Public aid for ultra-fast broadband development in archipelagos. The Canary Islands case

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Abstract

Purpose – *This paper aims to study the results of the public aid programmes, through supply-side subsidies, for ultra-fast next generation access (NGA) broadband deployment that have been developed in The Canary Islands since 2013. These findings will, in turn, hopefully help the policymakers of archipelagos define their own ultra-fast broadband development plans.*

Design/methodology/approach – *An empirical approach has been used, based on the observation of the historical results obtained in the archipelago and the way broadband was diffused throughout the territory.*

Findings – *Results show that the broadband has developed asymmetrically in the archipelago, which, in turn, has caused the onset of a triple spatial digital divide. It was also observed that some aspects of the current way that such programmes are created and, consequently, the way that public funds are allocated, that could be improved and might help prevent geographical discrimination. Lastly, several insights have been presented for further investigation.*

Originality/value – *A large amount of scientific research has been carried out studying ultra-fast broadband NGA networks deployment. Less literature can be found on this topic when considering the specificities of fragmented territories like archipelagos. This paper tries to contribute with some empirical insights about such specific scenarios.*

Keywords *Broadband deployment programmes, Digital divides, Public aid, Supply-side subsidies, Ultra-fast broadband, Archipelagos, Insular and fragmented territories*

Paper type *Case study*

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1. Introduction

Information and communications technologies (ICT), including its infrastructures, constitute a primary factor for the development of small and medium-sized enterprises (World Bank, 2016), making possible the social and economic improvement of countries, both developed (Castaldo *et al.*, 2018) and developing ones (Esselaar *et al.*, 2007; Shirazi *et al.*, 2009). This, in turn, contributes to the well-being of its inhabitants (Mbuyisa and Leonard, 2017). On the other hand, broadband internet access development and diffusion have a direct positive effect on economic activity (Van Gaasbeck, 2008), gross domestic product (GDP) and GDP per capita growth (Czernich *et al.*, 2011). In addition, it contributes to labour productivity (Katz, 2012; Tu and Sui, 2011), employment generation (Kolko, 2012) and efficiency in enterprises (Bertschek *et al.*, 2013).

However, broadband deployment is capital-intensive, with the costs of network roll-out in rural areas being higher than in urban or suburban ones (Flacher and Jennequin, 2014) because they are remote (Grubesic and Murray, 2004), fragmented and sparsely populated (Malecki, 2003). Moreover, not only do rural areas require more significant investments to be covered (Elixmann *et al.*, 2008); but also they have a smaller market niche that produces

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a lower revenue per unit of customer if compared with urban areas (Grubesic, 2010), so those investments have a longer pay-back period (Soldi *et al.*, 2016). Taking into account all of the above and considering that territories are covered only when they are profitable (Flacher and Jennequin, 2014), the result is that private Telco operators are more motivated to roll-out in areas with higher economic capacity and greater population density than in others (Abrardi and Cambini, 2019; Calzada *et al.*, 2018).

In consequence, there are territorial disparities in the opportunities to access ICTs, not only between rural and urban areas but also between zones within the same rural area (Rendon Schneir and Xiong, 2016). These gaps, known as spatial digital divides, have negative impacts upon personal and business lives (Philip *et al.*, 2017) and can be a barrier to economic growth (Kos-Łabędowicz, 2017), rendering rural development unsustainable and lopsided (Erdiaw-Kwasie and Alam, 2016).

Considering the above, it is desirable and convenient that governments and public administrators get involved in creating the appropriate environment to bring connectivity to those territories where the market, left to its own devices, fails to match supply and demand. With this in mind, over the past few years, a large amount of scientific research has been carried out that supports the decision to state intervention in telecommunication markets (Cave and Martin, 2010; Gómez-Barroso and Pérez-Martínez, 2005), emerging that the direct and indirect social and economic benefits of broadband investment (Briglauer *et al.*, 2019) outweigh their cost (Gruber *et al.*, 2014) and that regulatory tools (Cambini and Jiang, 2009), public aid programmes (Briglauer and Gugler, 2013) and other governmental actions (Kyriakidou *et al.*, 2013) are good instruments to foster network roll-out and broadband diffusion in underserved areas.

Less literature can be found on this topic when considering the specificities of fragmented territories like archipelagos (Sutherland, 2012). In an attempt to contributing empirical insights about such specific scenarios, this paper studies the state of ultra-fast next generation access (NGA) broadband roll-out in the Canary Islands, a Spanish archipelago situated near the north-west coast of Africa and one of the outermost regions of the European Union (EU).

The remainder of this paper is structured into five sections. Firstly, data sources and methodology adopted are described. In Section 2, to contextualize, a short introduction of the Archipelago along with a brief description of European and Spanish legal and regulatory frameworks on broadband development is presented. In Section 3, the evolution of ultra-fast NGA broadband coverage in the Canary Islands is shown, since 2014. This task has been accomplished at three levels: first, taking the archipelago as a whole and comparing it with mainland Spain; second, looking at the islands individually and comparing them to each other; and third, reviewing data at municipal level. As explained further on, an asymmetric broadband development has been found, showing that the Archipelago suffers from different spatial digital divides in every one of these three levels. In Section 4, the results of various public aid programmes given through supply-side subsidies, for ultra-fast NGA broadband deployment are evaluated. Section 5 concludes drawing up some ideas on how these programmes can be modified to eliminate the aforementioned imbalances and help better allocate the public funds. Finally, some insights are pointed out for further investigation to be carried out that might help the policymakers of archipelagos define their own ultra-fast NGA broadband development plans.

2. Methodology and data

2.1 Data sources

All data used in this analysis was obtained from official sources. National level economic and demographic data has been retrieved from the Spanish National Institute of Statistics (INE), while the same data at regional and island level has been collected from the Canary

Islands Institute of Statistics and from the Government of the Canary Islands. Geographic data has been gathered from the Spanish National Geographic Institute (IGN).

Broadband coverage data has been retrieved from the Spanish State Secretariat of Telecommunications (State Secretariat) that reports to the Ministry of Economic Affairs, while market and competition data comes from the National Commission on Markets and Competition (CNMC), the Spanish National Regulatory Authority (NRA).

Lastly, information about the Spanish broadband deployment plan and the Canary Islands broadband deployment plan comes from the Ministry of Economic Affairs and the Canary Islands Observatory of Telecommunications and Information Society (OCTSI), respectively.

2.2 Methodology

First, and foremost, an initial investigation on broadband development has been carried out using the databases of Web of Science, Scopus and Science Direct. Different papers where reviewed to identify similarities and conclusions that apply to the case of the Canary Islands.

Data gathering was then carried out from the sources mentioned above, taking into account the following considerations. On the one hand, the State Secretariat collects data directly from each Telco operator and obtains the joint coverage using an aggregation methodology that considers a total network overlap. This methodology assumes that every Telco deploys in the central part of each population centre and then extends its network to the outlying areas. This may lead to an underestimation of coverage, especially in larger locations. With this information, the State Secretariat publishes, on a yearly basis, a report of broadband coverage in Spain, containing data at the municipal level. The figures are given in steps of 10%, so it is not possible to conclude the exact percentage of coverage. To ease the analytical process the middle value of each range was taken. The number of households per population centre is retrieved from the municipal ratios and housing census published by INE.

On the other hand, all Telco operators are obligated to send to the CNMC the details of their subscribers on a weekly basis. With this information, the CNMC prepares monthly and quarterly reports summarising data at national level and a yearly report, which contains detailed data at province level. The number of subscriber's lines, penetration and market share has been collected from this last report.

Finally, data has been analysed and interpreted to determine its signification and implications to broaden knowledge on the subject.

3. Background

3.1 The Canary Islands archipelago

The Canary Islands is a Spanish autonomous community, consisting of an archipelago in the Atlantic Ocean, situated near the north-west coast of Africa more than 1,000 km from mainland Spain. It is one of the outermost regions of the EU, according to the Treaty on the Functioning of the European Union (TFEU) Figure 1.

