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Original Paper

On the Effects of Infrastructure Investments on the Regional Economic Mix in Portugal

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Abstract

In this paper, we deal with the issue of the effects of infrastructure investments on the regional mix of economic activity in Portugal. To address this issue we use a new data set for infrastructure investments in Portugal at the level of the NUTS II. We use a region-specific VAR approach, which considers, for each region, not only the effects of infrastructure investments in the region itself but also the regional spillover effects for each region from infrastructure investments elsewhere. Our results can be summarized as follows. First, we find that the largest aggregate effects are for investments in municipal roads, airports, ports, and education. Second, regional spillovers are very important across the board, and are particularly relevant for municipal roads and highways. Third, we find that for road transportation infrastructures, investments in national roads shift the regional concentration of economic activity towards North, Lisbon, and Alentejo, while investments in municipal roads have the same effects for Centre and investments in highways once again in North, Lisbon and Alentejo. For other transportation infrastructures the shifts in regional economic composition occur in North and Alentejo for railroad investments, Lisbon, Alentejo, and Algarve for airport investment, and Centre and Algarve for port infrastructure investments. Finally, investments in both education and health shift the regional output mix towards North and Centre, and in the case of health Alentejo as well. Accordingly, the aggregate effects of infrastructure investments hides a wide variety of effects across regions and across different infrastructure assets. Being mindful of these differences is fundamental in designing policies that help with aggregate economic performance without increasing regional disparities.

Keywords

Infrastructure Investment, Economic Performance, Regional Composition of Economic Activity, VAR, Portugal

1. Introduction

In this paper we deal with the issue of empirically identifying the effects of infrastructure investments on the regional mix of economic activity in Portugal. To address this issue we use a new data set for infrastructure investments in Portugal at the level of the NUTS II regions. We use a region-specific VAR approach, which considers, for each region, not only the effects of infrastructure investments in the region itself but also the regional spillover effects for each region from infrastructure investments elsewhere.

Our discussion is centered on three intertwined research questions. First, we want to determine the regional decomposition of the aggregate effects of different types of infrastructure investments. This helps us determine which locations benefit the most in absolute terms when we consider the patterns of infrastructure investments in the country. Second, we want to identify for each type of infrastructure asset the relevance of regional spillovers. This allows us to determine how much a region benefits from infrastructure investments elsewhere. Finally, and using the information on the two previous questions we want to determine the impact of national patterns of each type of infrastructure investment on the regional composition of economic activity. This allows us to identify which regions benefit the most relative to their economic size, that is, whether or not infrastructure investments contribute to the regional concentration or to the regional diversification of economic activity.

The body of empirical literature on the economic effects of infrastructure investment is rather extensive and includes a fair amount of work with a regional focus (see, for example, Munnell, 1992; Gramlich, 1994; Romp & de Haan, 2007; and Pereira & Andraz, 2013; for literature surveys as well as the literature review in Kamps (2005)).

The empirical evidence on the positive effects of infrastructure investments at the regional level has traditionally been unable to replicate the large effects often identified at the aggregate level. Some of the early contributions provide evidence of a positive effect although clearly lower than the aggregate estimates (Costa et al., 1987; Duffy-Deno & Eberts, 1991; Eberts, 1990; Garcia-Mila & McGuire, 1992; Merriman, 1990; Moomaw & Williams, 1991; Munnell & Cook, 1990; and Munnell, 1992). Later studies, however, find that after controlling for region and state specific unobserved characteristics, public capital effects are not significant (Andrews & Swanson, 1995; Eisner, 1991; Evans & Karras, 1994; Garcia-Milà et al., 1996; Holtz-Eakin, 1993, 1994; and Moomaw et al., 1995).

Evidence on the effects of public capital at the regional level for other countries is in many respects similar to the earlier evidence for the US. In general, output elasticities are positive and relatively large in Japan (Merriman, 1990), Spain (Cutanda & Patricio, 1992; and Mas et al., 1996), Belgium (Everaert & Heylen, 2004) and Germany (Stephan, 2003) and substantially lower for France (Cadot et al., 1999). Furthermore, the adoption of cost and profit equation approaches appears to have led to smaller estimates for the effects of public capital on economic performance (Boscá et al., 2000; Everaert, 2003; and Moreno et al., 2003).

