policy-designers. In many countries, specific policies are implemented to deter depopulation, given that it supposes a reduction in the value of public investments, increase the costs to provide services for the remaining inhabitants, generates a higher environmental impact on large cities as well as supposes the loss of cultural values and knowledge. So, having an accurate knowledge of the relevance of two elements (physical and digital communication) on the depopulation phenomenon will help to design more accurate policies and better use of the resources that both kinds of infrastructure required.

Then, we contribute to the existing literature in several ways. First, we provide a new vision to address the phenomenon of depopulation that, to our knowledge, had not been adopted before: considering communication, whether physical or virtual, as two sides of the same coin and therefore as two ways to consider together. Second, our approach allows us to demonstrate that communication, both physical and through ICTs, are factors that allow for population gains. And thirdly, our research offers a scientific basis so that politicians can develop actions against depopulation based on the results obtained in this study.

We address this question using Spain as the country for the study. A big part of Spain is suffering a large depopulation phenomenon with many localities reducing notably their populations, not only for vegetative growth reasons, but also for net migration outflows. Besides, along the first decades of the 21st century, around five million foreign immigrants have arrived and they had to select their dwelling without previous attachments to any location. The fact that a large road network exists connecting every locality with the province capital and the rest of the country, and that the broad band infrastructures were developed along the last decade makes that this can be a valid case to analyze in order to answer to those questions.

The remainder of this paper is organized as follows: Section 2 discusses the relevance of telecommunication access to challenge the role that physical distance may have to determine the appeal of a location to host population. Section 3 presents the data, paying special attention to the different technologies to access internet and the main types of broadband networks. Section 4 presents empirical analysis, and Section 5 discusses the main conclusions and some policy implications.

2. The role of distance and communications

Traditionally, (physical) distance has played a key role to determine the locations where people concentrate. The need of exchange products, the inherent desire of humans to establish social relations and interact among themselves are among the factors that explained that locations well connected with others had a larger appeal to host economic activities (which implies jobs) and people. This demand for good communications supposed mostly a demand of roads, ports or channels/rivers that made fluid the transportation both of merchandise as well as persons. Clearly, a short physical distance with other locations but with poor communications (whether due to lack of the necessary infrastructures or for physical elements) did not increase the appeal of a place to live and, in contrast, locations physically distant but endowed of infrastructures that made easier movements of goods and people with other locations become more attractive to host population.

This reasoning compelled the need to invest in transportation infrastructures to retain population. Assuming the existence of resources to develop economic activities that could generate income for its inhabitants, as transportation and movement improve the attraction of a certain locality to host people and economic activities will increase, may be compensating other disadvantages that may arise.

At the end of the 20th century, digitalization became a new revolution. Many activities that previously required physical movement of goods could be done just moving the relevant information, digitally coded. To read some information, it was not longer to move a physical item (book, piece of paper…) but just the information that could be read in a specific device. The digitalization process of more and more activities went hand-to-hand with the development and extension of telecommunication networks to carry on the movement of such information. The development of internet supposed that the circulation of information had a minimum cost, and independent of the physical distance between emitter and receiver, as well as incomparably easier to use at a point where almost all the population could use it. Further developments that departed from these elements (such as video streaming, social networks, safe payments, etc.) are part of the revolutionary changes that the first years of the 21st experienced. These changes (the massive digitalization of many elements) and the use of internet (with all the applications that have emerged) lead to suggest that physical distance and the endowment of transportation infrastructures have lost relevance to determine the appeal of one location to host population in favour of connectivity to the infrastructures that provide the digital connectivity. Some research has found that access to fast internet reduces those social activities that require physical proximity with other individuals such as participation in social organizations activities (Geraci, Nardotto, Reggiani, & Sabatini, 2022), this is the services that fast internet provide act as a substitute for such participation (weather because new activities are developed or because they are developed online). Other studies have shown that access to information and communication technologies are an engine of deep economic and social transformations in rural areas (Min, Liu and Huang, 2020) Furthermore, there is a consensus that the development and improvement of information and communication technologies (ICTs) it could be a determinant factor not only to contain the loss of population, but also to attract potential immigrants (Castelli, 2018; Guerrero, 2019; Pérez-Morote, Pontones-Rosa, Núñez-Chicharro, & Merino-Madrid, 2021; Pontones-Rosa, Pérez-Morote, & Santos-Peñalver, 2021), although this is not a factor that solely can reverse the depopulation process.

