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Spread or backwash: The impact on population dynamics and business performance of a new road in a rural county of Galicia (Spain) *

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Abstract

The natural experiment provided by the opening of a section that completed the A8 motorway in *Mariña de Lugo*, a rural area in Galicia (Spain), offers an opportunity to identify whether spread or backwash effects in economic activity are observed. The new section directly affects only a small strip of the territory, - where the transition from the inland rural areas to the more dynamic coastal area takes place. This allows us to test a separate dual inner-coastal socio-economic performance after the opening of the new road – an analysis that has rarely been performed for rural areas in developed countries. We study the impact over population growth, employment and business financial results, using the differences-in-differences approach. The results we obtain are consistent with the spread hypothesis for the nearest municipality to the new road section, while the spread effects did not disseminate to the neighbouring municipalities. These global results hide a different performance at the sector level, positive for transport and manufacturing companies, and negative for retail firms and hospitality.

Keywords: rural development, firm performance, intra-rural divides, DiD, Galicia

JEL Classification: R10, R50, O18, L25

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1. Introduction

Rural areas may benefit from having access to connective infrastructure to urban nodes. The impact of a new transport facility will be positive if it helps commuting to urban centres or the relocation of some business activity to rural areas. However, the new facility might only benefit the distant urban areas it connects, at the expense of accelerating the depopulation process of rural areas in between. The literature of spread and backwash effects à la Myrdal (1957) by urban areas in favour or at the expense of the economic and demographic performance of rural areas is a classic in that sense.

The natural experiment provided by the opening of a new section that completed the A8 motorway in *Mariña de Lugo* – a rural area in Galicia (Spain) – bypassing one of its rural inland municipalities (Mondoñedo), allowed us to study the impact over a series of socio-economic variables – including population growth, employment and business financial results. The objective of our research is to analyse the spread or backwash effects caused by the new infrastructure. We contribute with a case of study of particular interest, for two reasons. First, Galicia is one of the regions in Europe with the worst demographic dynamics and perspectives, particularly in its rural areas. In the territory of analysis, *Mariña de Lugo*, the transition from the inland areas – rural, aged and losing population – to the more dynamic coastal area takes place. Second, the fact that the new section that completes the facility directly affects only a small strip of the territory allows us to analyse the socio-economic effects on some specific rural municipalities.

The research question seeks to identify whether spread or backwash effects are observed for the inland rural municipality bypassed by the opening of the road section, Mondoñedo, as well as for all the inland municipalities in the county of Mariña Central – here to test whether a separate dual inner-coastal performance is observed. To the best of our knowledge, this analysis has rarely been performed for rural areas in developed countries, such as Spain. In Spain, previous works tend to focus more on the environmental and technical impact of the facility. In Galicia, moreover, these analyses are quite outdated now. Thus, we retrieve data from several public and private sources in order to measure, before and after the opening of the new road, population and migration rates, employees enrolled in the Social Security System, number of companies registered, and a set of financial measures of a sample of firms. Using the differences-in-differences approach, we tested for spread or backwash effects following

this logic: the new facility would impact employment and revenues in the treatment group, then affecting migratory flows, hence varying the number of inhabitants.

The structure of the article is as follows. We firstly review the state of arts in the literature of spread and backwash effects over rural areas and in the literature on the impact of new transport infrastructures. In Section 3, we motivate our case of study, the natural experiment provided by the completion of a motorway that runs through an inland rural area, and provide some data about the impact over traffic density in the roads of *Mariña de Lugo* after the opening of the new facility. The methodological approach is outlined in Section 4. In Section 5, we measure the impact of the new road over a series of socio-economic variables, as well as over business demographics and the financial performance of these firms. Finally, Section 6 concludes with some remarks.

2. State of the art

Rural areas that are close or well connected to urban centres often benefit from agglomeration economies, fostering population and employment. Spread effects to the hinterlands are frequent within daily commuting distance, leading to processes of rurbanisation (e.g., Eliasson et al., 2015) where rural areas benefit either from the increased business opportunities that networks with the urban centre offer, or from decentralisation processes where firms and households flee urban congestion and high costs (Partridge et al., 2007). However, peripheral rural areas, particularly those with low population density and weak economic activity, usually experience a backwash effect where people, voting with their feet, choose to move to an urban centre or close to it. Here, rural-to-urban migrants seek either the employment opportunities or the access to urban services that they lack in their rural area of origin. Recent examples of this literature are Veneri and Ruiz (2013) and Berdegué and Soloaga (2018).

The economic factors behind the positive or negative dynamics of rural areas are diverse. They may be summarized as the jobs-versus-people debate in economic development: in some cases, regions grow because firms create jobs and people follow; others, it is people who move to a region for quality-of-life reasons, demand grows, and jobs follow (Partridge and Rickman, 2006; Lavesson, 2017). The concrete developments of such debate are diverse. Examples are the impact of a specific sector (e.g., ecotourism, by Cater, 2002) and of amenities (e.g., Ferguson et al., 2007), the role of human capital (e.g., Corcoran et al. 2010), and the advantage of having good connections to urban areas (e.g., Dijkstra and Poelman, 2008).

In regards to the effects in terms of rural to urban commuting in particular, Partridge et al. (2010) observe that, for some rural areas, access to urban jobs is a key factor to help sustain population, but the impact depends on distance (first) and the size of the urban centre. Rural regions would benefit from economic growth in urban regions, although they compete with each other (Feng and Patton, 2017). According to Olfert and Partridge (2010), resource allocation into higher productivity areas would increase economic growth, improving living standards. Hence, the best practice for rural development would be improving integration (through connective infrastructure) with urban centres in order to access agglomeration economies, enhancing rural amenities, and increasing entrepreneurial capacities.

In this article, we focus specifically on the effects of connective infrastructure. Previous results for the region of Galicia (Martínez-Filgueira et al., 2017) suggest that the rural areas in recovery were helped by the quality of road connections to nearby urban nodes. Rural areas are often poorly connected to transport infrastructure, such that, the benefits of road construction can outweigh total costs, particularly in developing countries (Santos et al., 2010). The efforts to build a quality road network in Galicia over the last three decades, largely funded by European funds, sought to improve the connectivity within the region and with the rest of Spain and Europe. However, the impact of a new infrastructure could as well only benefit the distant urban areas that are now connected, while it gives the *coup de grâce* to the rural zones that it crosses – sometimes because it reduces the number of visitors who stop, some others because the new facility passes them by.

The literature on the impact of new infrastructures is abundant in many scopes of research, but the use of difference-in-differences (DiD) or similar approaches is recurrent. Examples are the impact of public subsidies on new venture creation in Germany (Audretsch et al., 2016), and the impact of investment in new stadiums for the FIFA World Cup 2006 (Feddersen et al., 2009). Particularly in rural areas, Lokshin and Yemtsov (2005) analyse the impact, over the welfare of poor households, of investments on infrastructure rehabilitation for schools, roads and water supply systems in rural Georgia. Dinkelman (2011) studies the effects of rural electrification on employment growth using an instrumental variables strategy and a fixed effects approach.

More specifically, several studies have analysed the impacts of transport infrastructure improvements on territorial inequalities (Jacobs-Crisioni et al., 2016). The natural experiment provided by the opening of a new road or railroad facility, in particular, is a frequent area of analysis. Recent articles that analyse the impact over demographic, economic and business

indicators are in order. The literature is extensive for the impact in developing countries. Khandker et al. (2009) examine the poverty reduction impact of road investment projects in Bangladesh with the use of household surveys collected before and after some rural road improvement programs. Rand (2011) observes a positive effect of a rural road in Nicaragua over employment, which comes from a combination of reduced travel time and better access to markets. Datta (2012) uses the quality improvement in specific highways in India to estimate the impact over days of inventory held by firms though a DiD strategy. In developed countries, Mayer and Trevien (2017) analyse the opening and progressive extension of a new railroad facility in the Paris metropolitan region to measure the impact on firm location, employment, and population growth. Pilgram and West (2018) use a DiD approach to measure the premium over residential property values due to the proximity to a light rail station in Minnesota.