One possible explanation for the discrepancy between large aggregate effects and small regional effects is that spillover effects captured by aggregate level studies are not captured at the regional level (Boarnet, 1998; and Mikelbank & Jackson, 2000). As such, it could be argued that spillover effects should be an integral part of the analysis of the regional impact of public capital formation (Haugwout, 1998, 2002) as the effects of public capital formation in a region can be induced by public infrastructures installed in the region itself as well as public infrastructure outside the region. Paradoxically, possibly due to the inconclusive nature of the results on the impact of public capital on output at the regional level, the issue of the possible existence of regional spillovers from public capital formation has received little attention. Munnell (1990) deals marginally with this issue. Holtz-Eakin (1993, 1995) concludes that regional level estimates are essentially identical to those from national data, suggesting no quantitatively important spillover effects across regions. On the other hand, several other studies report evidence of spillovers (Boarnet, 1998; Cohen & Paul, 2004; and Pereira & Andraz, 2004). The empirical results reported in Pereira and Andraz (2004), for example, suggest that only about one-fifth of the aggregate effects of public investment in highways in the US are captured by the direct effect of public investment in the state itself, the remaining corresponding to the spillover effects from public investment in highways in other states. In addition, the significance of spillover effects is observed in some countries such as Portugal (Pereira & Andraz, 2006) and Spain (Pereira & Roca, 2003, 2007), and help explain some of the divergences found between regional and aggregate results.

This paper is in the confluence of the regional literature on the effects of infrastructure investments and the issue of economic spillovers, which is central to the whole approach. We use a multivariate time series approach, based on the use of vector autoregressive (VAR) models, developed in Pereira and Flores (1999), Pereira (2000, 2001) and subsequently applied to the U.S. in Pereira and Andraz (2003, 2004), to Portugal in Pereira and Andraz (2005, 2006), and to Spain in Pereira and Roca-Sagales (2003), among others. This econometric approach highlights the dynamic nature of the interactions between infrastructure investments and the economy.

In terms of the scope of the analysis, we consider five regions at the NUTS II level– North, Centre, Lisbon, Alentejo, e Algarve - spanning the Portuguese continental territory. We use a newly developed data set for infrastructure investments in Portugal (see Pereira & Pereira, 2015a), including regionalized information for eight infrastructure assets: three types of road transportation infrastructures (national roads, municipal roads, and highways), three types of other transportation infrastructures (railroads, ports, and airports), and two types of social infrastructures (education and health infrastructures). Recent papers using this new data set include Pereira and Pereira (2017, 2018, 2019a, 2019b, 2019c) and Pereira et al. (2019).

We estimate region and asset specific models. For each of the five regions we estimate eight models one for each of the eight individual infrastructure investments. In each of these models, we consider in addition to regional output, employment and private investment, both infrastructure investment in the region and infrastructure investments elsewhere. This is consistent with the evidence on the potential relevance of regional spillovers, that is, economic performance in each region being affected also by infrastructure investments elsewhere.

In this context, it is relevant to mention that this work is also related to the literature on fiscal multipliers, i.e., on the macroeconomic effects of taxes and government purchases (see, for example, Baunsgaard et al., 2014; and Ramey, 2011), for recent surveys of this literature, and Leduc and Wilson (2012) for a related application). It is in fact very much in the spirit of the approach pioneered by Blanchard and Perotti (2002), which is based on a VAR approach and uses the Choleski decomposition to identify government spending shocks. We focus, however, on a specific type of public spending – infrastructure investment and its effects on the economy, as opposed to aggregate spending or military spending as it is traditional in this literature. In this sense, this paper is closer in focus to Leduc and Wilson (2012), but has much more disaggregated nature both in terms of infrastructure assets and in its spatial dimension.

This paper is organized as follows. Section 2 presents both the infrastructure investment data and the economic data. Section 3 presents the preliminary econometric results including the VAR model specification and discusses the identification of exogenous shocks to infrastructure investment as well as the measurement of their effects. Section 4 presents the main empirical results and address the three main research questions we mentioned above. Section 5 presents a summary, policy implications, and concluding remarks.

2. Data Sources and Description

2.1 The Regional Data Set

We consider annual data on output, employment, private investment for the five contiguous administrative regions defined under the NUTS II. These regions are North (Norte), Centre (Centro), Lisbon (Lisboa e Vale do Tejo), Alentejo, and Algarve, and their exact definition in terms of NUTS III is provided in Table 1. We can visualized mainland Portugal as a long rectangle with the vertical sides about three times as long as the horizontal ones. Broadly speaking, these regions run from north to south as five consecutive segments of this rectangle, with the middle region of Lisbon and the southernmost region of Algarve being geographically smaller than the other three.