Let's note that access to new communication technologies has become a key element for modern lifestyle. Beyond its role for personal relations (as social networks) or to satisfy personal desires (from leisure to education), it has become a key infrastructure for many firms that need to have fast and efficient communication channels to interact with their suppliers and clients. ICTs enhance the exchange of information and, therefore, are considered important factors of production for increased productivity and economic growth, also in rural areas (OECD, 2018). The evidence is positive in different developing countries as, inter alia, China (Liu, Yang, Li, & Li, 2017; Ma, Nie, Zhang, & Renwick, 2020; Ma & Wang, 2020), Bangladesh (Lee, Morduch, Ravindran, Shonchoy, & Zaman, 2021), Mexico (Martínez-Domínguez & Mora-Rivera, 2020), Peru (Prieto-Egido et al., 2020), West Africa (Rodríguez-Castelán, Ochoa, Lach, & Masaki, 2021).

The outbreak of the COVID-19 highlighted this aspect, making a reality the extension of remote work (Euroforum, 2020) that, although technically possible before it, was not common before it for different reasons. Remote work allowed that ceased to displace daily to their workplace and, encouraged by the perceived risks of the pandemic, pushed many people to move to secondary residences located far from cities, even in remote rural areas while they had good internet access. Another consequence of the COVID-19 pandemic, and the subsequent measures to control it, is that teleworking has been proved to be an efficient alternative in many more jobs that were previously considered and the rejections and suspicious that existed have been dismissed notoriously after the forced experience. This process increased the awareness of the importance of ICTs in the fight against depopulation since it facilitates that people can dwell wherever they prefer, independently on where they develop many of their economic and social activities. Besides, the energy crisis consequence of the Ukranian war, may consolidate that trend to reduce physical displacements when the activities can be done remotely. So, implementing and developing a powerful Internet access network that favours and facilitates communications is an undeniable requirement that will allow it to be a vehicle for social cohesion and economic development in depopulated areas.

These ICTs emerge as a powerful factor (Cavallaro & Dianin, 2022) that can contribute to modifying the decision-making process of the population to leave (or settle) in the most depopulated rural areas, since they have a very attractive increase in the endowment of factors that would allow accessibility, "defined as the potential of opportunities for interaction" (Handy, 2020, p:1) and the development of work (but also leisure and social relations) in better conditions.

Furthermore, rural dwellers often face problems of accessibility and mobility. It has frequently been considered that the use of ICTs can complement or substitute for commuting (Blumenberg, Paul, & Pierce, 2021; de Graaff & Rietveld, 2007; Mokhtarian, 2002).Thus for example, the use of services based on internet can result in a person needing to travel less (substitution) by having other ways to communicate with others, access services or information (Lachapelle, Tanguay, & Neumark-Gaudet, 2018), while in other cases, e.g. telecommuting is found to have a positive impact on different types of non-work trip by workers, thus acting as a complement (Zhu, 2012). In this sense, internet technologies would make it possible to obtain population gains in small rural municipalities.

Reducing travel times that allow the rural dwellers to move from their place of residence to larger population centres with services not available in these areas, such as financial, entertainment, education, or business/professional services can be a determining factor to reduce the depopulation that these territories could suffer. In addition, a good broadband infrastructure minimizes the penalty in terms of long travel times to access these services or opportunities (Townsend, Sathiaseelan, Fairhurst, & Wallace, 2013).

In this situation, the European Union launched in 2010 a decisive and essential path towards digitization to achieve more prosperous growth throughout the European territory. In this path to advance in digitalization, one of the priorities is that this digital transformation does not leave out the most depopulated areas. The legal frameworks that have determined the path to follow in this process are marked, on the one hand, by the European Digital Agenda 2010–2020 and 2020–2030 (European Parliament, 2022) and, on the other, by the agenda determined by "A long-term vision for rural areas of the EU until 2040" (European Commission, 2022), with two components: the Rural Pact and the EU Rural Action Plan.