In Spain, and Galicia in particular, there are two early works that analyse the impact of the AP9 motorway – the road that connects the main urban areas along the Atlantic Corridor from North to South to the Portuguese border, the area with the greatest economic thrust and demographic vitality in Galicia. Thus, Pérez Touriño et al. (1997) analyse the impact on employment, added value and productivity, and offer a cost-benefit analysis of the social return of the new facility. More specifically oriented to the impact on commuting and business location, we may find the report by OBECAUDE (2000). A key part of it is a mobility study that, based on a high number of surveys, confirms the existence of intense commuting links between the cities of the Corridor, providing an increasingly cohesive functional area between its urban centres.

In other regions of Spain, the historical analysis by Bel (2011) reveals a long-term pattern of infrastructure policy driven by the desire to centralise transportation around Madrid. This would be related as well with the oversupply in Spain's transport infrastructure (Albalate et al., 2015). Nonetheless, Montolio et al. (2009) obtain evidence that public investment in road infrastructures in Spain has improved productivity. With this basis, the impact of connective infrastructures is analysed in a large number of studies. Focused on the effects on demographics, mobility and business activities in particular, we may find, among others, Fariña et al. (2000), who analyse the impact on population and business location caused by a new motor road and a high-speed railway in rural areas of central Spain. Martín and Nombela (2008) measure the impact of high-speed trains on mobility, suggesting they are expected to capture larger market shares in the future due to travel time savings. Fageda and Gonzalez-Aregall (2017) examine the impact, through spatial econometric methods, of all transport modes on industrial employment in Spain. They find that only ports are able to generate positive effects

overall, while the increase in industrial employment that some regions obtain from new roads often results in less employment in nearby regions. Finally, Albalate et al. (2017) use a DiD approach to test whether high-speed rail services increase the number of tourists at the local level in Spain, only to find extremely weak results or restricted to larger cities. However, to the best of our knowledge, little can be find that focus on rural areas of Spain at a micro level.

Beyond that, another relevant stream of literature is transport economics, more oriented to the impact in terms of accessibility and transport time. These studies frequently require the use of econometric approaches alternative to DiD. Some examples are in order. Jacobs-Crisioni et al. (2016) compare accessibility measures by using a simulation approach, to estimate changes in future population distribution that are consequence of transport investments. Li and Li (2013) use a quasi-experiment based on differential demand for distant suppliers, to identify the causal relationship between road investments and inventory decline. Louw et al. (2013) compare the ex post effects over employment and businesses revenues of a new tunnel opened in the Netherlands with the ex-ante impact estimated by various studies made before the facility was opened. Other studies use alternative accessibility measures (e.g., López et al., 2008; Meijers et al., 2012) and research procedures (e.g., data envelopment analysis by Martin et al, 2004; gravity models by Fageda, 2017, López-Iglesias et al., 2018).

Most academic research agrees that road connections improve territorial cohesion (Stepniak and Rosik, 2013; Jacobs-Crisioni et al., 2016), with peripheral regions being the most benefited (Gutiérrez and Urbano, 1996). High-speed railway connections, on the contrary, accentuate differences in accessibility between regions (López et al., 2008; Martin et al, 2004). However, in general, studies find it easier to observe a direct and immediate impact over market variables (e.g., land prices and property values) than over socio-economic variables such as population or business activities – which require more time and must be accompanied by complementary political, economic and social measures (Fariña Tojo et al., 2000). Thus, Pilgram and West (2018) observe that there is a premium for residential property values due to the proximity to a light rail station, but the premium varies depending how the control group is defined. Firms are also frequently benefited from improved connections. For instance, Datta (2012) finds firms benefited by the opening of the new road significantly reduce inventory holdings. Nonetheless, Louw et al. (2013) find that the impact over employment tends to be lower than expected by the planned studies, while the expectations on business performance tend to be too pessimistic or too positive.

With this background, the purpose of the research that follows is to provide new insights on the socio-economic effects of a new road infrastructure. We seek to contribute with a series of specificities. Thus, the opening of a small section that completes the road and directly impacts over a small strip of the territory allows us to analyse the socio-economic effects on some specific rural municipalities. Moreover, to the best of our knowledge, this analysis has rarely been performed for rural areas in developed countries, such as Spain. In Spain, previous works tend to focus more on the environmental and technical impact of the facility. Furthermore, Galicia is an interesting case where to study the socio-economic impact of new roads in rural environments, since this is one of the regions in Europe where rural areas face worse demographic perspectives. With the subsequent analysis, we seek to confirm some of the previous results in the literature, namely, the impact of the new road infrastructure on the financial results of the companies that operate in these areas, then the impact over employment, and, as a result, on migration and population growth rates.

3. Case of study. Motivation

We use the natural experiment provided by the opening, in *Mariña de Lugo* (Galicia, Spain), of a section that completes the A8 motorway, an infrastructure that connects Galicia – the NUTS 2 region in the northwest of Spain where *Mariña de Lugo* falls – with the French border. This infrastructure improved the road connection of the inland rural area of that territory, while it avoided the forced drive through it to any users of the motorway.

3.1 Mariña de Lugo

Mariña de Lugo is a coastal and rural area of the province of Lugo, a rural NUTS 3 region according to the Eurostat urban-rural typology, following DEGURBA standards.[1] The province falls in the North West of Iberian Peninsula (Galicia and North of Portugal), where all NUTS 3 regions but the city of Porto (Portugal) are classified as rural or intermediate. Figure 1 below maps Galicia and the complete route of the A8 motorway.

The macro-region of Galicia and North of Portugal is paradigmatic in Europe in terms of demographic decline. The last Eurostat Regional Yearbook 2017 (Eurostat, 2017) shows that the North-West of Spain and North of Portugal face the worst rates of population change – below -6.0 per thousand inhabitants –, a pronounced ageing and among the lowest fertility rates

[1] Source: http://ec.europa.eu/eurostat/statistics-explained/index.php?title=Territorial_typologies. Last access, June 2019.

in Western Europe. Moreover, Galicia has historically lagged Spain in terms of population and GDP growth, persistently losing relative weight. According to Eurostat statistics, the GDP per capita by 2015 was 79.4% of the EU-28 average in PPS terms, down from 92.3% in 2009.[2] The statistics for rural areas are even worse: Galicia experienced a late and abrupt agricultural sector decline, reducing its share in total employment from 70% in 1950 to less than 5% today, which lead to a strong decrease in rural population. The intense external migration in the period 1950-1975 was only comparable to that recorded by Ireland, Southern Italy and, to a lesser extent, by some regions of central and southern Spain (Aldrey, 2006), contributing to a stagnation of the regional population and to growing internal imbalances between rural and urban areas (López Iglesias, 1995). In *Mariña de Lugo*, these imbalances have a peculiarity: the transition from the inland areas – rural, aged and losing population – to the more dynamic coastal area, with demographic indicators similar or above the Galician average, takes place within a small strip of land of barely 20 km. We identify this territory as the highlighted rectangle in Figure 1, which includes 15 municipalities divided into 3 of the 53 counties in Galicia:

- The county of *Mariña Occidental* ("West coast"), which includes four municipalities in the coast (Cervo, O Vicedo, Viveiro, and Xove) and an inner municipality (Ourol).
- The county of *Mariña Central* ("Central coast"), with two coastal (Burela and Foz) and four inner municipalities (Alfoz, Lourenzá, Mondoñedo, and O Valadouro), where the new section of the motorway was opened.
- The county of *Mariña Oriental* ("East coast"), with two coastal (Barreiros and Ribadeo) and two inner municipalities (A Pontenova and Trabada).

The total extension is 1,400 km^2, for a total population of 72,000 inhabitants by year 2016 – about 5% of the surface of Galicia, but less than 3% of its population. It is a territory of complex natural and socioeconomic structure, with high internal diversity. Thus, population settlement is characterized by an average population density about 50 inhab/km^2 that hides a contrast between the coastal area (91 inhab/km^2, similar to the Galician average) and the depopulated inner municipalities, with an average density of 21 inhab/km^2. This is the result of disparate population growth performances over the last century, as it is shown in Figure 2. Almost 80% of the population lives in the coastal municipalities today, while population growth is clearly negative for inner municipalities, losing almost 45% of its population since year 1981.

[2] Source: Eurostat statistics – GDP at regional level, http://ec.europa.eu/eurostat/statistics-explained/index.php/GDP_at_regional_level#Regional_GDP_per_capita. Last access, June 2019.