The data covers the period from 1980 to 2011. This is because regional output, nvestment and employment data are only available in a consistent manner after 1980. Output and private investment are in millions of 2005 Euros, while employment is in fulltime equivalent employees.

The macro data at the regional level were obtained from the different annual issues of the Regional Accounts published by the National Institute of Statistics/Instituto Nacional de Estatística, which for the period after 1995 are available on-line at http://www.ine.pt. The regional disaggregation of private investment poses a particular challenge since such data does not exist until 1995. To obviate this problem, we constructed a data series for private investment by region from 1980 to 1994, using regional data for private output and data for aggregate private investment. Specifically, private investment figures by region were obtained as the product of the aggregate private investment by the fraction of the private output in that region.

Summary statistics for the regional macro data are provided in Table 2. North and Lisbon are the two largest regions in terms of their share on the country's economy. Over the sample period North accounted for 30.59% of the output, 27.21% of investment and 35.68% of employment while Lisbon accounted for 37.84%, 40.22% and 29.02%, respectively. Centre is a middle-sized region with 20.06% of output, 21.16% of investment, and 25.27% of employment. The two remaining regions Alentejo and Algarve are substantially smaller and together account for around 11% of the economic activity in the country.

Of these regions, North, Centre and Alentejo experience a decreasing trend in terms of their shares of output while Lisbon and to a lesser extent Algarve show an increasing trend. The same is true in terms of employment although there has been a rebound in Alentejo in the last decade. Finally, in terms of investment North and Alentejo have seen their shares increase, while Centre and Algarve have seen a rebound in the last decade. On the flip side investment in Lisbon declined significantly in relative terms in the last decade.

Overall, the predominance of North and Lisbon remained high and relatively stable during the sample period. This is particularly the case for output and employment for which a slight decline in North was matched by a slight increase in the Lisbon. In turn, there is a pattern of slight decline in the concentration of private investment mostly through a great reduction in the share of Lisbon.

2.2 The Infrastructure Investment Data Set

The data for infrastructure investment are from a new data set developed by Pereira and Pereira (2015a) and covers the period between 1978 and 2011, although we only use the data for 1980-2011, due to the limitations in the availability of economic data prior to 1980. Infrastructure investment is measured in millions of 2005 euros. The data set includes infrastructure investments in twelve individual types of infrastructures grouped in five main categories: three road transportation infrastructure assets, three other transportation infrastructure assets, two social infrastructures assets, three types of public utility assets and telecommunication infrastructures. Of these twelve assets the data set provides information about the regional location of investments for eight, specifically to the exclusion of the three public utility assets and of telecommunication infrastructures. Table 3 presents summary information for infrastructure investment effort, as a percent of GDP, as well as a percent of total infrastructure investment.

Road transportation infrastructures include national roads, municipal roads and highways and account for 28.49% of total infrastructure for the sample period. Investment efforts and the extension of motorways in Portugal grew tremendously during the 1990s with the last ten years marked by a substantial increase in highway investment made possible due to public private partnerships. This corresponds in absolute terms to an increase from 0.74% of the GDP in the 1980s to 1.52% in the last decade.

The largest component of road transportation investments for the sample period was national road investment, amounting to 0.52% of GDP and 12.46% of total infrastructure investment. What is most striking, however, is the substantial increase in investment in highways since 2000. In fact, the extension of freeways in Portugal increased by more than a third since 2000. In the last decade, highway infrastructure investment amounted to 0.59% of GDP and surpassed national road infrastructure investment in importance, with highway investment amounting now to 11.70% of total infrastructure investment. In contrast, the past thirty years have seen a steady decline in municipal road infrastructure investment.

Other transportation infrastructures include railroads, airports and ports. Other transportation infrastructure investment accounted for 8.91% of total infrastructure investment between 1980 and 2011. Investment in social infrastructures reached its greatest levels, as a percent of total infrastructure investment, with the modernization of the railroad network and port expansion projects in the context of the second community support framework during the 1990s. The last ten years has also brought with it substantial growth in investment in airports with the renovation and expansions of the airports in Lisbon and Oporto. This is reflected in an increase from 0.22% of the GDP in the 1980s to 0.46% in the last decade.