Each EU member country has transposed these guidelines into its national legal system. In the case of Spain, a country affected by an intense process of depopulation in its interior areas (Eurostat data indicates that the less densely populated NUTS3 regions are in Northern Scandinavia and parts of Spain), a real action against depopulation and the digitization of depopulated areas has been launched based on the *National Strategy for the Demographic Challenge* (Gobierno de España, 2019) and *2025 Spain Digital* (Gobierno de España, 2020).

The demographic challenge currently plays a prominent role in Spain, since it can affect the sustainability of the Welfare State and it can put social cohesion, the territorial structure and the coexistence model at risk. The strategy is conceived as a global and transversal action, with a multidisciplinary perspective that incorporates the demographic challenge in the analysis of sectoral actions. The first of the seven cross-cutting objectives consists of guaranteeing full territorial connectivity, with adequate broadband internet and mobile telephony coverage throughout the territory, in accordance with the European Digital Agenda 2020. The first of the three basic lines of action is the fight against depopulation.

So, we find that both from a theoretical perspective (digitalization and internet access provide access to valuable and needed services in locations, independently of its physical distance to other places) and from the designed and implemented policies, the access to internet has become a key element to fight against depopulation of rural areas. However, we cannot forget that the displacement of physical elements (merchandises and persons) remains being necessary and, then, we cannot forget that the physical connectivity of each location may also be important to determine the appeal of each location.

Taking in mind these elements, the aim of this paper is to test whether the population gains observed in small municipalities (between 101 and 10,000 inhabitants) are related to the greater or lesser distance from the municipality to the capital (measured both in time and kilometres) and with the greater or lesser percentage of penetration of different internet technologies.

3. Data

In order to test the relevance of physical distance and internet access to keep the appeal of localities, we will study the relationship between the population evolution and the internet access in the Spanish municipalities. As it was explained in the introduction, Spain is a good case to study this topic since depopulation is intense in large parts of its territory, although a large inflow of immigrants has arrived in the last decades, while telecommunication networks and infrastructure is spreading.

Spain is characterized by a large number of municipalities (over 8000) with a large number of them with a very small amount of population (49 % of them have <500 inhabitants). So, the municipality becomes the adequate measure to determine the situation of each locality.

Telecomm companies spread their networks and services based on a large series of parameters. Obviously, population and the forecast of its evolution can be one of them. However, in the initial deployment of these technologies in small-medium locations, other ones such as the proximity to the networks that serve large cities, business centers or infrastructures or geographical considerations are more important. Even that, to minimize endogeneity biases in the analysis, we will use the percentage of the locality with access to the different technologies that provide internet access in 2013 (logically the consequence of deployment of these services in the previous years) as explanatory variable of the population evolution from 2017 to 2020 (four to seven years ahead). The gap of four years between the internet access and the initial moment (2017) allows to circumvent this issue.

The evolution of the population in each municipality is provided by the Spanish Continuous Census. In it, the inhabitants of each municipality are registered, and the figures are published yearly. Deaths and births are registered and, when one person registers in another municipality (which is a requirement for many services such as health, education or even public transportation passes) it is automatically erased from the location where previously was registered. In this sense, it qualifies adequately for this kind of analysis.

The population of the municipalities exhibits a largely skewed distribution as we can see in Table 1, with >60 % of them with <1000 inhabitants and only 63 (out of 8126) with >100,000. Even more, there are many really small municipalities (16 % do not reach to 1000

Table 1
Distribution of Spanish municipalities according to their number of inhabitants (2017).

Size (number of inhabitants)	Number of municipalities	% of the total
0–100	1360	16.7
101–1000	3635	44.7
1001–10,000	2375	29.2
10,001-50,000	611	7.6
50,001–100,000	82	1.0
100,001-1000,000	61	0.8
>1000,000	2	..
Total	8126	100.0

registered people) whose dynamics do not depend on economic, societal, factors, nor their resources, but on the ageing of the last inhabitants. So, our analysis will focus on localities that fall in a certain size range, since it is in them where the appeal that internet access may help to retain population or to attract from other places.