The socioeconomic diversity is also shown through the sectoral structure of the different municipalities. Table 1 summarizes sectoral data of gross value added (GVA) at county level, as well as the employment structure at municipality level, measured by the percentage of employees enrolled in the Social Security System in the different activities. By GVA, it stands out the weight of electricity and metal products in the Mariña Occidental. Nonetheless, this is due to the presence of a factory of Alcoa, the U.S. aluminium producer, in the municipality of Cervo. Indeed, when measured in terms of employment, this difference is much smaller. Mariña Central, where the new section of the motorway was opened, shows greater weight of primary sector and public services, and lower in industrial activities (compared to Mariña Occidental) and in market services (compared to Mariña Oriental). In any case, these differences are moderate, especially if we compare Mariña Central with the other two Mariñas together (which later in our analysis will be used as one of the control groups).

In addition to the duality between coast and hinterland, a distinctive feature of *Mariña de Lugo* is that it lacks of a dominant urban centre, resulting in a diverse economic and social profile of several villages along the coast with different economic specialisations (AGADER, 2008). Figure 2 shows this urban sprawl in year 2015, where we may particularly observe the strong dispersion of rural habitat. The duality between a rural hinterland in decline and coastal urban sprawl is a distinctive profile of *Mariña de Lugo* recognized in the Galician Planning Guidelines (Xunta de Galicia, 2011). These guidelines recommend strengthening a dozen of Galician small towns of between 7,000 and 40,000 inhabitants. However, they offer a different suggestion for *Mariña de Lugo*, based on two axes. First, it defines an urban corridor with the villages of Viveiro (12,900 inhabitants by year 2016) to the West, and Ribadeo (6,900 inhabs.) to the East as main nodes, and, in the middle, the villages of Foz (6,100 inhabs.) and Burela (9,500 inhabs.) as secondary nodes. Second, the articulation of this urban system is based on two routes: the A8 highway on one hand, and the roads and railway along the coast on the other. The A8 highway is the main structuring facility, providing connections southbound with the city of Lugo and the Atlantic Corridor (the main urban axis of Galicia), and eastbound with the neighbouring region of Asturias, the North of Spain, to the French border. On its turn, the N-634 and N-642 national roads (in red in Figure 2), as well as the FEVE railroad, are high-quality facilities for local commuting purposes, helping to configure the coastal urban sprawl with a more integrated urban profile.

3.2 The opening of the new facility

The A8, also known as Transcantabrian, is one of the largest free-of-charge motorways in Spain, running 468 kilometres along the coast of the Cantabrian Sea in the North of the country. It connects the regions of Galicia, Asturias, Cantabria and Pais Vasco. There, nearby Bilbao, it becomes a toll motorway that connects these regions of Northern Spain with France and the rest of Europe. On the other side, to the West, the A8 runs through *Mariña de Lugo* to end joining the A-6 – also one of the largest motorways in Spain, connecting Galicia with Madrid – (see Figure 1).

Until 2014, the A8 was not finished on its way through *Mariña de Lugo*. A section of barely 20 kilometres near the municipalities of Mondoñedo and Lourenzá were to be finished between years 2012 and 2014. This implied that, before 2014, drivers along the A8 highway needed to leave track and drive along the N-634 road through the town of Mondoñedo. To illustrate, the daily transit density on the roads of *Mariña de Lugo* by year 2012, collected from different official bodies, is described in Figure 3. Mobility by road was structured along two axes, one running along the coast and connecting the most populated villages, the other running inlands nearby Mondoñedo (a municipality of barely 4,000 inhabitants by that date), connecting Galicia with the North of Spain.

Then, on February 2014 the last section to be completed in Galicia was opened, from Abadín to Lourenzá, running top of the hills of *Alto do Fiouco* in the municipality of Mondoñedo (Mariña Central). Despite the fact that the opening was marred by temporary closures due to fog, the new section completed the road infrastructure, allowing drivers to go from the urban areas of Galicia to Asturias, and vice versa, making it unnecessary to leave track and drive through the town of Mondoñedo. Hence, the new facility affected the municipality of Mondoñedo in first instance and nearby inner municipalities of Mariña Central in second term. The impact of the new facility might result in spread or backwash effects in this area depending on whether positive effects outweigh the negative. In a nutshell, positive effects might come from: (1) commuting, because it improves the possibility of living these municipalities, while working or having access to services in the coastal urban corridor and in the city of Lugo; (2) stimulating the location of new companies due to the improved connectivity with Lugo, the Atlantic Corridor, and other regions of Northern Spain. Negative effects, on its part, might basically come from drivers who used to pass by and stop and now they will not. Therefore, the backwash effects are expected to affect specific sectors, such as hospitality and retail trade. Figure 4 provides the impact over traffic density on the main roads of Mariña de Lugo, between

years 2012 – two years before the opening of the new facility – and 2016 – two years after. See Table A1 in the Appendix for further detail.

Traffic density in the main roads, under the supervision of the Spanish Ministry of Infrastructure, increased 27.5% on average (20.2% without considering the new section opened), comparing the average figures for years 2015 and 2016 with those for 2012 and 2013. However, this average performance hides large divergences between the alternative routes. As expected, since the new section is aimed at improving connectivity, diversion led to a positive impact on traffic density on the A8 (+41.5%), while inland areas concentrate the negative change, particularly in the inner Mariña Central, including the alternative route to A8 along the N-634 road nearby Mondoñedo (-10.4%). Average traffic densities of coastal roads along the urban sprawl increased, although moderately, while inland secondary roads under the supervision of the regional Galician Government) barely lost traffic (-3.0%), but hiding significant variance.

4. Methodology

The research question is whether the impact of the new facility over the municipality of Mondoñedo and the other inner municipalities in the county of Mariña Central, is positive or negative. We measure the impact over a set of variables of socio-economic and business performance. Following our reasoning in the previous section, regarding the sources for positive and negative impacts of the new facility, the resulting spread or backwash effects would obey the following logic. The potential socio-economic effects would impact the dynamics of employment in first instance. Then, these dynamics would affect migratory flows, and this would end up influencing the evolution of the number of inhabitants. Consequently, we will first focus on the impact over population growth, emigration rates, and employment growth, and then we will explore the impact over business demographics and financial performance. The goal is to test whether the inland municipalities of Mariña Central – the ones that might directly benefit from the opening of the new facility, but also face the traffic decrease along the former route in use – have experienced a spread or backwash effect since year 2014.

The fact that the opening affected the traffic along the alternative N-634 road through the rural hinterland of Mariña Central, while leaving the coastal area of *Mariña de Lugo* basically unaffected, allows for a difference-in-differences (DiD) estimation strategy. DiD is implemented as a regression with pooled cross sections with appropriately chosen interactions

(Woolridge, 2010). Being *A* the control group, and *B* the treatment group (here, the municipalities directly affected by the opening of the new road), we may denote *dB* a dummy variable that equals one for individuals in the treatment group, and *dT* a dummy variable that equals one for the post-policy period. Then, the simplest equation to analyse the impact of the policy change would be

$$y = \beta_0 + \beta_1 dB + \delta_0 dT + \delta_1 dT dB + \mu \quad (1)$$

The coefficient of interest is δ_1, which measures the policy effect for those in the treatment group in the post-policy period. The OLS DiD estimator for δ_1 has a simple interpretation: it compares the time changes in the means for the treatment and control groups, such that both group-specific and time-specific effects are allowed for (Woolridge, 2010):

$$\hat{\delta}_1 = \left(\bar{y}_{B,2} - \bar{y}_{B,1}\right) - \left(\bar{y}_{A,2} - \bar{y}_{A,1}\right) \quad (2)$$

where $\bar{y}_{I,T}$ represents the sample average of *y* for group *I* over period *T*, *I*=*A*,*B*, *T*=1,2.

The regression approach will be implemented when dealing with the impact of the new facility over the financial performance of a large set of companies in *Mariña de Lugo*. However, if we wish to compare the impact over socio-economic variables, we only have data at the municipal level. That leaves a statistical approach unsound, since we have four 'individuals' in the treatment group (the inner municipalities in Mariña Central), or even only one (if we wish to compare the effect for Mondoñedo). Instead, there we will use a non-statistical approach where we directly compute the OLS estimator for two regions – the treatment and control groups – over years 2010 to 2012 for the pre-policy period and years 2015 to 2017 for the post-policy period. In DiD estimations, the control group includes all the municipalities in *Mariña de Lugo* but those in the treatment group.