The archipelago is divided into two provinces, namely, Las Palmas and Santa Cruz de Tenerife. The first one, Las Palmas, is formed by the inhabited islands of Gran Canaria, Fuerteventura, Lanzarote and La Graciosa (a former islet, which has acquired the status of island, as the approval of the reform of the Statute of Autonomy of the Canary Islands on the 5 November 2018). The second one, Santa Cruz de Tenerife, is formed by the islands of Tenerife, La Gomera, La Palma and El Hierro. The capital of the archipelago is shared between the islands of Gran Canaria and Tenerife. Each island has its own capital, except for La Graciosa, which is under the administrative control of Lanzarote.

Figure 1 The Canary Islands archipelago, situated more than 1.000 Km from mainland Spain and 100 Km from the west coast of Africa

Source: Google (2020)

Hereinafter in this document, Tenerife and Gran Canaria will also be referred to as main islands, while the rest (Fuerteventura, Lanzarote, La Palma, El Hierro, La Gomera and La Graciosa) will also be referred to as peripheric islands Table 1.

3.1.1 Brief socio-economic description of the Canary Islands. The Canary Islands is the 13th largest Spanish autonomous community by area; the eighth in population, highly concentrated in the metropolitan areas of the capital and the touristic areas of each island; and the third in population density. The archipelago has a population of 2,127,685 inhabitants (2018), distributed in 88 municipalities, with a total of 1,196 population centres. The average population density of the archipelago is 286 inhabitants per Km^2 Table 2.

In 2017, the contribution made by the Canary Islands to the Spanish GDP was €44,206m, which places the economy of the Archipelago in number 8 in reference to the whole country. In terms of nominal GDP per inhabitant, that year was € 20,425, which meant 79% of the average GPD per inhabitant of Spain, being € 25,800 Table 3.

The economy of the Canary Islands is highly focussed in the service industry where, according to EXCELTUR (2017) report, tourism accounts for 35.2% of the overall GDP and 40.3% of employment. Analysing the contribution of the productive sectors to the gross added value, various things stand out; the importance of the third sector, the reduced weight of the manufacturing industry (5%) and the limited presence of the primary sector (1%).

3.1.2 Broadband in the Canary Islands. This sub-section details the broadband coverage provided by terrestrial networks in the Canary Islands and the position occupied by the archipelago when compared to the rest of autonomous communities of Spain. According to

Table 1 The Canary Islands provinces, islands and their capitals

Capital of archipelago	*Provinces*	*Islands*	*Capitals of the islands*
Shared between Santa Cruz de Tenerife (Tenerife) and Las Palmas de Gran Canaria (Gran Canaria)	Santa Cruz de Tenerife	Tenerife	Santa Cruz de Tenerife
		La Palma	Santa Cruz de La Palma
		La Gomera	San Sebastián de La Gomera
		El Hierro	Valverde
	Las Palmas	Gran Canaria	Las Palmas de Gran Canaria
		Lanzarote	Arrecife
		Fuerteventura	Puerto del Rosario
		La Graciosa	–

Source: Self-elaborated

Table 2 Demographic data of the Canary Islands (2018)

Islands	*Municipalities*	*Population*	*Surface (Km^2)*	*Population density (inh/Km^2)*
Tenerife	31	904,713	2,034.38	445
La Palma	14	81,863	708.32	116
La Gomera	6	21,136	369.76	57
El Hierro	3	10,798	268.71	40
Gran Canaria	21	846,717	1,560.10	543
Lanzarote	7	148,449	845.95	175
Fuerteventura	6	113,275	1,659.74	68
La Graciosa	–	734	24.05	31
TOTAL	88	2,127,685	7,446.95	286

Source: ISTAC (2019a)

Table 3 Economic data of the Canary Islands (2017)

GDP (million €)	*Annual growth rate (%)*	*GDP/inh (€)*	*Unemployment rate (%)*	*RPI (%)*
44,206	3.63	20,425	19.99	1.4

Source: ISTAC (2019b)

the last report of June 2018 on broadband coverage by the Spanish State Secretariat of Telecommunications, fast broadband coverage ($\geq$ 30 Mbps) in the archipelago was of 76.8%, while ultra-fast broadband coverage ($\geq$ 100 Mbps) was 74.6%, both at quite some distance from the national average coverage, which were 85.1% and 80.9%, respectively (State Secretariat of Telecommunications, 2019). Table 4 shows the information classified by technology and Table 5 classified by download speed. Table 6 shows coverage by type of population centre according to the number of its inhabitants. The coverage provided by satellite networks must be added to these figures, which guarantees basic broadband access to all citizens, regardless the place of residence.

On the other hand, last CNMC report of the broadband market in Spain shows that, although having a percentage of coverage below national average, the Canary Islands has good broadband penetration (CNMC, 2019). This shows a higher willingness of the citizens of the Canary Islands to have broadband services despite its lower availability. Table 7 shows broadband penetration figures, while Table 8 shows the number of existing broadband connections.

Finally, if you look at fixed broadband market share by telecommunication operator, the CNMC report shows that, in comparison to the rest of Spain, the Canary Islands presents a

Table 4 Broadband coverage in the Canary Islands by technology. Position compared to the rest of Spanish autonomous communities (2018)

Technology	*Coverage in the Canary Island (%)*	*Average coverage in Spain (%)*	*Position of the Canary Islands (out of 19)*
ADSL ≥ 2 Mbps	84.3	89.8	16th
ADSL ≥ 10 Mbps	59.4	71.7	17th
VDSL ≥ 30 Mbps	9.8	11.8	17th
HFC	32.2	48.9	15th
FTTH	74.1	77.4	10th
Fixed wireless ≥ 2 Mbps	21.8	59.8	13th
Fixed wireless ≥ 30 Mbps	5.7	11.4	9th
UMTS/HSDPA (3.5 G)	99.9	99.9	12th
LTE (4 G)	99.8	99.5	8th

Source: State Secretariat of Telecommunications (2019)

Table 5 Broadband coverage in the Canary Islands by speed. Position compared to the rest of Spanish autonomous communities (2018)

Fixed broadband speed	*Coverage in the Canary Islands (%)*	*Average coverage in Spain (%)*	*Position of the Canary Islands (out of 19)*
≥ 2 Mbps	92.4	97.6	17th
≥ 10 Mbps	85.9	92.5	17th
≥ 30 Mbps	76.8	85.1	15th
≥ 100 Mbps	74.6	80.9	15th

Source: State Secretariat of Telecommunications (2019)

Table 6 Broadband coverage in the Canary Islands by speed and type of population centre according to the number of inhabitants. Compared to Spain average (2018)

Fixed broadband speed	*Population (inhabitants)*									
	100,001 to 500,000 (%)	*50,001 to 100,000 (%)*	*20,001 to 50,000 (%)*	*10,001 to 20,000 (%)*	*5,001 to 10,000 (%)*	*2,001 to 5,000 (%)*	*1,001 to 2,000 (%)*	*501 to 1,000 (%)*	*101 to 500 (%)*	*< 100 (%)*
≥2 Mbps	99.3	100	95.2	94.4	91.6	92.2	88.6	79.7	70.9	44.6
Spain average	100	99.3	99.2	98.4	98.5	98	96.7	94	87.2	62.9
≥10 Mbps	99.3	10	90.1	88.9	87.5	84.3	74	60.5	46.8	28.7
Spain average	99.9	97.6	96	94.8	94.6	92.8	86.2	76.3	54.2	23.6
≥30 Mbps	99.3	100	90.1	83.9	72.7	73.2	52.5	33.8	22.3	10.7
Spain average	99.9	97.5	93.9	88.1	82.4	67.3	54.6	47.5	34.7	12.6
≥100 Mbps	99.3	100	90.1	83.6	69.4	68.4	47.3	28.2	18	9.3
Spain average	99.9	97.4	92.3	85.7	78	57.2	35.2	23.7	15.6	5

Source: State Secretariat of Telecommunications (2019)

more concentrated market. The incumbent operator possesses the biggest proportion of market share compared to the rest of the country (59.5% in the Canary Islands vs 39.7% the rest of Spain). This is not a surprise as other small island states and territories of Europe show similar imbalances (Sutherland, 2012).