3.1. Distance: Main types of broadband networks

High-speed broadband has become a fundamental part of everyday life for both businesses and individuals. In recent years, taking into account the increased demand for bandwidth, telecomm operators have been upgraded their legacy copper networks and so-called “next generation access” (NGA) broadband networks based on fibre optic technology have started to be deployed (Abrardi & Cambini, 2019). Over the years, different broadband services have been provided, which can be divided according to their technology into wired and wireless:

- Wired (or fixed-line) technologies: These are solutions that communicate over a physical network that provides a direct “wired” connection to the user's terminal. These wired technologies can be classified into: (1) xDSL, which is broadband Internet access through copper pair cables, the most widely used are asymmetric digital subscriber line (ADSL) and very high transfer rate digital subscriber line (VDSL), they provide broadband Internet access through copper pair cables; (2) hybrid fibre-coaxial (HFC) which provides broadband Internet access by combining optical fibre and coaxial cables; and (3) fibre to the home (FTTH), which uses exclusively fibre optic.
- Wireless technologies: These are wireless solutions that use electromagnetic waves or radio waves to provide a connection, although the user must be within range of the access point. They can be classified into three categories: (1) wireless access, the most commonly used being Wi-Fi technology and WiMax technology with the latter having greater coverage and quality than the former; (2) mobile access, with the Universal Mobile Telecommunications System (UMTS) equipped with HSPA or HSPA+ technology being the most widely used, also called 3.5 G, together with Long Term Evolution (LTE), 4G or 5G, and; (3) satellite.

The data for internet access is provided by the Comisión Nacional de los Mercados y la Competencia (2013), that collects information from all the authorised suppliers of this service and, throughout the established methodology establishes and publishes the percentage of each municipality that is covered by each of the used technology to provide internet access in Spain. As can be observed in Table 2, the technology platform with the greatest coverage is HSPA, while technologies such as HFC and FTTH, which enable fast and optimal Internet access, are not widely deployed in rural areas. So, taking into account the degree of penetration of the different technologies, ADSL, copper, wireless and HSPA are selected as appropriate technologies for the analysis.

Previous studies in this field have pointed out the significant digital divide between rural and urban areas (Pontones-Rosa et al., 2021; Salemink, Strijker, & Bosworth, 2017). Wired internet technologies as well as mobile broadband technology are available on a fairly widespread basis in Spain, except in rural areas (Pereira, 2016). Inequalities exist among different populations in broadband access depending on their geographic location and with the aim of achieving absolute coverage. Although it is recognized that an increase in broadband coverage protects rural areas from depopulation (Briglauer, Dürr, Falck, & Hüschelrath, 2019), the cost of deploying a network infrastructure (80 % higher in rural areas compared to deployment in urban or suburban areas, Schneir & Xiong, 2016), and the limited incentives for telecomm operators to merit entry (Prieger, 2003; Reddick, Enriquez, Harris, & Sharma, 2020) are actually conditioning their spread, although the Spanish Government develops different actions to increase the broadband coverage at every level (rural areas, urban centres, industrial environments, etc.) (Gobierno de España, 2020). So, given the different penetration across localities of some of the technologies to provide internet access (and, then, its quality and speed), the data can be used for the analysis.

3.2. Distance: Physical (roads)

Both for people and merchandises, in Spain the main transportation method in smaller localities is the road. The railway network is scarce out of the main cities and the suburbs of large cities like Madrid, Barcelona or Valencia and water channels are inexistent. In Spain the road network differs notably across regions[1] (see Ministerio de Fomento, 2008), so both the travelling time as the kilometres to be made differs notably across regions for two localities at the same geographical distance between them. For this reason, we cannot consider the geographical distance form each location to a reference city, but need to take into account those factors.[2]

It must be noted that there are two archipelagos (Balearics and Canary Islands), each of them formed by different inhabited islands. Since in them, the communication with a large city will differ if it is the same island or not (so, to reach it requires to take a ferry or a plane, whose costs are inherently larger and will depend on the proximity of each locality to a port/airport), they have been excluded from the analysis.

For the rest of Spanish municipalities, the distance by road of each of them to the provincial capital (usually the closest large city) where many services are provided and that, was obtained from Google maps using the best option that this tool provides.