To improve the reliability of the results, we offer three alternative estimations. First, use an alternative time frame, 2010-2013 and 2014-2017, to check if the results are robust to the periods immediately before and after the opening of the road (year 2014). Second, we perform similar estimations for Mondoñedo alone, to check whether the impact was similar to the

municipality most closely affected by the opening of the road. Third, we perform a difference-in-difference-in-differences (DiDiD) estimation. Using both a control group within the treatment county and the other counties (Mariña Occidental and Mariña Oriental) as control groups, we would have:

$$y = \beta_0 + \beta_1 dB + \beta_2 dE + \beta_3 dBdE + \delta_0 dT + \delta_1 dTdB + \delta_2 dTdE + \delta_3 dTdBdE + \mu \quad (3)$$

where *dB* is a dummy variable that takes value equal one for county *B* (Mariña Central), the one that implements the "policy" (i.e., the one affected by the new road), and zero otherwise (*A*, the other two counties), and *dE* is a dummy variable that takes value equal one for inland municipalities (*E*) and zero otherwise (*N*, for coastal municipalities). The OLS estimate for the coefficient on the triple interaction term, δ_3, would be (Woolridge, 2010):

$$\hat{\delta}_3 = \left[\left(\bar{y}_{B,E,2} - \bar{y}_{B,E,1}\right) - \left(\bar{y}_{B,N,2} - \bar{y}_{B,N,1}\right)\right] - \left[\left(\bar{y}_{A,E,2} - \bar{y}_{A,E,1}\right) - \left(\bar{y}_{A,N,2} - \bar{y}_{A,N,1}\right)\right] \quad (4)$$

We must be aware that the time horizon considered is limited since the complete opening of the new section in 2014. Therefore, the potential socio-economic effects of the new facility are expected to be revealed only partially. Moreover, year 2014 coincides with the turning point in the economic situation in Galicia and Spain. The period immediately before, years 2012-2013, the economy hit bottom with a second recession, while the period immediately after the opening of the new facility, years 2015-2016, corresponds to the start of an economic recovery after the crisis.[3] Consequently, the validity of the control group may be undermined if the sectoral structure of the municipalities (e.g., coast vs. hinterland) were so different as to expect the impact of the economic upturn to favour some municipalities over others. As provided in Table 1, the differences in sectoral structure between the treatment and control groups – i.e., between the inland and coastal municipalities of Mariña Central, as well as with the other two counties – are moderate, and of diverse sign in any case (because the structures of the control

[3] For further information on the macroeconomic situation of the Galician economy by years 2012 to 2016, we recommend Foro Económico de Galicia (2018). Data show that in 2012-2013 the Galician economy (as well as the Spanish economy as a whole) hit bottom, with annual GDP rates of -3.5% by the end of year 2012 and negative rates until the last quarter of year 2013. Unemployment rate in Galicia peaked in year 2013, 21.6% by the third quarter. Then, a recovery begun from year 2014, with positive GDP rates that consolidated in subsequent years, with annual GDP rates of about +3.0% from year 2015 to 2018. Unemployment rate steadily decreased, down to 16.3% in year 2016 and 12.2% in year 2018.

groups are heterogeneous as well). Therefore, we do not see why these differences would severely affect the results we obtain. Nonetheless, we must reckon this as a limitation of the study that follows.

5. Results

We measure the impact at three different levels: socio-economic, business demographics, and business financial performance.

5.1 Socio-economic impact

Using data by the Spanish National Statistics Institute (INE), the impact over the annual average growth rate of the total residents in the treatment and control groups, as well as the annual average growth rate of the migratory balance and the number of employees enrolled in the Social Security System, using the alternative estimations above described, is summarized in Table 2. We must be aware that the number of employees enrolled in the Social Security System is provided according to the municipality of residence of the worker. Consequently, this variable would suffice to reveal the two positive sources of socio-economic impact of the new facility: namely, the location in the area of new companies that create jobs, and the improvement of commuting that allows more residents in the area to work in other municipalities.

All DiD measures show a positive impact for Mondoñedo in terms of the three socio-economic variables analysed, with robust results if measured for the alternative time frame. Since employment data considers the municipality of residence of the worker, the results suggest that the logic for the potential socio-economic effects above described is valid. That is, the impact on employment was positive, either because more firms located in Mondoñedo and created jobs, or because more people chose to live in Mondoñedo and work in other municipality due to improved commuting. As a consequence, the impact on migration flows would be positive, and this would result in an increasing total population.

Instead, the results for the four inner municipalities in Mariña Central are only positive in terms of population growth, negligible in terms of migration rates, and negative in terms of employment.[4] These results are difficult to interpret: if the impact on employment was negative

[4] These results are robust to alternative measures of migration and employment. Thus, as regards migrations, we alternatively considered to measure net migrants to/from other municipalities of Galicia, but only emigration (departures) to other regions of Spain and abroad. The reason for this is that most immigrants from Spain and abroad

and on migration negligible, this would indicate that the socio-economic effects were not significant or negative and, consequently, the positive results for population dynamics would not be relevant in socio-economic terms. It seems population dynamics here respond more to changes in vegetative balances, although the brief time horizon available might have influenced the results. Nonetheless, all results are robust to alternative estimations – either DiD or DiDiD – and to alternative time frames. This analysis is complemented with a statistical test of the difference in means, for data at the municipal level, using an unpaired Welch test. Results are offered in Table 3 below: in particular, the positive impact in terms of population would be statistically significant.

To sum up, we saw on the map in Figure 5 that, of the four inland municipalities of Mariña Central, only Mondoñedo and Lourenzá were directly affected by the opening of the A8, while Valadouro and Alfoz are more distant to the facility. Moreover, the road sections from Lourenzá to the coast were already opened before 2012, so it might be that the direct effects over this municipality were to be observed earlier. The results we obtain suggest that the observed socio-economic impact is positive at all levels for Mondoñedo, while the effects did not spread to the other three municipalities.

5.2 Business demographics

Rural areas usually face worse perspectives in terms of business development and entrepreneurship, due to the lack of agglomeration economies. However, self-employment has been positively associated with income growth, and promoting entrepreneurial capacities would be among the best economic development strategies for rural and lagging regions (Stephens and Partridge, 2011; Stephens et al, 2013). The purpose of this section is to analyse the impact of the opening of the new road over the business demographics, to observe whether the inner municipalities in Mariña Central, and in particular the municipality of Mondoñedo, were positively affected by the new facility.

The growth rate in the total number of firms registered in the *Mariña de Lugo*, according to the Galician Statistics Institute (IGE), is compared for the treatment and control groups, before and after the new road section was opened. Since data is at the municipal level, the methodology we use is similar to the one described in the previous Section, using a non-statistical approach

to rural areas of Galicia are former Galician migrants that come back when retired –hence, these flows do not obey to local economic conditions. In addition, in terms of employment, we alternatively considered excluding the employees enrolled in the Social Security System in agriculture and fishing sectors – since employment in these sectors is strongly affected by demographic factors (independent of economic dynamics). In both cases, however, the results obtained with these alternative data are similar.

where alternative time frames, treatment groups (Mondoñedo and the Inner Mariña Central), and methodologies (DiD and DiDiD) were used for robustness. Finally, we also compare the results for the most representative economic sectors in the area. The results are summarized in Table 4. For ease of interpretation, only results that are robust to alternative time frames are provided.

The analysis shows that the impact over the total number of firms was positive for Mondoñedo and, although to a lesser extent, for all the inland municipalities of Mariña Central. A sectoral analysis helps to better clarify the impact of the A8 motorway over the local economy. Indeed, the differences by sector are revealing: as we anticipated, backwash effects are observed in sectors that are more oriented to local demand – hospitality, retail trade – which would be impaired by the reduced number of drivers that passed by and stop, while a positive impact is observed in the transport sector, benefited by the new facility. The latter positive effect is the strongest in quantitative terms, with an average increase in number of transport companies of Mondoñedo of 14.4% in relative terms, compared to the control groups. Finally, and for Mondoñedo in particular, there is also evidence of a positive impact over the manufacturing sector and over professional activities.