Railroads represent the bulk of investment in other transportation infrastructures, nearly 75% of total investment in other types of transportation infrastructures. Investment in railroad infrastructures amounted to 0.29% of GDP over the sample period, reaching 0.37% of GDP during the 1990s in the context of the community support frameworks. Investment in ports and airports over the past thirty years has represented relatively smaller investment volumes due to the rather limited number of major airports (3) and ports (12) in the country. Nonetheless, very substantial investments in the airports of Lisbon and Oporto were undertaken in the last decade with investment volumes reaching 0.06% of GDP nearly double that seen in the 1980s, a period in which major investments were directed towards the Lisbon airport, and 1990s. During the last decade, investments in airports accounted for 1.21% of total infrastructure investment.

Social infrastructures include health facilities and educational buildings. Social infrastructures have accounted for 23.76% of infrastructure investment and shown a slowly declining pattern over time in terms of their relative importance in total infrastructure investment. Yet, as a percentage of the GDP these investments remained stable over the last two decades representing just over 1%.

Table 1. Definition of Regions by NUTS II

NUTS II	NUTS III
North	ALFÂNDEGA DA FÉ, ALIJÓ, AMARANTE, AMARES, ARCOS DE VALDEVEZ, ARMAMAR, AROUCA, BAIÃO, BARCELOS, BOTICAS, BRAGA, BRAGANÇA, CABECEIRAS DE BASTO, CAMINHA, CARRAZEDA DE ANSIÃES, CASTELO DE PAIVA, CELORICO DE BASTO, CHAVES, CINFÃES, ESPINHO, ESPOSENDE, FAFE, FELGUEIRAS, FREIXO DE ESPADA À CINTA, GONDOMAR, GUIMARÃES, LAMEGO, LOUSADA, MACEDO DE CAVALEIROS, MAIA, MARCO DE CANAVESES, MATOSINHOS, MELGAÇO, MESÃO FRIO, MIRANDA DO DOURO, MIRANDELA, MOGADOURO, MOIMENTA DA BEIRA, MONÇÃO, MONDIM DE BASTO, MONTALEGRE, MURÇA, OLIVEIRA DE AZEMÉIS, PAÇOS DE FERREIRA, PAREDES, PAREDES DE COURA, PENAFIEL, PENEDONO, PESO DA RÉGUA, PONTE DA BARCA, PONTE DE LIMA, PORTO, PÓVOA DE LANHOSO, PÓVOA DE VARZIM, RESENDE, RIBEIRA DE PENA, SABROSA, SANTA MARIA DA FEIRA, SANTA MARTA DE PENAGUIÃO, SANTO TIRSO, SÃO JOÃO DA MADEIRA, SÃO JOÃO DA PESQUEIRA, SERNANCELHE, TABUAÇO, TAROUCA, TERRAS DE BOURO, TORRE DE MONCORVO, TROFA, VALE DE CAMBRA, VALENÇA, VALONGO, VALPAÇOS, VIANA DO CASTELO, VIEIRA DO MINHO, VILA DO CONDE, VILA FLOR, VILA NOVA DE CERVEIRA, VILA NOVA DE FAMALICÃO, VILA NOVA DE FOZ CÔA, VILA NOVA DE GAIA, VILA POUCA DE AGUIAR, VILA REAL, VILA VERDE, VIMIOSO, VINHAIS, VIZELA,