3.2 European Union legal and regulatory framework

In the EU, telecom markets regulation is based on competition principles. It combines *ex-ante* measures and obligations, with *ex-post* control and supervision of market behaviour. This model was first introduced in the 1990s, when the openness and liberalization of former national telecommunication's monopolies started in the EU (Cave *et al.*, 2019). The main idea of EU framework is the intervention by NRAs when a Telco operator has a position of

Table 7 Broadband penetration in the Canary Islands by technology. Position compared to the rest of Spanish autonomous communities (2018)

Technology	*Penetration in the Canary Islands (%)*	*Average penetration in Spain (%)*	*Position of the Canary Islands (out of 19)*
Fixed broadband	32.9	33.5	8th
xDSL	9.5	8	5th
FTTH	19.8	18.7	8th
HFC	3	5.2	15th

Source: CNMC (2019)

Table 8 Active broadband connections in the Canary Islands (2018)

Territory	*Total*	*xDSL*	*(%)*	*HFC*	*(%)*	*FTTH*	*(%)*	*Other*	*%*
Spain	15,176,954	3,743,409	24.7	2,431,559	16	8,735,172	57.6	266,814	1.8
The Canary Islands	717,312	205,928	28.7	64,367	9	431,825	60.2	15,192	2.1

Source: CNMC (2019)

significant power in a market, obligating it to provide access to its network to other operators willing to compete in that market (Intven, 2000). When a certain level of competition is reached, the NRAs should de-regulate the market (Briglauer and Gugler, 2013) and monitor the behaviour of it, actuating only when the preservation of effective competition is threatened, but keeping in mind that once at this point, a variation in regulation may diminish the investment in infrastructure made by incumbent operators (Grajek and Röller, 2012).

When the broadband market, left to its own devices, fails to match supply and demand, and results in significant inequalities (market failure), state intervention is justified (Gómez-Barroso and Pérez-Martínez, 2005). That is why this legal and regulatory framework needs to define the right measures and conditions to correct those market failures, guaranteeing access to secure and trustworthy electronic communications infrastructure and services for every EU citizen as a way to reduce the digital divide. To do so, the EU framework allows Public Administrations to intervene to ease investments in new infrastructure roll-out, but ensuring not to displace private investments of market players (Cambini and Jiang, 2009). Here is where the EU Guidelines for the application of state aid rules in relation to the rapid deployment of broadband networks, published in the Official Journal of the EU with reference 2013/C 25/01, take the leading role.

These Guidelines establish the criteria to evaluate if a state aid scheme designed to develop or accelerate broadband coverage is compliant with Article 107 of the TFEU and, therefore, does not adversely alter competition. In brief, the measures must contribute to the achievement of common interest, incentivising the investment where a market failure exists and minimising the distortion of market competition, all of it done transparently and limiting the aid to the minimum necessary. To do so, the Guidelines distinguish between white, grey and black areas. White areas are those where no network is present and is not likely to be built within three years; grey areas are those where only one network exists or is going to be deployed in the coming three years; black areas are those where at least two different networks exist or will be deployed in the coming three years (European Commission, 2013). White areas can receive state aid for NGA deployment, while no public funds can be invested in black areas. Grey areas need a more detailed assessment by the European Commission to evaluate the existence of a market failure that justifies state intervention. That is why it is mandatory to have a reliable broadband map. This topic will be discussed in Section 3.5

The Guidelines also establish that the selection of beneficiaries should be done using a competitive process, giving an adequate publicity using a central web page at national level. Finally, the Guidelines determine that, wherever possible, nationwide framework should exist, to guarantee that all public interventions carried out (state, regional or municipal) are coordinated, coherent and not duplicated.

On the other hand, the Commission Regulation (EU) N° 651/2014, of 17 June 2014, establishes that aid for broadband network deployment shall be compatible with the internal market of the EU when the general conditions listed in its Chapter 1 are fulfilled. The requirements of its Article 52 also need to be met. This implies that only investments in passive infrastructure, civil engineering works and network deployment in white areas shall be considered eligible costs. It also implies that the aid must be allocated on the basis of a transparent and open non-discriminatory competitive selection process and respecting the principle of technology neutrality. Telecommunications operators being beneficiaries of the aid shall offer active and passive wholesale access for at least seven years and right of access to ducts and poles during their expected life, with prices based on a pricing model set by the NRA (European Commission, 2014).

Finally, Directive 2014/61/EU of the European Parliament and the Council, of 15 May 2014, defines a series of measures to reduce the cost of high-speed broadband roll-out. These measures promote efficient coordination of civil works, a simpler permit-granting procedure and the joint deployment and use of physical passive infrastructure, including in-building ones (European Parliament, 2014).

3.3 Spanish legal and regulatory framework

The Spanish telecommunications retail market is fully liberalized, with the CNMC taking the role of NRA and the State Secretariat of Telecommunications, under the authority of the Ministry, legislating (García Paramio *et al.*, 2016; García Paramio *et al.*, 2018). The State Secretariat also leads the public policies for telecommunications promotion, including broadband roll-out and development (Spanish Government, 2014).

Complying with the EU Guidelines, some instruments and procedures have been developed in Spain. First, a map of black and white areas. Second, to avoid duplications and to guarantee that all interventions are coordinated, every Public Administration willing to develop its own actions to foster network roll-out must apply for a report from the State Secretariat. This report, whose conclusions are legally binding, will decide on the compatibility with the map of the white areas referred to before and with the national broadband plans. In addition, third, a CMNC report is also required, regarding wholesale prices and third-party access to the infrastructures that will be built with the public aid (Spanish Government, 2015).

3.4 Spanish public aids scheme for broadband infrastructure deployment

The Digital Agenda for Europe (DAE) emerged in May 2010, following the Lisbon strategy and was conceived as one of the seven flagship initiatives of the Europe 2020 strategy (European Commission, 2010). One of its main targets is to promote broadband deployment as a tool for social inclusion and development competitiveness in the EU. Three of its 14 key objectives were defined to measure the degree of progress in that field:

1. Basic broadband for all Europeans by 2013.
2. Fast broadband (> 30 Mbps) for all Europeans by 2020.
3. In total, 50% of European homes subscribed to ultra-fast broadband (> 100 Mbps) by 2020.

One of the 10 political priorities of the European Commission for the future of Europe and part of the DAE is the so-called European Digital Single Market strategy. It was adopted on the 6 May 2015 and reviewed on the 10 May 2017. Its aim is "to generate a digital single market where the free movement of goods, persons, services, capital and data is guaranteed and where citizens and businesses can seamlessly and fairly access online goods and services, whatever their nationality and wherever they live" (European Commission, 2015). The execution of different measures within the framework of the DAE has contributed to cover every Member state of the EU with basic broadband (2013). The objectives established for NGA networks are also about to be fulfilled by 2020.

To take the next step, the European Commission proposed in September 2016 a set of initiatives and legislative proposals to ensure the best possible internet connection for every EU citizen. One of the initiatives, the strategy on Connectivity for a European Gigabit Society (European Commission, 2016), establishes a new group of targets for the Digital Single Market to be fulfilled by 2025:

- Availability of Gigabit connectivity (download/upload speeds of 1 Gbps) for all principal socio-economic drivers such as public authority buildings, schools, transport hubs and business parks, through investment in very high-capacity networks.
- Uninterrupted 5G coverage for all urban areas and major terrestrial transport paths.
- At least 100 Mbps download speed internet access for all European households, rural or urban. Access must be upgradable to 1 Gbps.

At the national level, the Digital Agenda for Spain (DAS) was approved by the Council of Ministers on the 15 February 2013, to establish the strategy to achieve the above-mentioned objectives of the DAE. The first of the six areas detailed in the DAS aims to promote the deployment of ultra-fast broadband infrastructures to develop networks and services to guarantee digital connectivity (Spanish Government, 2013). With this purpose, the Ministry of Industry, Tourism and Energy has been providing, since 2013, public aid for NGA networks deployment in Spanish white areas. Through this plan, called PEBA-NGA, the Spanish state has allotted a total amount of nearly €500m from the period from 2013 to 2018, of which almost 25 m were earmarked for projects to be developed in the Canary Islands (Ministry of Industry, n.d.).