5.3 Business financial performance

The purpose of this section is using a financial database of companies registered in the Mariña de Lugo to perform a DiD regression analysis to test the impact on firms' revenues, profitability, inventory days, and number of employees. In order to obtain a dataset of companies that are representative of the economy of *Mariña de Lugo*, we retrieved from *SABI – Bureau van Dijk* (BvD) database the financial statements from 2009 to 2016 of all firms of any size and from all sectors in the municipalities of this territory (a total of 2,139 companies in that database). We subsequently excluded cases with missing values in the key variables or with errors in the accounting data. Thus, we required total assets and revenues of a company in any year to be positive, to end up with a sample of 684 companies (32% of the population). In addition, we winsorized all variables at the 1% and 99% levels – to mitigate the effects of extreme outliers in the data. Since we measure the annual increase in variables such as employees, revenues and profits, our dataset finally considered seven annual observations (years 2010 to 2016) per company. The main descriptive statistics are summarized in Table 5.

Requiring total assets and revenues to be positive in any year implies that the analysis focuses on existing firms. Since entrance of new firms and exit of existing firms cannot be captured in

this way, the spread and backwash effects are captured only partially. The variables considered in the subsequent econometric analysis allow us to measure different financial aspects. In particular, we focus on the activity – the annual increase in sales revenues – and profitability of firms in the sample – the annual increase in the earnings before interest and taxes (EBIT) and the return on assets (ROA). Besides, we measure the change on business logistics with an estimation of the inventory days. Finally, in order to account for the evolution of staff recruitment, we use the number of employees hired by the company – which allows us as well to observe differences in firm size across municipalities.

Two alternative econometric models were applied to our data. On the one hand, the DiD regression approach described in Equation (1) was firstly applied using firms in the municipality of Mondoñedo as a treatment group, and secondly, for firms in the inland municipalities of Mariña Central as a treatment group. On the other hand, the DiDiD regression approach described in Equation (3) was also applied using firms of inner Mariña Central as a treatment group. The main results are summarized in Table 6. The coefficients of interest, δ_1 and δ_3, being the double and triple interaction terms in the equations, respectively, measure the policy effect for those firms in the treatment group in the post-policy period – *dBT* and *dBET*, respectively.

When both econometric models are applied to the entire sample, we find that the interaction terms lack of statistical significance in most cases, reflecting a high level of heterogeneity in the data. Nonetheless, the results suggest some positive, albeit moderate, impact over companies based in Mondoñedo. Thus, there is significant evidence of a positive impact for these firms in terms of a higher ROA and a higher number of employees after the opening of the new facility. Instead, there is not clear impact over firms in all the inner municipalities of Mariña Central. The only result we obtain is significant evidence of a negative impact over the revenues of firms in all the treatment groups, but the impact is minimum in quantitative terms and lacks of statistical significance.

The results hide, however, a high level of heterogeneity across industries, suggesting that, if there is an impact of the new road facility over the business financials, these must have had a different sign across industries. Consequently, we move top-down to categorize the firms in seven sectors, coherent with the classification in Table 4 above: agriculture (companies under NACE codes 1 to 3, forestry and fishing), manufacture (including manufacture and industrial companies, NACE codes 4 to 39), construction (codes 40 to 45), trade (wholesale and retail trade), transport (land transport and warehousing), hospitality (codes 55 and 56) and

professional services (codes 57 to 99). This way, when the econometric models are applied at the sectoral level, we obtain some significant results for the interaction terms *dBT* and *dBET*.

First, there is significant evidence that the new facility had a negative impact on revenues for companies in the wholesale and retail trade sector both in Mondoñedo and the inner Mariña Central, and in the construction sector in the inland municipalities of Mariña Central. However, this effect is not passed down in the income statement to profits. Thus, we obtain only weak statistical evidence of a negative impact on the EBIT of companies in the construction sector that is neither consistent for different control groups, nor it causes a differential impact in terms of ROA. Other results are a positive impact over the number of employees in the construction sector, while we did not obtain any statistically sound results in the transport and hospitality sectors – contrary to what we observed in Table 4, where a clear positive impact over the growth rate in the number of businesses in the transport sector and a clear negative impact in the hospitality sector were observed.

In regards to the hypothesis that new road investments lead to an inventory decline, we obtain results in the opposite sense: the increase in inventory days is statistically significant for firms in the construction sector. Beyond the analysis of the interaction terms, other regression coefficients provide clear results with consistent interpretation. Thus, the coefficient for the temporal dummy (*dT*) shows the general improvement after the crisis (years 2014 to 2016), both in terms of revenues (+3,000 euros) and profits (+19,000 euros) for companies in any group of municipalities. In addition, the coefficient for the dummy variable for individuals in the treatment group (*dB* and *dBE*) shows that companies in Mondoñedo and the inner Mariña Central are of a smaller size, having between 1 and 3 employees less than companies in other municipalities of *Mariña de Lugo*.

6. Conclusions

The natural experiment provided by the opening, in 2014, of a new section that completed the A8 motorway in *Mariña de Lugo*, a rural area in Galicia (Spain), allowed us to study the impact of this facility over a series of socio-economic variables – including population growth, employment and business financial results – in the most directly affected municipalities (firstly Mondoñedo and secondly the other inner municipalities of the Mariña Central). The main objective is to observe whether spread or backwash effects to these rural inland areas of *Mariña de Lugo* were caused afterwards.

Using data from several sources, including public (the INE, IGE and the Social Security) and private (SABI-BvD database), we measured population and migration rates before and after year 2014 for the different municipalities in *Mariña de Lugo*, the number of employees enrolled in the Social Security System, the number of companies registered in the area, and a set of measures from the financial statements of a sample of companies. The latter allowed us to obtain individual data in order to account for the activity and profitability of firms, as well as the number of employees hired by them. Using the differences-in-differences approach, we tested for spread and backwash effects following this logic: the new facility would impact the dynamics of employment and revenues in the treatment group in first instance, these would affect migratory flows, varying the number of inhabitants.

Thus, regarding the financial performance of the sample of companies in *Mariña de Lugo*, the econometric evidence we obtain is rather inconclusive due to a high level of heterogeneity in the data. Nonetheless, we find there was a positive impact in the municipality of Mondoñedo over business return and employee recruitment. When compared with the socio-economic variables analysed for Mondoñedo, the results are more robust. Thus, we find that the impact on employment was positive, the impact on migration flows was positive, and this increased total population. The results for the inner Mariña Central, however, are less conclusive, since the positive impact on population seems not to obey sound socio-economic interpretation. Finally, differences at the sectoral level are revealing when using data on business demographics (the number of companies registered in *Mariña de Lugo*): the impact was negative in sectors oriented to local demand (hospitality and retail trade), while a positive impact is observed in the transport sector. However, we could not trace any confirming results at the individual level, when using data from financial statements.

The results that are consistent with the spread hypothesis, obtained for the municipality of Mondoñedo, would be in line with previous results for Galicia suggesting that the rural areas in recovery were helped by the quality of road connections to nearby urban nodes (Martínez-Filgueira et al., 2017). Nonetheless, the spread effects did not disseminate to the other neighbouring municipalities of the inner Mariña Central. This is related to the fact that the road section that was opened in 2014 essentially affected Mondoñedo: Lourenzá was already connected to the A8 on the way to the coast, while the other inner municipalities lie at some distance from the facility. These global results hide a different performance at the sector level,

in line with what we expected: an improvement in the dynamics of transport companies and, less clearly, in the manufacturing industry; and a negative impact on retail firms and hospitality.

The research contributes to the field by making use of a natural experiment in which the new section that completed a key motorway facility at a regional level directly affected only a small strip of a rural area. This allowed to identifying whether spread or backwash effects were observed for the inland rural municipality bypassed by the opening of the road section. The main lesson to be learned in terms of implication for policymakers is the need for road infrastructure investments to be accompanied by rigorous assessments of their foreseeable effects that include the impact on the rural areas they pass through. All this with the aim of designing policies, at a local and regional level, that mitigate possible negative impacts over rural areas and favour the use of the new economic opportunities it generates.

The strong points of our research include, first, that it meets a gap in the literature – the impacts at a local level of a new road facility in a rural county has rarely been done in the context of developed countries. Second, the econometric method is sound, as the difference-in-differences has been widely applied in evaluation type of research and, in addition, we use DiDiD as a robustness test. Third, the interest of this research has a broader relevance than for the region of analysis, derived from two facts. One is the high volume of public investment in road transport infrastructure in the Southern countries of the EU over the last three decades, funded with European funds. The other is the fact that measuring the impact of these investments has been often limited to traffic intensity, reduction of travel time, and reduction of accidents. And, in terms of economic impact, it is usually limited to the impact on GDP and employment – rarely on the socio-economic dynamics of the areas it passes by.