4. Empirical analysis

In order to study the relation between digital access and physical distance to the capital city on the evolution of the population with raise an econometric model to test the significance of those two variables. In the model, the population growth between 2013 and 2017 is put in relation with the physical distance, both in kilometres as well as in time of travel, and the penetration of six of the internet technologies in each location. Given that very small locations will have a different dynamic, we have considered they are not adequate for this analysis. In the same way, in large municipalities other effects may be present and, in many of them, the penetration of the studied technologies in 2013 was close to 100 %. So, we have centred our analysis in the locations with an initial size between 101 and 10,000 inhabitants which suppose 5955 municipalities (out of the 8126 that there are in Spain). In the regressions, the size of each municipality (measured by the number of its inhabitants in thousands) in 2017 was also included as a control variable. The results are presented in Table 3.

The results of the econometric regressions highlight that a larger

[1] https://www.mitma.gob.es/carreteras/catalogo-y-evolucion-de-la-red-de-carreteras/longitudes-provinciales/longitudes-provinciales-2011-2012-y-2013

[2] The official map of transport infrastructures in Spain is available at http://centrodedescargas.cnig.es/CentroDescargas/buscadorCatalogo.do?codFamilia=02309

Table 2
Penetration of broadband internet connections in Spain by technology type in % of population (2013).

ADSL ≥2 MBPS	ADSL ≥10 MBPS	VDSL	HFC	FTTH	COPPER ≥2 MBPS	COPPER ≥10 MBPS	COPPER ≥30 MBPS	WIRELESS ≥2 MBPS	HSPA	LTE
88.98	69.03	10.88	46.42	26.29	94.96	82.01	60.39	52.93	98.95	47.80

Source: Comisión Nacional de los Mercados y de la Competencia.

Table 3
Regression results.
Dependent variable Growth rate of population in 2017–2020 (OLS with heteroscedasticity-robust errors).

Internet measure: % of the local population with access to	Regression results (Dep. Variable: Pop. Growth 2017–2020)									
	Internet (2013)		Distance (Km)		Population 2017		Constant		R^2	Joint significance
ADSL 2 Mb	1.588	**	−0.028	**	0.6091	**	−2.258	**	0.100	284.6 **
	(6.687)		*(−13.468)*		*(18.202)*		*(−9.935)*			
ADSL 10 Mb	1.057	**	−0.027	**	0.6191	**	−1.711	**	0.095	276.4 **
	(5.147)		*(−13.368)*		*(18.512)*		*(−8.668)*			
INALAM 2 Mb	0.135		−0.027	**	0.6862	**	−1.366	**	0.091	274.2 **
	(0.772)		*(−12.532)*		*(21.395)*		*(−6.041)*			
COPPER 2 Mb	1.236	**	−0.027	**	0.6656	**	−2.356	**	0.093	275.9 **
	(3.650)		*(−12.991)*		*(20.668)*		*(−6.805)*			
COPPER 10 Mb	1.128	**	−0.027	**	0.6085	**	−1.749	**	0.100	276.7 **
	(5.464)		*(−13.329)*		*(18.055)*		*(−8.864)*			
HSPA	1.783	**	−0.027	**	0.6126	**	−2.730	**	0.100	280.2 **
	(6.001)		*(−13.022)*		*(18.565)*		*(−9.009)*			
	Regression results (Dep. Variable: Pop. Growth. 2017–2020)									
Internet measure: % of the local population with access to	Internet (2013)		Distance (hours)		Population 2017		Constant		R^2	Joint significance
ADSL 2 Mb	1.511	**	−2.039	**	0.0006	**	−2.189	**	0.092	256.7 **
	(6.365)		*(−11.170)*		*(18.353)*		*(−8.829)*			
ADSL 10 Mb	0.991	**	−2.028	**	0.0006	**	−1.657	**	0.089	249.3 **
	(4.825)		*(−11.126)*		*(18.676)*		*(−7.492)*			
INALAM 2 Mb	0.235		−2.004	**	0.0007	**	−1.386	**	0.085	248.2 **
	(1.352)		*(−10.556)*		*(21.391)*		*(−5.600)*			
COPPER 2 Mb	1.198	**	−1.977	**	0.0007	**	−2.295	**	0.087	249.3 **
	(3.532)		*(−10.796)*		*(20.688)*		*(−6.296)*			
COPPER 10 Mb	1.066	**	−2.017	**	0.0006	**	−1.698	**	0.089	249.6 **
	(5.161)		*(−11.079)*		*(18.230)*		*(−7.684)*			
HSPA	1.771	**	−1.973	**	0.0006	**	−2.692	**	0.092	254.0 **
	(5.952)		*(−10.838)*		*(18.599)*		*(−8.399)*			