Although it can be concluded that it has been an effective instrument to foster broadband deployment, the PEBA-NGA has resulted in the asymmetric diffusion of broadband in the Archipelago, leaving some islands with less coverage than others. This phenomenon takes relevant importance in the peripheric islands of the Archipelago (Fuerteventura, La Palma, Lanzarote, El Hierro and La Gomera). For this reason, the Canary Islands Government launched in 2016 his own broadband plan, focussed on white areas situated in those islands where the state plan has been less successful (OCTSI, 2018).This topic will be discussed in Section 4.

3.5 Broadband mapping

As it has been said before, to ensure that state aid for broadband is compatible with the internal market of the EU, it is mandatory to have a detailed map where reliable information is shown about the geographic areas that will be covered by the support measure in question (European Commission, 2013). The process of collecting, processing and presenting data related with broadband mapping can be classified as follows (Arnold *et al.*, 2014):

- *Infrastructure mapping*: Focussed on mapping available infrastructures (ducts, chambers, poles, etc.) to reduce costs in further deployment of broadband networks.

- *Investment mapping*: Focussed on visualisation of financing sources and instruments for broadband project funding.
- *Service mapping*: Focussed on mapping the actual broadband coverage and existing investment plans of Telco operator. It also deals with the presentation of broadband services in terms of available bandwidth, quality of service and technologies. This type of broadband mapping is key for the purpose of the identification of white, grey and black areas.
- *Demand mapping*: Focussed on presentation of demand and take-up of broadband services.

There are different approaches to carry out this mapping, each with its pros and cons (Arnold *et al.*, 2014). In general, they suffer from the same core problem: difficulties to achieve a perfect representation of the market and excessive dependency on Telco operators inputs (Johnson, 2011). Some countries such as Denmark [1] or the UK [2] gather, process and represent data at postal code level. Others such as Germany [3] or Sweden [4] do it by dividing the territory in a grid of 250 x 250 metres cells. In addition, others such as France [5] or Spain [6] do it using local administrative units. In the Spanish case, the local administrative unit used is a type of population centre called singular population entity (SPE). A SPE is a habitable area of the municipality, clearly identified on the ground and known by a specific name that identifies it without possibility of confusion. A municipality might be composed of one or more SPEs.

To elaborate the Spanish broadband map, the State Secretariat carries out every year a two-phase process. First, it collects, from all the Telco operators that provide services in Spain, detailed information of their coverage and their deployment plans for the coming three years. They are obliged to respond by article 10.1 of Law 9/2014, General of Telecommunications (Spanish Government, 2014). With this information, the State Secretariat prepares a preliminary map of black areas. Second, this preliminary map is subjected to public consultation open to all stakeholders to verify its accuracy and completeness. Once all of the issues raised into the public consultation are resolved, the State Secretariat publishes the definitive broadband map, with a final list of population centres classified in black, grey and white areas.

4. The Canary Islands broadband development

4.1 National scope: first spatial digital divide

The last European Commission study on broadband coverage in Europe shows that ultra-fast broadband, capable of speeds above 100 Mbps, is available in 55.1% of EU28 households. Spain appears in ninth position, with a coverage of 83.6% of Spanish households, well above the European average (Point Topic and IHS Markit, 2018). As stated above, the Canary Islands figures in ultra-fast broadband coverage (74.6%) are below the national average (80.90%), with the Archipelago in position number 15 when compared with the rest of Spain's Autonomous Communities.

Interestingly, when taking into consideration the population, there are 11 Spanish provinces, out of the total 50, smaller than Santa Cruz, which have better household coverage; 10 in Las Palmas. When we observe population density, numbers seem even worse: up to 15 provinces with lower population density than Santa Cruz have a better percentage of household coverage; 13 in the case of Las Palmas. What's more, up to eight provinces with lower GDP than Santa Cruz de Tenerife have a better percentage of household coverage; whereas 10 in Las Palmas. Furthermore, if you look at GDP per capita, there are eight provinces with lower GDP per capita than Santa Cruz that have better household coverage; seven in the case of Las Palmas. Finally, up to 20 provinces with a higher percentage of

rural municipalities have a better household coverage than Santa Cruz de Tenerife; whereas in the case of Las Palmas 15.

On the other hand, as mentioned in Section 3.1.2, the incumbent Telco operator holds a higher share of the market in the Canary Islands than in the rest of Spain (59.5% vs 39.7%). This situation has been historically the same, showing a less competitive market in the archipelago (Figure 3).

In conclusion, broadband coverage in the Canary Islands has historically been lagging behind, showing the existence of a first spatial digital divide, between the archipelago and mainland Spain (74.6% vs 80.90% in 2018, Figure 2).

4.2 Islands scope: second spatial digital divide

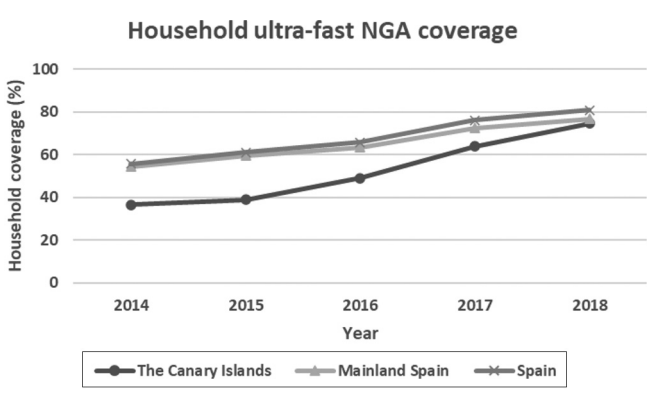
According to the last available report "Broadband Coverage in Europe 2018" (Point Topic and IHS Markit, 2019), prepared for DG Communications Networks, Content and Technology, there is a substantial presence of NGA networks on the main islands of the archipelago (Tenerife 88.8% and Gran Canaria 91.0%), with a household coverage above that year's national average (80.9%).

Lanzarote is a particular case because it is the only island, apart from the two main ones, where an HFC broadband network exists, since the 1990s, which covers almost all the capital of the island. As expected, the presence of this cable competitor has had a positive effect, increasing the percentage of NGA household coverage in the island (82.1%) (Höffler, 2007; Nardotto *et al.*, 2015).

The figures in the rest of the peripheric islands are not as good: Fuerteventura, La Gomera and La Palma covered less than half of the households (45.6%, 38.1% and 39.0%, respectively), while El Hierro barely achieved that mark, showing in mid-2018 a household coverage of 55.0%.

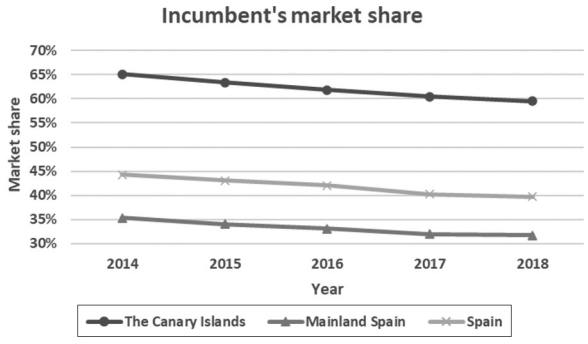
The main islands also show better figures in their capitals municipalities when compared with their equivalents in the peripheric islands (94.56% vs 79.02% coverage in 2018). The same can be said of the remaining municipalities (72.52% vs 32.87% coverage in 2018) Figure 5.