Fourth, the limitations in the transferability of results to other regions due to differences in the sectoral structure are bounded. Thus, the differences in the sectoral and (particularly) the employment structure of the case of study compared to the control groups are moderate, and of diverse sign in any case (because the structures of the control groups are heterogeneous as well). In that sense, the use of DiDiD as a robustness test help make the results more reliable. We acknowledge that the main limitation to improve the external validity of the results is the time span considered – in particular, for the post-opening period. Nonetheless, a time frame of analysis of 7-8 years exceeds that of some classics in the literature –e.g., Lokshin and Yemtsov (2005) use 5 years; Dinkelman (2011) uses 6 years. Yet, the potential socio-economic effects of the new connective infrastructures either on demographics or economic activity are expected

to be revealed only partially over a short period of time, and are better to be observed over the long term (Fariña Tojo et al., 2000). This limitation does not affect, however, the interest of research and of the results obtained.

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APPENDIX

Table A1. Impact on daily traffic density of the opening of the new facility

ROAD	Gauging station	Section	avg 2012-13	avg 2015-16	Increase	Percentage
Former route (Spanish Ministry of Infrastructure)						
N-634	LU-37-2	Abadín - Mondoñedo	1,536	1,498	-38	-2.4%
N-634	LU-36-2	Mondoñedo norte	7,195	6,300	-895	-12.4%
N-634	LU-10-2	Lourenzá - Nudo A8 PK 524	3,320	2,999	-322	-9.7%
A8 highway (Spanish Ministry of Infrastructure)						
A-8	LU-241-2	Abadín - Mondoñedo	6,312	7,632	1,320	20.9%
A-8	E-168-0	Alto do Fiouco (new section)	0	7,326	7,326	-
A-8	LU-243-2	Alto do Fiouco (section #2)	6,273	7,757	1,484	23.6%
A-8	LU-240-2	Lourenzá - Nudo A8 PK 524	6,320	8,397	2,077	32.9%
A-8	LU-65-1	PK 524 - PK 516	7,265	8,890	1,625	22.4%
A-8	E-194-0	PK 516 - PK 508	7,572	9,398	1,827	24.1%
A-8	LU-60-2	PK 508 - PK 506	5,313	7,054	1,741	32.8%
A-8	LU-113-2	River bridge	9,505	12,240	2,736	28.8%
Coast line roads (Spanish Ministry of Infrastructure except *)						
LU-862*	LU-862	Viveiro - Xove	-	6,735	-	-
N-642	LU-97-3	Xove - San Cibrao	3,781	3,164	-617	-16.3%
N-642	LU-39-2	San Cibrao - Burela	7,396	7,343	-53	-0.7%
N-642	E-262-0	Burela - Foz	8,680	9,360	681	7.8%
N-642	LU-104-2	Foz - N634	9,345	10,306	961	10.3%
N-634	LU-103-2	Nudo A8 PK 524 - Barreiros	5,322	5,508	186	3.5%
N-642	LU-61-1	Nudo A8 PK 516 - Ribadeo	1,324	1,580	256	19.3%
N-642	LU-35-2	Ribadeo - Vegadeo	2,755	3,049	294	10.7%
Secondary roads (Galician Government except **)						
LU-862	AC-862-58	West - O Vicedo	2,264	2,419	155	6.8%
LU-862	LU-862-90	Viveiro - Xove	6,477	6,735	259	4.0%
LU-540	LU-540-33	Landrove - Ourol - South	2,735	2,821	87	3.2%
LU-162	LU-162-0	Cangas - Valadouro / Alfoz	1,765	1,613	-152	-8.6%
LU-160	LU-160-9	Alfoz - Masma (Mondoñedo & A8)	1,294	1,129	-165	-12.8%
LU-132	LU-132-1	Lourenzá - Trabada (N-642)	402	408	6	1.4%
LU-122	LU-122-30	Lourenzá - South (Cruz da Cancela)	1,870	1,627	-243	-13.0%
N-642**	LU-98-2	River Eo to Asturias	2,662	2,424	-239	-9.0%
N-642**	LU-45-2	Asturias - A Pontenova	1,603	1,450	-153	-9.5%
N-642**	LU-208-2	A Pontenova - Meira	1,690	1,453	-238	-14.1%

Former route N-634. Average increase 2012-13 vs 2015-16	-10.4%
A8 highway. Average increase 2012-13 vs 2015-16	41.5%
Main roads (all but secondary roads). Average increase 2012-13 vs 2015-16	27.5%
Coastline roads. Average increase 2012-13 vs 2015-16	4.4%
Secondary roads. Average increase 2012-13 vs 2015-16	-3.0%

Source: Own elaboration.

Table 1. Gross value added (GVA) by county and activity, and percentage of employees enrolled in the Social Security System, by sector.

	Galicia	Mariña Occid.	Mariña Central	Mariña Oriental
GVA Primary sector	5.4	12.1	18.1	14.7
GVA Mining and manufacture of other non-metallic mineral products	0.8	0.7	2.2	1.2
GVA Agri-food industry	2.9	1.7	1.3	2.9
GVA Manufacture of wood, paper, and furniture	1.2	0.3	1.9	0.6
GVA Metal products, electronics, electrical equipment and machinery	2.8	25.8	0.6	1.2
GVA Manufacture of transport equipment	3.9	1.8	1.3	0.4
GVA Other manufacturing	2.2	0.4	0.3	0.4
GVA Electricity, water and waste treatment	5.3	21.1	6.9	1.8
GVA Construction	6.7	3.2	7.6	7.4
GVA Wholesale and retail trade, transport and hospitality	23.7	11.4	17.7	28.7
GVA IT, financial services, real estate and other professionals	21.6	10.7	17.4	21.6
GVA Public administration, education, health and other services	23.4	10.8	24.8	19.1

		Total	Agricult.	Fishing	Industry	Construct.	Services
	Mariña Occidental	**100**	**4.3**	**7.7**	**18.0**	**8.1**	**61.7**
coast	Cervo	100	2.3	7.1	24.9	7.2	58.4
coast	Vicedo, O	100	10.8	9.9	14.2	11.4	53.1
coast	Viveiro	100	2.7	7.6	16.1	8.1	65.3
coast	Xove	100	6.3	9.6	19.6	7.7	56.7
inland	Ourol	100	23.8	0.0	13.0	9.7	52.7
	Mariña Central	**100**	**7.3**	**4.9**	**14.5**	**9.9**	**63.3**
coast	Burela	100	0.7	11.2	13.5	7.7	66.7
coast	Foz	100	4.4	3.1	14.8	11.3	66.3
inland	Alfoz	100	16.0	0.6	18.1	9.3	55.5
inland	Lourenzá	100	19.1	0.2	15.3	10.4	54.8
inland	**Mondoñedo**	**100**	**17.4**	**0.1**	**14.4**	**10.7**	**57.4**
inland	Valadouro, O	100	12.3	1.0	13.7	12.5	60.6
	Mariña Oriental	**100**	**13.7**	**0.8**	**9.3**	**9.3**	**66.6**
coast	Barreiros	100	15.9	0.7	9.0	10.9	63.4
coast	Ribadeo	100	9.4	1.2	7.7	8.2	73.2
inland	Pontenova, A	100	13.7	0.0	13.4	12.0	60.2
inland	Trabada	100	37.4	0.0	13.2	7.3	41.9

Source: Own elaboration.

Data: Galician Statistics Institute (IGE).

Table 2. Difference in differences for population, migration and employment growth rates (in %): Inner Mariña Central vs. control groups.