Centre	ABRANTES, ÁGUEDA, AGUIAR DA BEIRA, ALBERGARIA-A-VELHA, ALCANENA, ALCOBAÇA, ALENQUER, ALMEIDA, ALVAIÁZERE, ANADIA, ANSIÃO, ARGANIL, ARRUDA DOS VINHOS, AVEIRO, BATALHA, BELMONTE, BOMBARRAL, CADAVAL, CALDAS DA RAINHA, CANTANHEDE, CARREGAL DO SAL, CASTANHEIRA DE PÊRA, CASTELO BRANCO, CASTRO DAIRE, CELORICO DA BEIRA, COIMBRA, CONDEIXA-A-NOVA, CONSTÂNCIA, COVILHÃ, ENTRONCAMENTO, ESTARREJA, FERREIRA DO ZÊZERE, FIGUEIRA DA FOZ, FIGUEIRA DE CASTELO RODRIGO, FIGUEIRÓ DOS VINHOS, FORNOS DE ALGODRES, FUNDÃO, GÓIS, GOUVEIA, GUARDA, IDANHA-A-NOVA, ÍLHAVO, LEIRIA, LOURINHÃ, LOUSÃ, MAÇÃO, MANGUALDE, MANTEIGAS, MARINHA GRANDE, MEALHADA, MEDA, MIRA, MIRANDA DO CORVO, MONTEMOR-O-VELHO, MORTÁGUA, MURTOSA, NAZARÉ, NELAS, ÓBIDOS, OLEIROS, OLIVEIRA DE FRADES, OLIVEIRA DO BAIRRO, OLIVEIRA DO HOSPITAL, OURÉM, OVAR, PAMPILHOSA DA SERRA, PEDRÓGÃO GRANDE, PENACOVA, PENALVA DO CASTELO, PENAMACOR, PENELA, PENICHE, PINHEL, POMBAL, PORTO DE MÓS, PROENÇA-A-NOVA, SABUGAL, SANTA COMBA DÃO, SÃO PEDRO DO SUL, SARDOAL, SÁTÃO, SEIA, SERTÃ, SEVER DO VOUGA, SOBRAL DE MONTE AGRAÇO, SOURE, TÁBUA, TOMAR, TONDELA, TORRES NOVAS, TORRES VEDRAS, TRANCOSO, VAGOS, VILA DE REI, VILA NOVA DA BARQUINHA, VILA NOVA DE PAIVA, VILA NOVA DE POIARES, VILA VELHA DE RÓDÃO, VISEU, VOUZELA,
Lisbon	ALCOCHETE, ALMADA, AMADORA, BARREIRO, CASCAIS, LISBOA, LOURES, MAFRA, MOITA, MONTIJO, ODIVELAS, OEIRAS, PALMELA, SEIXAL, SESIMBRA, SETÚBAL, SINTRA, VILA FRANCA DE XIRA,
Alentejo	ALANDROAL, ALCÁCER DO SAL, ALJUSTREL, ALMEIRIM, ALMODÔVAR, ALPIARÇA, ALTER DO CHÃO, ALVITO, ARRAIOLOS, ARRONCHES, AVIS, AZAMBUJA, BARRANCOS, BEJA, BENAVENTE, BORBA, CAMPO MAIOR, CARTAXO, CASTELO DE VIDE, CASTRO VERDE, CHAMUSCA, CORUCHE, CRATO, CUBA, ELVAS, ESTREMOZ, ÉVORA, FERREIRA DO ALENTEJO, FRONTEIRA, GAVIÃO, GOLEGÃ, GRÂNDOLA, MARVÃO, MÉRTOLA, MONFORTE, MONTEMOR-O-NOVO, MORA, MOURA, MOURÃO, NISA, ODEMIRA, OURIQUE, PONTE DE SOR, PORTALEGRE, PORTEL, REDONDO, REGUENGOS DE MONSARAZ, RIO MAIOR, SALVATERRA DE MAGOS, SANTARÉM, SANTIAGO DO CACÉM, SERPA, SINES, SOUSEL, VENDAS NOVAS, VIANA DO ALENTEJO, VIDIGUEIRA, VILA VIÇOSA,
Algarve	ALBUFEIRA, ALCOUTIM, ALJEZUR, CASTRO MARIM, FARO, LAGOA, LAGOS, LOULÉ, MONCHIQUE, OLHÃO, PORTIMÃO, SÃO BRÁS DE ALPORTEL, SILVES, TAVIRA, VILA DO BISPO, VILA REAL DE SANTO ANTÓNIO,

Table 2. Summary of Regional Composition of Economic Activity

	North	Centre	Lisbon	Alentejo	Algarve
% GDP					
1980-2011	30.5914	20.0550	37.8427	7.2890	4.2219
1980-89	31.3566	20.1121	36.8297	7.6442	4.0574
1990-99	30.9163	20.2332	37.5622	7.2579	4.0303
2000-09	29.6333	19.9236	38.8550	7.0530	4.5351
% Private Investment					
1980-2011	27.2098	21.1647	40.2233	6.7580	4.6442
1980-89	26.5371	21.8878	41.6967	5.7321	4.1463
1990-99	26.4555	20.6526	42.9658	5.9801	3.9460
2000-09	27.9919	21.2783	37.0182	7.9839	5.7277
% Employment					
1980-2011	35.6761	25.2699	29.0247	6.3434	3.6860
1980-89	36.0457	26.1692	27.8952	6.7912	3.0987
1990-99	35.9548	25.3440	29.1080	5.9198	3.6734
2000-09	35.2519	24.4907	29.7136	6.3559	4.1879