Figure 2 Household fixed ultra-fast NGA coverage. Comparative between the Canary Islands, mainland Spain and country average. The Canary Islands historically lags behind mainland Spain



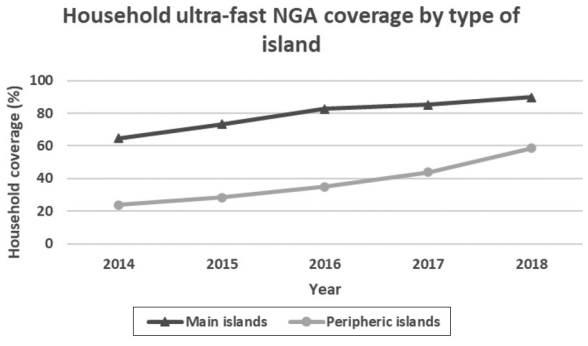
Source: Self-elaborated from INE (n.d.) and State Secretariat of Telecommunications (n.d.) data

Figure 3 Incumbent's market share. Comparative between the Canary Islands, mainland Spain and country average. The Canary Islands presents worse figures than mainland Spain, with a highly concentrated and, thus, less competitive market



Source: Self-elaborated from CNMC (n.d.) data

Figure 4 Household fixed ultra-fast NGA coverage by type of island. Comparative between main islands (Tenerife and Gran Canaria) and peripheric islands (La Gomera, El Hierro, La Palma. Fuerteventura and Lanzarote). Peripheric islands historically lag behind main ones



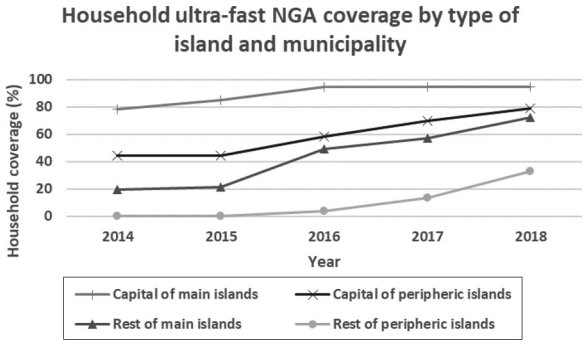
Source: Self-elaborated from DG Communications Networks (n.d.) and INE (n.d.) data

In conclusion, there is a second spatial digital divide, between the two main and most populated islands of the archipelago and the rest (89.9% vs 58.5% coverage in 2018, Figure 4).

4.3 Municipal scope: third spatial digital divide

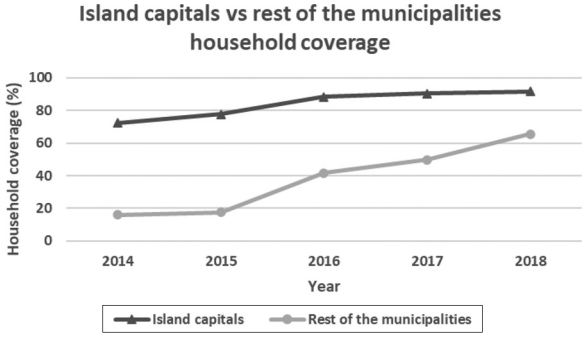
The State Secretariat publishes, every year, a report of broadband coverage in Spain. Although the report contains data at the municipal level, it is shown in ranges of 10 percentage points, so it is not possible to conclude the exact percentage of coverage. In any case, it is enough to make a comparative of household coverage figures taking into account the type of municipality. Figure 6 compares the 7 island capitals with the rest of the municipalities, showing a gap of coverage between them (91.76% vs 65.65% coverage in 2018).

Figure 5 Household fixed ultra-fast NGA coverage by type of island and municipality. Figures are historically better in main islands (Tenerife and Gran Canaria), either in capital municipalities or in non-capital municipalities



Source: Self-elaborated from INE (n.d.) and State Secretariat of Telecommunications (n.d.) data

Figure 6 Household fixed ultra-fast NGA coverage by type of municipality. Figures are historically better in the island capitals than in the rest of the municipalities



Source: Self-elaborated from INE (n.d.) and State Secretariat of Telecommunications (n.d.) data

To determine when a municipality can be considered rural, the most frequently used criterion is population density. In line with that provision, Spanish Law 45/2017, of the 13 December 2017, for sustainable development of the rural areas, define an area to be rural when its population density is lower than 100 inhabitants per Km^2 and its population lower than 30,000 inhabitants (Spanish Government, 2017). With these criteria, the Canary Islands presents a distribution of rural municipalities as shown in Table 9.

Figure 7 compares household coverage in rural municipalities with household coverage in urban municipalities showing the existence of a gap between them (79.45% vs 27.57% coverage in 2018).

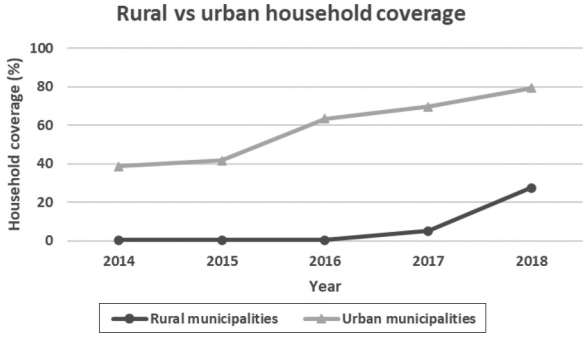
On the other hand, the last State Secretariat report, of April 2019 that summarizes the situation of June 2018, shows that there are 41 municipalities in the archipelago, out of 88,

Table 9 Rural municipalities in the Canary Islands and their population (2018)

Island	*Total Municipalities*	*Rural municipalities*	*Urban municipalities*	*Population in rural municipalities (%)*	*Population in urban municipalities (%)*
Tenerife	31	4	27	1.9	98.1
La Palma	14	9	5	35.1	64.9
La Gomera	6	5	1	79.2	20.8
El Hierro	3	3	0	100.0	0.0
Gran Canaria	21	3	18	1.3	98.7
Lanzarote	7	4	3	33.4	66.6
Fuerteventura	6	5	1	64.9	35.1

Source: Self-elaborated from ISTAC (2019a) and IGN (n.d.) data

Figure 7 Household fixed ultra-fast NGA coverage by type of municipality. Figures are historically better in urban municipalities than in the urban ones



Source: Self-elaborated from INE (n.d.), State Secretariat of Telecommunications (n.d.) and IGN (n.d.) data

that have an ultra-fast NGA broadband coverage above 50%. These municipalities are mostly located in the main islands of the archipelago (Tenerife and Gran Canaria) and only three of them are rural. Table 10 shows the distribution by island.

Moreover, in 2018 there were 22 municipalities in the archipelago with no coverage of ultra-fast NGA broadband networks, of which 77.27% of them are rural. In total, 13 of these 22 municipalities are located in the peripheric islands of La Gomera, La Palma, Lanzarote and Fuerteventura. In fact, 100% of the municipalities with no ultra-fast coverage in the peripheric islands are rural. On the other hand, there are 41 municipalities with more than 50% ultra-fast NGA coverage, of which 92.68% of them are urban. Nearly 83% of these 41 municipalities are located in the main islands (Tenerife and Gran Canaria). From those located in the peripheric islands, 71.43% are urban. These figures, put together, indicate the existence of a third digital divide, between the most densely populated areas and the rural areas of each island.

5. Development of public aids for broadband deployment in the Canary Islands

The aforementioned PEBA-NGA programme has been, since 2013, the most important Spanish public initiative designed to achieve the broadband objectives established in the DAE. The aid is given, in a combination of subsidy and reimbursable loan, to roll-out projects in white areas that have been previously identified by the State Secretariat in a

Table 10 Municipalities with an ultra-fast broadband coverage over 50%; municipalities with and ultra-fast broadband coverage between 1% and 50%; and municipalities with no ultra-fast NGA coverage (2018)

	No. of municipalities					
NGA coverage	*100%–51%*	*Rural (%)*	*50%–1%*	*Rural (%)*	*0%*	*Rural (%)*
Island						
Tenerife	22	1 (4.55)	5	1 (20)	4	2 (50)
La Palma	1	0	5	1 (20)	8	8 (100)
La Gomera	1	0	3	3 (100)	2	2 (100)
El Hierro	2	2 (100)	1	1 (100)	0	0
Gran Canaria	12	0	4	1 (25)	5	2 (40)
Lanzarote	2	0	4	3 (75)	1	1 (100)
Fuerteventura	1	0	3	3 (100)	2	2 (100)
Total	41	3 (7.32)	25	13 (52.00)	22	17 (77.27)

Source: Self-elaborated from State Secretariat of Telecommunications (n.d.-b) data

public consultation [7]. The rest of the funding, up to the total amount of project investment, is provided by the Telco operators themselves. This state aid is compatible with the internal market of the EU and is granted under Article 52 of Commission Regulation (EU) N° 651/2014, cases number SA.48000 [8] and SA.35834 [9], so it only permits investments in passive infrastructure, civil engineering works and network deployment.