Population growth (annual average, %)		n	2010-2012	2015-2016		
DiD Mondoñedo	Control group	14	-0.56	-0.65	Impact	0.67
	Treatment group	1	-2.61	-2.03	Robustness	0.30
DiD Inner Mariña Central	Control group	11	-0.42	-0.56	Impact	0.60
	Treatment group	4	-2.18	-1.72	Robustness	0.32
DiDiD Inner Mariña Central	Non policy - Inland	3	-2.24	-2.62		
	Non policy - Coast	6	-0.49	-0.58	Impact	0.97
	Treatment group	4	-2.18	-1.72	Robustness	0.42
	Control group	2	0.19	-0.04		
Migration (annual average growth, %)			2010-2012	2015-2016		
DiD Mondoñedo	Control group	14	-0.16	-0.22	Impact	0.45
	Treatment group	1	-0.92	-0.53	Robustness	0.28
DiD Inner Mariña Central	Control group	11	-0.09	-0.14	Impact	0.11
	Treatment group	4	-0.56	-0.50	Robustness	0.04
DiDiD Inner Mariña Central	Non policy - Inland	3	-0.48	-0.11		
	Non policy - Coast	6	0.08	-0.02	Impact	0.02
	Treatment group	4	-0.56	-0.50	Robustness	0.08
	Control group	2	0.55	0.12		
Employment (annual average growth, %)			2010-2012	2015-2017		
DiD Mondoñedo	Control group	14	-3.86	0.31	Impact	1.02
	Treatment group	1	-4.79	0.39	Robustness	0.60
DiD Inner Mariña Central	Control group	11	-3.77	0.62	Impact	-0.58
	Treatment group	4	-4.34	-0.52	Robustness	-0.62
DiDiD Inner Mariña Central	Non policy - Inland	3	-4.65	0.23		
	Non policy - Coast	6	-3.56	0.73	Impact	-1.08
	Treatment group	4	-4.34	-0.52	Robustness	-0.93
	Control group	2	-2.45	1.85		

Source: Own elaboration.

Table 3. Statistical test of the difference in means across municipalities

	unpaired Welch t-test	
DiD Inner Mariña Central	difference in means	p-value
Population growth	0.63	0.006
Migration	0.11	0.693
Employment	-0.58	0.653

Source: Own elaboration.

Table 4. Difference in differences for the annual growth rate in the number of firms (in %): Inner Mariña Central vs. control groups.

	DiD Mondoñedo		DiD inner M.Central		DiDiD inner M.Central	
	Impact	Robust	Impact	Robust	Impact	Robust
ALL SECTORS	**2.0**	**0.7**	**0.7**	**0.3**	**1.8**	**0.0**
MANUFACTURE	4.7	1.8	7.5	0.9	-3.0	-7.5
CONSTRUCTION			2.8	1.4		
RETAIL & WHOLESALE			-1.9	-4.4		
TRANSPORT	14.4	8.6	10.4	8.5	1.8	0.9
HOSPITALITY	-3.3	-0.9	-0.6	-0.6	-5.8	-4.5
PROFESSIONAL ACTIVITIES	3.8	0.1				

Source: Own elaboration.

Table 5. Data referred to the companies of the *Mariña de Lugo* 2010-2016. Descriptive statistics

		Descriptive statistics							
VARIABLE	**Definition [units]**	N. obs	Mean	Std. Dev.	Min	p25	Median	p75	Max
ASSETS	Total assets [1.000 Euros]	4698	868.84	1,572.38	20	131	334	925	18,536
EQUITY	Equity [1.000 Euros]	4560	407.19	901.98	-262	36	116	391	9,240
EMPLOYEES	Number of employees	4306	7.22	7.63	1	2	5	9	47
REVENUES	Total sales revenues [1.000 Euros]	4697	820.97	1,327.86	7	120	304	881	11,028
EBITDA	EBITDA [1.000 Euros]	4693	70.50	165.11	-116	4	18	62	1,414
EBIT	EBIT [1.000 Euros]	4181	39.34	116.03	-188	1	9	35	995
INVENTORY DAYS	Inventories over sales * 365 [days]	3654	175.66	495.79	0	16	53	141	6,083
ROA	ratio of EBT to total assets [%]	4694	1.27	11.49	-63.92	-0.74	1.62	5.32	40.90
gASSETS	Annual increase in total assets [1.000 Euros]	4651	2.92	18.70	-47.62	-6.58	0.16	9.72	110.71
gREVEN	Annual increase in revenues [1.000 Euros]	4177	1.10	24.81	-60.00	-5.56	0.00	0.00	100.00
gEBIT	Annual increase in EBIT [1.000 Euros]	3930	-26.20	199.96	-1,200.00	-67.50	-16.11	25.00	1,023.53

Source: Own elaboration from SABI database.

Table 6. Evolution of the companies of Mondoñedo and inner Mariña Central. Summary of DiD and DiDiD regression results

DiD Mondoñedo		DiD inner M.Central		DiDiD inner M.Central	
Revenue growth					
dT	2.86 ***	dT	3.16 ***	dT	2.96 ***
dB		dB		dBE	
dBT	-2.51	dBT	-3.08	dBET	-5.05
Trade	-19.71 ***	Trade	-8.08 *	Manufact	-13.71 ·
		Constr.	-8.79 *	Constr.	-12.54 *
EBIT growth					
dT	19.36 ***	dT	19.45 ***	dT	19.60 **
dB		dB		dBE	
dBT	35.77	dBT	13.61	dBET	-2.29
Hospit.	275.61 ·	Hospit.	166.10 ·	Constr.	-121.61 *
ROA					
dT	0.67 *	dT	0.70 *	dT	
dB		dB	-1.12 *	dBE	
dBT	2.53 *	dBT	0.81	dBET	-0.64

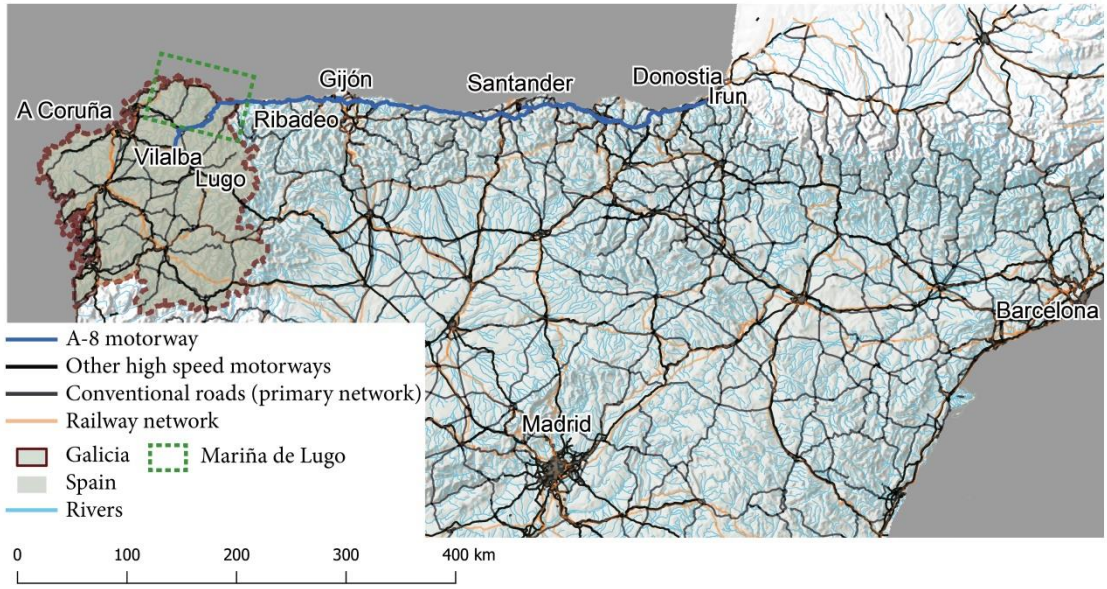
DiD Mondoñedo		DiD inner M.Central		DiDiD inner M.Central	
Inventory days					
dT	28.87 *	dT	30.13 *	dT	53.62 **
dB	106.02 **	dB		dBE	
dBT	86.50	dBT	22.00	dBET	102.96
Constr.	789.00 ***			Constr.	335.72 ·
Hospit.	163.17 *				
Employees					
dT		dT		dT	
dB	-1.84 ***	dB	-1.37 ***	dBE	-3.09 ***
dBT	1.57 ·	dBT	0.21	dBET	0.40
Constr.	5.12 **	Constr.	1.93 ·	Constr.	2.81 ·
		Services	-2.36 ·		