Table 3. Infrastructure Investment in Portugal by Type of Asset

% of GDP	1980-2011	1980-89	1990-99	2000-09
Total Infrastructure Investment	**4.1768**	**2.8789**	**4.3952**	**5.0430**
Road Transportation	**1.1940**	**0.7409**	**1.3199**	**1.5186**
National Roads	0.5174	0.3297	0.6055	0.5718
Municipal Roads	0.3615	0.3379	0.4139	0.3604
Highways	0.3151	0.0732	0.3005	0.5864
Other Transportation	**0.3798**	**0.2183**	**0.4682**	**0.4649**
Railroads	0.2855	0.1488	0.3720	0.3487
Airports	0.0506	0.0348	0.0620	0.0555
Ports	0.0438	0.0347	0.0342	0.0607
Social Infrastructures	**0.9564**	**0.8087**	**1.0764**	**1.0193**
Health	0.4591	0.2835	0.4740	0.6044
Education	0.4973	0.5252	0.6024	0.4149
Public Utilities	**1.6465**	**1.1111**	**1.5306**	**2.0401**
Water and Wastewater	0.3121	0.1424	0.2684	0.4156
Petroleum Refining	0.1569	0.0948	0.1797	0.1466
Electricity and Gas	0.6051	0.4615	0.3801	0.8714
Telecommunications	0.5725	0.4123	0.7024	0.6066

Table 4. Regional Infrastructure Investments as a % of GDP

	Total Infrastructures	Road Infrastructures	Other Transportation Infrastructures	Social Infrastructures
North				
1980-2011	0.7796	0.3961	0.0898	0.2937
1980-89	0.5502	0.2551	0.0539	0.2412
1990-99	0.8386	0.4302	0.0785	0.3299
2000-09	0.9538	0.4892	0.1419	0.3227
Centre				
1980-2011	0.6639	0.3505	0.0769	0.2365
1980-89	0.5050	0.2468	0.0417	0.2165
1990-99	0.6681	0.3135	0.0986	0.2560
2000-09	0.8380	0.5053	0.0878	0.2449
Lisbon				
1980-2011	0.6283	0.1868	0.1348	0.3067
1980-89	0.4535	0.1218	0.0704	0.2613
1990-99	0.8433	0.3169	0.1709	0.3555
2000-09	0.6127	0.1267	0.1712	0.3148
Alentejo				
1980-2011	0.3159	0.1798	0.0587	0.0774
1980-89	0.1718	0.0700	0.0367	0.0651
1990-99	0.3682	0.1737	0.1047	0.0898
2000-09	0.3979	0.2817	0.0369	0.0793
Algarve				
1980-2011	0.1426	0.0808	0.0196	0.0422
1980-89	0.0854	0.0472	0.0156	0.0226
1990-99	0.1464	0.0855	0.0155	0.0454
2000-09	0.2002	0.1155	0.0272	0.0575