At the beginning, the programme distinguished between networks capable of download speeds higher than 100 Mbps (Line A of the aid scheme) and those only capable of lower speeds (from 30 Mbps to 100 Mbps, Line C). There was also a Line B, to finance projects destined not to deploy access networks but to act at backhaul level. However, because of the development of NGA networks coverage in Spain, since 2017, only Line A projects are considered.

For the whole country, in the period of 2013-2018 this Line A has mobilized €347m in public aids to NGA networks roll-out projects that covered more than 4.77 m households located in 7,600 population centres that were formerly white areas. In the particular case of the Canary Islands, in the same period, 18 projects received up to €20.8m in public funding to deploy NGA networks that covered more than 600 population centres. The total investment in the Canary Islands was nearly €45.5m, which means that private investment provided by the Telco operators themselves amounted to €24.7m Table 11.

To decide, which project to fund, the Ministry evaluates each proposal using a set of criteria that take into account not only technical issues but also the socio-economic impact. From all these criteria, the most important one is the cost per user: the lower it is, the more points you get. Only the best scored project in a certain white area obtains public funds, so Telco operators must compete with each other to be the chosen one. Benefits of this model arise as the number of competitors increases, resulting in more white areas covered with lower investment. However, in such territories such as the Canary Islands, with a highly concentrated market (59.5% of total market share is of the incumbent, Telefónica), these benefits tend to fade, as in almost all cases only the incumbent applied for funding. This lack of competition has made the PEBA-NGA in the Canary Islands too dependent on the incumbent deployment plans, with the result that the two main islands have concentrated more than 65% of the white areas of the archipelago where public initiative has been developed since 2014[10] (Figure 8).

Figure 8 shows that the proportion of projects in the peripheric islands has grown significantly only when the percentage of aid has reached the minimum of 55% of the project's eligible costs. This increment in the percentage has also had a positive impact in the total number of white areas covered by each call, as can be seen in Figure 9.

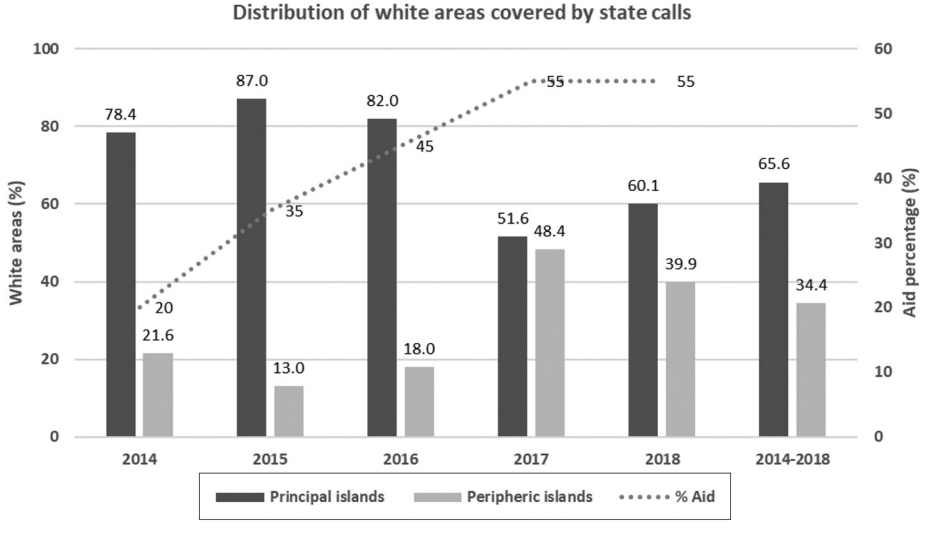
Despite this, Figures 8 and 9 also show that Telco operators participating in the state calls still prefer to roll-out their network in the two main islands of the Archipelago (Tenerife and

Table 11 PEBA-NGA projects developed in the Canary Islands

Year	*Project name*	*Public funds (€)*	*Total investment (€)*	*Aid (%)*	*Premises covered*
2014	TSI-061000–2014-040	567,884.00	2,771,028.00	20	27,398
2015	TSI-061000–2015-041	1,309,184.00	3,741,596.00	35	36,900
2015	TSI-061000–2015-042	1,171,065.00	3,346,855.00	35	20,767
2015	TSI-061000–2015-043	1,055,155.00	3,015,591.00	35	28,774
2016	TSI-061000–2016-129	1,214,146.00	2,698,103.00	45	14,444
2016	TSI-061000–2016-130	1,192,774.00	2,650,609.00	45	6,622
2016	TSI-061000–2016-133	1,113,424.00	2,474,277.00	45	12,248
2016	TSI-061000–2016-135	1,286,673.00	2,859,275.00	45	21,990
2016	TSI-061000–2016-136	146,780.00	326,177.00	45	2,437
2017	TSI-061000–2017-0180	1,258,893.00	2,288,898.00	55	8,274
2017	TSI-061000–2017-0182	551,256.38	1,002,284.34	55	3,052
2017	TSI-061000–2017-0183	1,286,556.00	2,339,193.00	55	5,438
2017	TSI-061000–2017-0185	561,457.83	1,020,832.41	55	3,233
2018	TSI-061000–2018-258	1,336,250.00	2,429,547.00	55	7,598
2018	TSI-061000–2018-262	1,857,557.00	3,377,378.00	55	10,512
2018	TSI-061000–2018-274	1,963,999.00	3,570,908.00	55	15,153
2018	TSI-061000–2018-275	2,039,682.00	3,708,514.00	55	5,281
2018	TSI-061000–2018-277	976,332.00	1,775,150.00	55	12,318
Total	18	20,889,068.23	45.396.215,75		242,444

Source: Self-elaborated *from* Ministry of Industry (n.d.) data

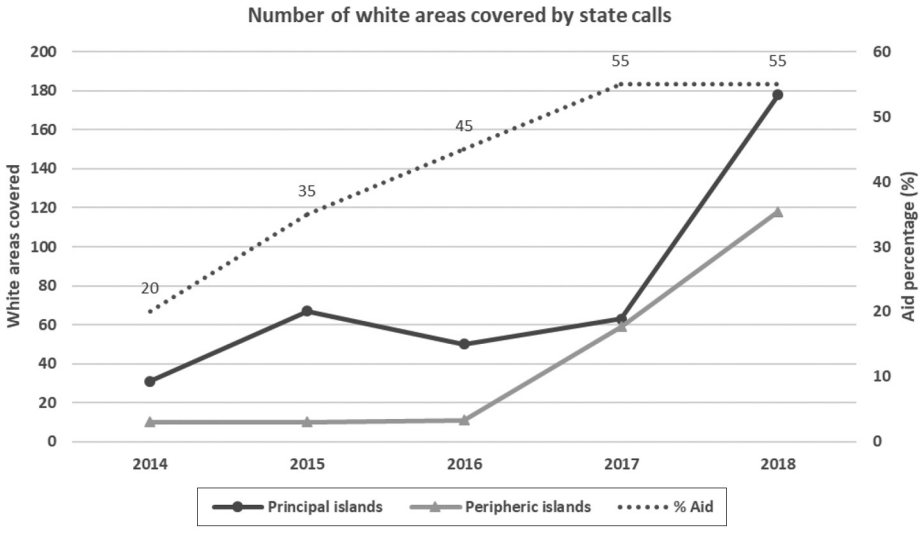
Figure 8 Distribution of white areas covered by each state call from 2014 to 2018. In dark the main islands (Tenerife and Gran Canaria) and in light the peripheric islands (El Hierro, La Gomera, La Palma, Lanzarote and Fuerteventura). The dotted line represents the percentage of aid



Source: Self-elaborated from Ministry of Industry (n.d.) data

Gran Canaria), which definitely shows that market size and population density is of the utmost importance in their deployment strategies (Calzada *et al.*, 2018). These islands are closer to commercial profitability than the peripheric ones because they have greater population density (Table 2) and more market niche living in the urban areas (Table 9), so they generate a higher revenue per unit of customer if compared with rural areas (Grubesic, 2010) and, thus, have a shorter pay-back period (Soldi *et al.*, 2016).