Notes: Number of observations: 5955. ** and * indicate statistically significant coefficients at 95 and 90 % respectively. *t*-ratios in parenthesis.

penetration of broadband services in a municipality in 2013 is positively correlated with the evolution of its population in the future (2017–2020). This result holds for all the internet technologies we have analysed (ADSL, Cupper and HSP), being the only exception the wireless services. At the same time, we observe that distance to the provincial capital, both if it is measured on the number of kilometres or in the travelling time by road, is negatively correlated with the population growth. Finally, the initial size of each municipality is positively correlated with the population growth, showing that smaller cities are growing less which, besides the numerical effect, reveals the existence of some size effects that make that smaller localities are the ones with a higher depopulation trend, beyond its connectivity with the rest of the territory.

5. Results and discussion

The results of the empirical analysis reveal that connectivity of small localities (101–10,000 inhabitants) is a determinant of their demography. The empirical analysis has focused on the role that physical distance (a classical factor for the appeal of a location) to the capital city as well as internet connectivity may have to retain or increase its population. As we have seen in the econometric results presented in Table 3, both measures of physical distance as digital connectivity are factors that affect, with the expected signs, to the population growth of each locality.

Traditionally, physical distance supposed the access to markets (whether to buy inputs needed in the production processes of one locality or to sell the output) and then, lack of infrastructures or physical barriers hard to surpass, became a handicap to retain the population. Besides its relevance for economic activities more difficult connections reduced the social interactions and the leisure alternatives for their inhabitants as well as made more expensive the access to certain services. The spread of the digitalization of many elements and the subsequent extension of internet made possible that many services could be channelled through it, reducing the role of physical distance. That made that the focus changed from having good physical infrastructures for physical transportation to have high quality internet access.

The analysis has revealed that the population growth in middle/small sized localities is positively affected by the previous extension of internet in the locality. So, whether for the necessity to have internet access for economic and professional activities or for social relations and leisure activities, we are seeing that those localities with more internet access are the ones that years after increase more their population. But this element has not made that physical distance becomes a negligible factor. Locations farther from a large city (the provincial capital that in many cases host some key services such as hospitals, high schools, for institutional reasons) have less appeal to live. This factor is not due solely to the travelling time; so, even the roads would be improved (reducing the travelling time) our results are showing that the kilometres to the provincial capital remain being an important factor that slows its population growth (actually, accelerates its declining).

Some interesting questions emerge from these results. The fact that physical distance remains being a significant factor on the population growth can be affected by the kind of economic activities that are developed in each area. Although in many of them the weight of agriculture is important, it must be noted that the size of the studied localities (between 101 and 10,000 inhabitants) does not imply huge differences in the economic structure as if localities with over 100,000 inhabitants were included. Furthermore, similar analyses as the one presented in Table 3 for localities of more homogeneous sizes confirm this result. Another interesting question, not treated in the paper, is the actual availability of dwellings for potential new inhabitants. The fact that the Spanish renting house market suffers from many distortions, the burdens to build new houses in many localities may generate an extra difficulty to find an accommodation for potential inhabitants in localities whose residents reduce. This element can be specially interesting if we consider that Spain is a country that in the first decades of the 21st received an inflow of close to five million migrants.

The digital divide in terms of access to and quality of ICTs is still significant in many localities. Attention must be paid to the ageing of the population with policies that favour digital inclusion, as well as reinforcing public policies that mitigate depopulation and improve the living conditions of the inhabitants of the smallest localities.

CRediT authorship contribution statement

Fernando Merino: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing, Visualization, Supervision, Project administration. **María A. Prats:** Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing, Visualization, Supervision, Project administration. **Carlos-Javier Prieto-Sánchez:** Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing, Visualization, Supervision, Project administration.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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