*** *significant at 1%* * *significant at 10%*

** *significant at 5%* · *significant at 15%*

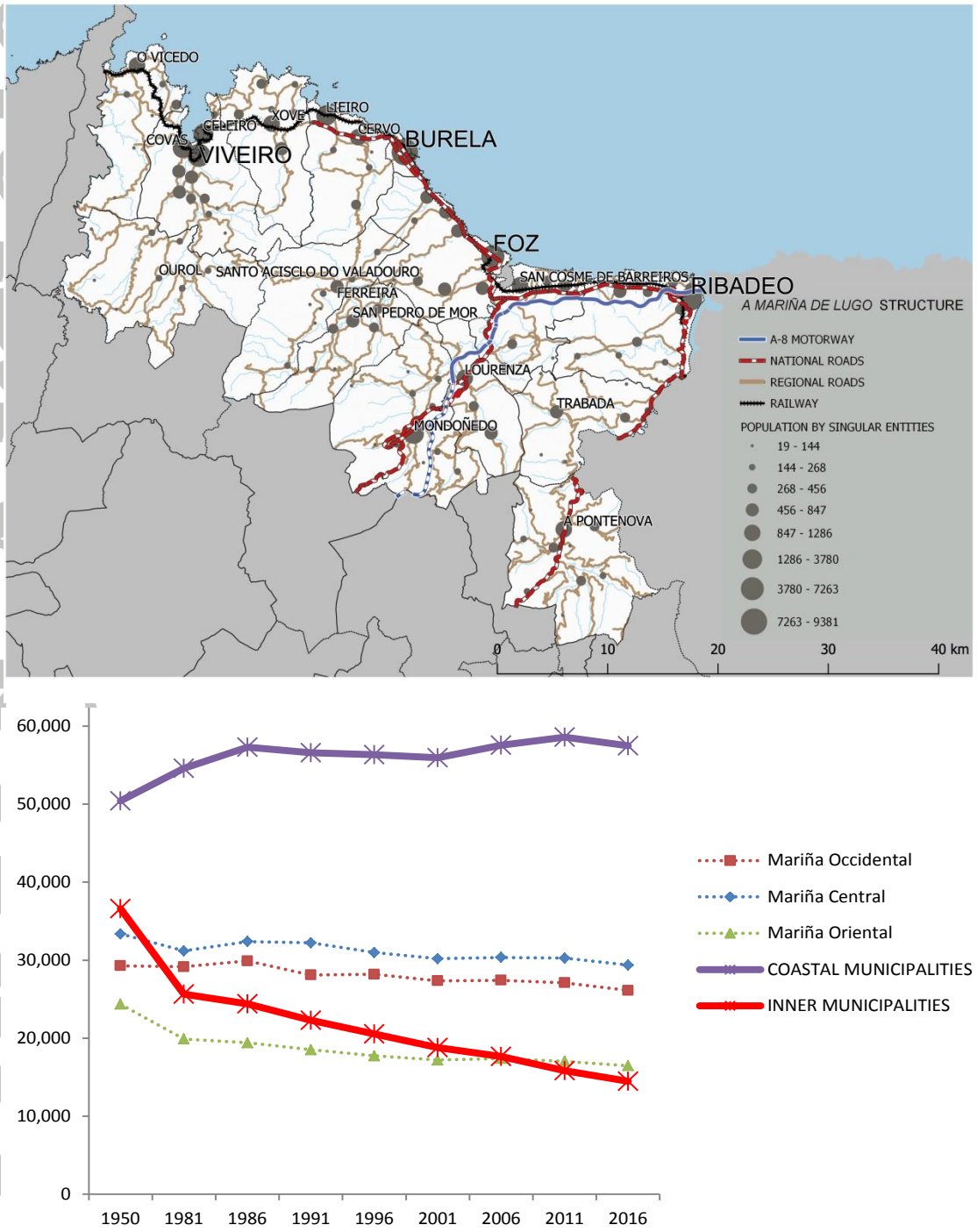
Source: Own elaboration.

Figure 1. Galicia and the A8 motorway



Source: Own elaboration.

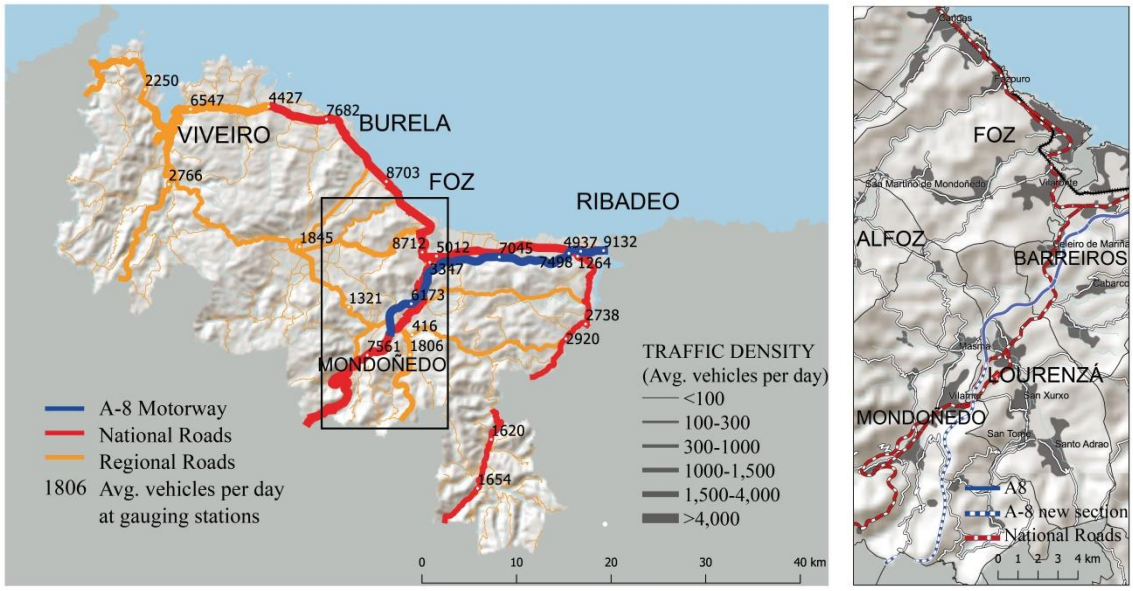
Figure 2 – Population of *Mariña de Lugo* in year 2015 (LHS) and population performance since year 1950 (RHS)



Source: Own elaboration.

Data: Spanish National Statistics Institute (INE) & Galician Statistics Institute (IGE). Population Census and Municipal Register of Inhabitants.

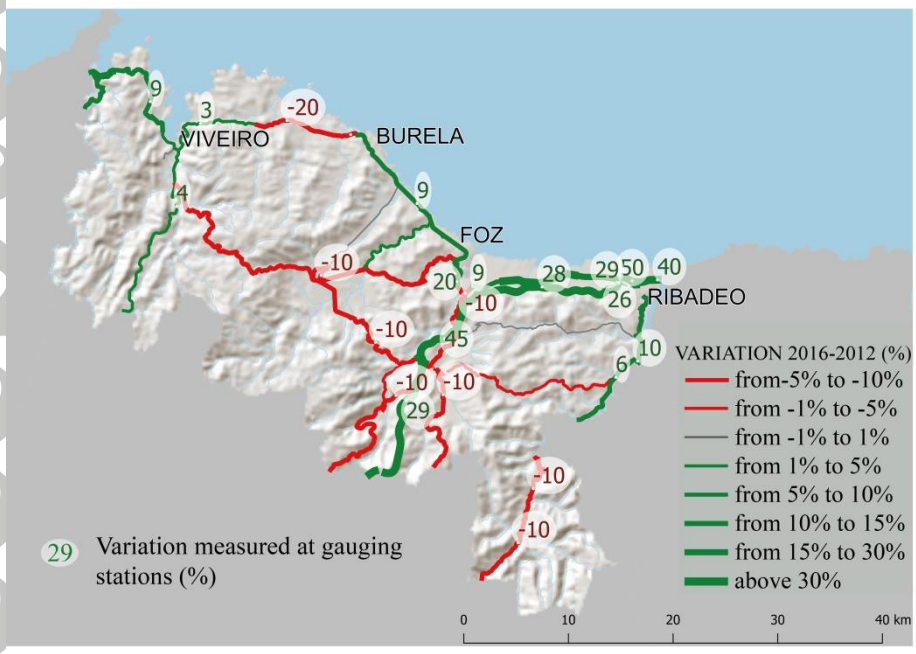
Figure 3. Daily traffic density on main roads of *Mariña de Lugo*, year 2012



Source: Own elaboration.

Data: Spanish Ministry of Infrastructure, Galician Government.

Figure 4. Impact on daily traffic density, year 2016 vs. 2012



Source: Own elaboration.