Figure 9 Total amount of white areas covered by each state call from 2014 to 2018. In dark the main islands (Tenerife and Gran Canaria) and in light the peripheric islands (El Hierro, La Gomera, La Palma, Lanzarote and Fuerteventura). The dotted line represents the percentage of aid



Source: Self-elaborated from Ministry of Industry (n.d.) data

Trying to minimize this circumstance, the Canary Islands Government launched in 2016 its broadband plan focussed solely on white areas of the peripheric islands (OCTSI, 2018). The plan gave funds, via non-refundable subsidies that covered up to 85% of total eligible costs, to roll-out ultra-fast NGA networks in 85 white areas of La Gomera, El Hierro[11], Lanzarote, Fuerteventura and La Palma[12]. This state aid is compatible with the internal market of the EU and was granted under Article 52 of Commission Regulation (EU) N° 651/2014, case number SA.46165 Table 12[13].

These calls were coordinated with the state ones through the mechanisms mentioned in Section 3.3 (Spanish Government, 2015), so they used the same list of white areas, identified by the State Secretariat in the correspondent year public consultation[14]. The state call was launched several months before the one of the Canary Islands Government: five months earlier in 2016 and eight months earlier in 2017. This implies that applicants to the state call prepared their offers without knowing that there was going to be another call at the local level and, therefore, proposed for the first call those white areas that best-fitted roll-out costs, percentage of aid given and their commercial interest.

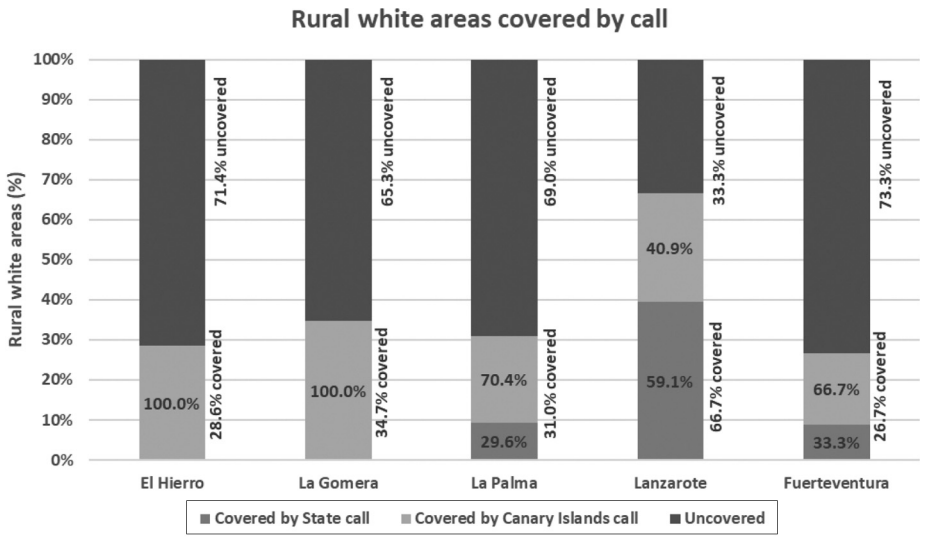
Comparing the results of the calls in the same year in terms of rural white areas covered and rural and sparsely populated white areas covered, it can be seen that, in almost all cases, the call in the Canary Islands covered a higher percentage of them than the state call did (Figures 10 and 11).

Table 12 The Canary Islands government projects developed

Year	*Project name*	*Public funds (€)*	*Total investment (€)*	*Aid (%)*	*Islands*	*Premises covered*
2016	2016_BA_01_TESA	1,993,333.30	2,345,098.00	85	El Hierro and La Gomera	9,717
2018	2018_BA_01_TESA	1,588,984.06	1,869,393.01	85	La Palma, Lanzarote and Fuerteventura	3,660
TOTAL	2	3,582,317.36	4,214,491.01			13,377

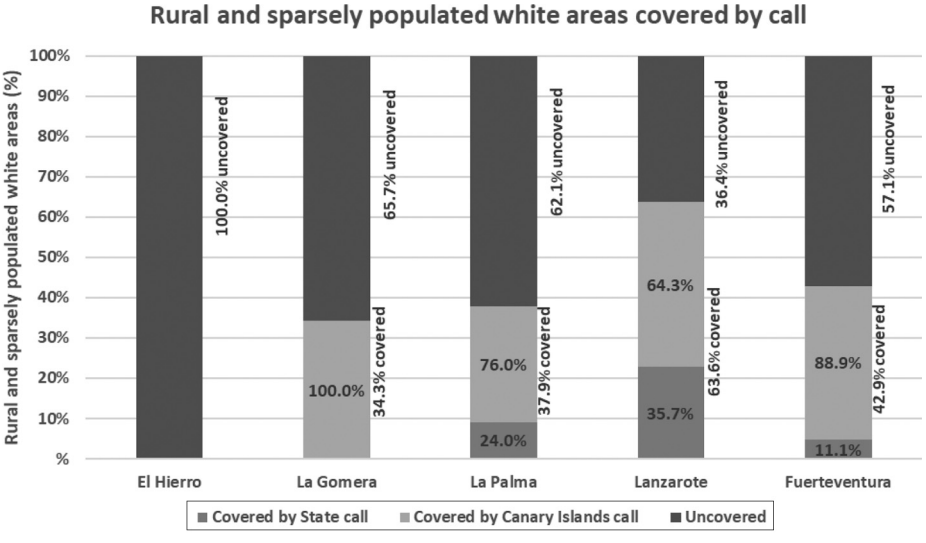
Source: Self-elaborated from OCTSI (n.d.) data

Figure 10 Distribution of rural white areas of each island covered by state call (medium grey) and the Canary Island's call (light grey) from 2016 to 2018. In dark grey, uncovered white areas



Source: Self-elaborated from Ministry of Industry (n.d.), OCTSI (n.d.), INE (n.d.) and IGN (n.d.) data

Figure 11 Distribution of rural and sparsely populated white areas of each island covered by state call (medium grey) and the call of the Canary Islands (light grey) from 2016 to 2018. In dark grey, uncovered white areas



Source: Self-elaborated from Ministry of Industry (n.d.), OCTSI (n.d.), INE (n.d.) and IGN (n.d.) data

The two main differences between both calls (state and local) were the way the budget was allocated (total archipelago vs islands) and the percentage of aid given (55% vs 85%). These results support the idea that assigning public funding at the island level is a good practice to force the development of roll-out projects on desired islands. In addition, also that good results in rural, sparsely populated and, thus, less profitable areas, require to be supported by significant financial public sums, via a higher percentage of aid, in line with Feijóo *et al.* (2018) conclusions.

5.1 White areas determination

As mentioned above, the EU Guidelines for the application of state aid rules in relation to broadband deployment, demands a mapping exercise, to detect areas affected by a market failure and to serve as a basis to the planning of public instruments to foster broadband roll-out (Arnold *et al.*, 2014). In the case of Spain, as mentioned in Section 3.5, the State Secretariat has been doing this exercise via a yearly public consultation in which they gather information from all Telco operators, which are obliged to provide by article 10.1 of Law 9/2014, General of Telecommunications.

In line with Johnson (2011) insights, granularity is one of the issues to be faced. In Spain, data is geographically aggregated at the level of local administrative units [15]. This granularity is insufficient in large population centres because it does not allow the identification of underserved areas within them.

According to Table 13, there are 62 population centres in the archipelago with more than 1,000 inhabitants that have an NGA broadband coverage between 1% and 50% and, thus, are not white areas. These population centres bring together 208,393 inhabitants (10% of total population of the archipelago). In total, 38 of those population centres are located in the peripheric islands with more than 68% of them being part of rural municipalities. This means that at least 99,376 inhabitants of rural areas of the peripheric islands have no access to NGA broadband services and live in population centres that cannot benefit from public aid for broadband deployment because they are not white areas. It is the 26.5% of the population of the peripheric islands.

To fill these gaps, a more accurate representation of reality is necessary, which can be achieved through gathering the data with a more detailed level of spatial resolution, at least in large population centres. Different approaches to do this can be found, from exact spatial level to aggregated spatial level (Arnold *et al.*, 2014). One of the best practices for countries lacking small-scale administrative units (as Spain) is to divide the territory in a grid of cells of 250 x 250 metres to do the broadband mapping exercise (Arnold *et al.*, 2014; Asociados, 2014).

Another area for improvement is data quality checking, as a way to reduce the misidentification of underserved areas. Table 14 summarizes an analysis made of the 23

Table 13 Population centres with more than 1,000 inhabitants and an ultra-fast NGA coverage between 50% and 1% (2018)

Island	*> 10,001 inhabitants*	*Rural (%)*	*10,000-5,001 inhabitants*	*Rural (%)*	*5,000-1,000 inhabitants*	*Rural (%)*
Tenerife			2	0	13	2 (15.38)
La Palma					16	6 (37.50)
La Gomera			1	1 (100)	1	1 (100)
El Hierro					1	1 (100)
Gran Canaria			1	0	8	1 (12.5)
Lanzarote	2	1 (50)	2	1 (50)	5	5 (100)
Fuerteventura	1	1 (100)	3	3 (100)	6	6 (100)
Total	3	2 (66.67)	9	5 (55.56)	50	22 (44)

Source: Self-elaborated from State Secretariat of Telecommunications (n.d.-b), INE (n.d.) and IGN (n.d.) data

Table 14 Population centres in municipalities with 0% ultra-fast NGA broadband coverage

Island	*Ultra- fast NGA white areas*	*Ultra- fast NGA black areas*	*Changed their status at least twice*	*Black for three or more years*
Tenerife	2	28	3	
La Palma	5	89	6	4
La Gomera	5	24	2	1
Gran Canaria	12	50	5	14
Lanzarote	1	9	2	
Fuerteventura	6	3	2	
TOTAL	31	203	20	19

Source: Self-elaborated from State Secretariat of Telecommunications (n.d.-d, 2019)

municipalities of the Canary Islands that have 0% ultra-fast NGA coverage in accordance with 2019 State Secretariat report:

The analysis made in these 23 municipalities detected two unusual circumstances: first, a total amount of 20 population centres have seen their status changed from black to white and then back again to black at least once. Second, 19 population centres have been considered as black areas for three or more consecutive years, but still have no ultra-fast NGA coverage. If you take into consideration that an area can only be considered black if at least two NGA networks of different operators are present or will be deployed in the coming three years, it is clear that some misidentification has occurred that has caused that the private investment did not take place while at the same time the public intervention was stalled.

This situation can be dealt, on the one hand, with better data quality checks. Although it might demand a lot of effort, involving end users in the public consultation could help to verify the data supplied by Telco operators (Arnold *et al.*, 2014). On the other hand, with certain commitment required by the Telco operators participating in the broadband mapping process (European Commission, 2013). This commitment could combine incentives for those who, at the end of the three years period, achieved significant progress in their deployment plans, with deterrent measures for those who did not. Regardless of hypothetical errors, any breach or unjustified modification of those plans should be avoided. It is not only that this situation can delay for years the arrival of NGA broadband networks to rural and sparsely populated areas but also it is a way to prevent the use of the public consultation as a tool in disputes between telecommunication operators: without dissuasive measures, a Telco can declare a false interest in a certain zone not to deploy its network there but to prevent others from receiving public funds.

6. Conclusions and lessons learned from the Canary Islands

A large amount of scientific research has been done regarding the positive impact that broadband diffusion has over countries and their societies and economies. Those countries where telecom regulation is based on competition principles must develop mechanisms to allow Public Administrations to intervene when market failure occurs. As outlined in this paper, those broadband market failures tend to appear in rural and sparsely populated territories. As it has also been explained, things can get worse in archipelagos such as the Canary Islands, where a triple spatial digital divide has appeared: first, between the whole archipelago and the mainland territory (74.6% vs 80.90% coverage in 2018, Figure 2); second, between the main and most populated islands and the remaining (89.9% vs 58.5% coverage in 2018, Figure 4); and third, between the urban and the rural areas of each island (79.45% vs 27.57% coverage in 2018, Figure 7).

The European framework on broadband development establishes when a public intervention is considered to comply with state aid rules. Among other considerations commented in this paper, the public intervention must be executed in white areas, those where no network is present and is not likely to be built within three years. These areas have

to be geographically identified in a public consultation. The funds must be allocated using a competitive process and only investments in passive infrastructure, civil engineering works and network deployment, shall be considered eligible costs.

The benefits of this scheme are more evident as the number of competitors increase, but in cases of insular and fragmented territories such as the Canary Islands, with a highly concentrated market (incumbent's market share of 59.5% in 2018, Figure 3), state efforts to foster broadband development have had asymmetrical results (Figures 8 and 9). In these cases, the empirical conclusions of this study support the idea that a good practice to achieve fairer results and to bridge the triple spatial digital divide, is to establish a staggered scheme. In this scheme, the percentage of aid to be given can be used as a tool to allot sufficient public funds to force the development of roll-out projects in islands and areas where it is less interesting for the private initiative (Figures 10 and 11). This will prevent these islands and areas from having a delayed deployment compared to the rest of the archipelago.

On the other hand, the process of white areas identification can also be improved to prevent an uncovered area to be considered black for long time. First, incorporating tools to increase granularity and accuracy when determining the status of an area. In addition, second, using a combination of incentive and deterrent measures to avoid unjustified modification of the deployment plans that the Telco operators submit during the public consultation (Section 5.1).

As a continuation of this work, further research is needed. First, of all, to better understand the behaviour of broadband development in archipelagos, a mathematical model has to be constructed and validated with data over a longer period of time. This model has to group, in a single formula, not only the explanatory variables studied in this paper but also other factors like competition. Second, a model to estimate the cost of fixed ultra-fast NGA network deployment in archipelagos should also be designed, taking into account the impact of submarine backbone sections when needed. Identifying a cost per household passed in this type of scenarios would help policymakers define the percentage of public aid necessary to bridge each step of the triple digital divide without crowding out private investment. Also, the way the other archipelagos perform their broadband mapping should be studied, trying to identify points in common and best practices that could be useful to improve the method proposed for the Canary Islands in this paper. On a final note, it should be pursued further research on tools to foster broadband development, like public-private partnerships, demand-side instruments and geographically differentiated regulatory and legal frameworks adapted to archipelagos.

Notes

1. Energy Agency of Denmark (n.d.).
2. OFCOM (n.d.).
3. Federal Ministry of Transport and Digital Infrastructure (n.d.).
4. Post and Telecom Agency of Sweeden (n.d.).
5. French Government (n.d.).
6. State Secretariat of Telecommunications (n.d.-c).
7. State Secretariat of Telecommunications (n.d.-d).
8. DG Competition (2017).
9. DG Competition (2012).
10. In 2013 no project was developed in The Canary Islands.
11. GOBCAN (2016).
12. GOBCAN (2018).

13. DG Competition (2016).

14. State Secretariat of Telecommunications (n.d.-d).

15. The local administrative unit used is a type of population centre called SPE, which is a habitable area of the municipality, clearly identified on the ground and known by a specific name that identifies it without possibility of confusion. A municipality might be composed of one or more SPE.

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Appendix. Highlights

- Broadband deployment in archipelagos can suffer from a triple spatial digital divide.
- Allocating public funds in a staggered scheme helps to bridge spatial digital divides.
- A more accurate method to identify white areas is desirable.

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