Table 5. Regional Composition of Infrastructure Investment

	Total	**Road Infras.**	Nat. Roads	Munic. Roads	High ways	**Other Trans. Infras.**	Rail roads	Ports	Air ports	**Social Infras.**	Health	Educ
North												
1980-2011	30.81	33.33	31.53	36.38	29.92	23.60	21.63	25.87	27.39	30.36	24.31	35.63
1980-89	31.15	34.69	34.14	37.76	19.96	24.33	20.46	35.23	24.72	29.17	17.09	35.78
1990-99	29.28	32.22	32.09	33.00	32.35	17.02	16.96	17.89	14.41	30.55	27.78	32.69
2000-09	31.76	32.14	28.71	37.86	31.14	30.19	28.70	19.74	46.28	31.42	28.26	36.62
Centre												
1980-2011	26.24	29.76	27.81	27.27	43.91	20.44	26.30	10.62	0.00	25.20	32.17	21.61
1980-89	28.60	32.96	32.69	25.03	73.99	19.03	26.64	4.74	0.00	27.75	47.49	17.44
1990-99	23.32	24.40	25.91	24.40	20.83	21.63	27.02	3.95	0.00	24.07	26.78	22.36
2000-09	27.91	33.21	25.33	31.08	44.16	19.16	22.74	23.61	0.00	24.03	24.09	24.08
Lisbon												
1980-2011	24.83	16.12	15.60	19.38	12.89	35.37	31.96	37.56	57.08	31.96	29.09	31.80
1980-89	25.68	16.55	16.70	18.60	6.06	32.84	28.52	35.82	57.90	32.31	20.62	38.33
1990-99	29.44	23.70	21.02	27.17	25.23	36.65	32.78	41.34	72.43	32.64	31.26	33.11
2000-09	20.41	8.63	10.16	14.03	4.18	37.79	36.60	38.33	38.91	31.01	33.71	26.60
Alentejo												
1980-2011	12.48	14.13	17.82	9.98	10.80	15.25	15.65	24.62	0.00	8.14	10.46	6.50
1980-89	9.73	9.42	10.74	10.38	0.00	17.00	18.67	23.42	0.00	7.94	12.25	5.42
1990-99	12.85	12.82	10.57	8.81	21.49	21.27	20.06	36.34	0.00	8.54	11.18	6.69
2000-09	13.25	18.83	29.88	10.29	12.70	7.37	7.45	15.68	0.00	7.86	8.18	7.33
Algarve												
1980-2011	5.64	6.65	7.25	6.99	2.49	5.35	4.47	1.33	15.52	4.34	3.97	4.46
1980-89	4.84	6.39	5.73	8.23	0.00	6.81	5.71	0.80	17.38	2.83	2.55	3.02
1990-99	5.11	6.87	10.41	6.63	0.09	3.43	3.18	0.48	13.16	4.21	3.00	5.14
2000-09	6.67	7.19	5.92	6.74	7.82	5.49	4.51	2.64	14.80	5.68	5.77	5.38

Investment in health facilities and educational buildings both figure heavily in investment in social infrastructures with health facilities accounting for 10.82% and educational buildings accounting for 12.94% of total infrastructure investment. Investment in health facilities amounted to 0.46% of GDP and investment in educational facilities amounted to 0.50% of GDP over the sample period. While both relatively important, their evolution through time is marked distinct. In particular, investment in health facilities has been increasing steadily both as a percent of GDP but also a percent of total infrastructure investment. In contrast, investment in educational buildings has been declining steadily in relation to the remaining infrastructure types. In addition, investment in educational facilities reached their highest levels, as a percent of GDP, in the 1990s, amounting to 0.60% of GDP. In turn, investment in health facilities reached its greatest volumes in the last decade and amounted to 0.60% of GDP.

Overall, infrastructure investments grew substantially in the last decades of the previous century to slow down in the last decade. They average 2.88% of the GDP in the 1980s, 4.40% in the 1990s and 5.05% over the first decade of the new millennium. The increase in infrastructure investment levels is particularly pronounced after 1986, the year in which Portugal joined the EU, and in the 1990s in the context of the EU Structural and Cohesion Funds, with the Community Support Framework I (1989-1993) and the Community Support Framework II (1994-1999). The investment effort decelerated substantially during the last decade during the Community Support Framework III (2000-2006) and the QREN (2007-2013). These landmark dates for joining the EU as well as the start of the different community support frameworks are all considered as potential candidates for structural breaks in every single step of the empirical analysis that follows.

The regional decomposition of infrastructure investments as a percentage of the GDP is summarized on Table 4, while the regional decomposition of investments in road infrastructures, other infrastructures, and social infrastructure is presented in Table 5.

Over the sample period, the North region concentrates the higher proportion of infrastructure investment, 30.81%, followed by Centre, with 26.24%, Lisbon with 24.84%, Alentejo with 12.49% and Algarve with 5.64%. Over the sample period North, Alentejo and Algarve show an increasing trend in terms of the relative importance of infrastructure investments in the region to reach 31.76%, 13.25%, and 6.67%, respectively.

As to the Centre it reached a low point in the nineties and has recovered in the last decade, the opposite being the case of Lisbon, where infrastructure investments peaked in the nineties and declined substantially in the last decade to reach just 20.41%.

In terms of the regional composition of investments in road infrastructures North captures the largest share, 33.33%, followed by Centre with 29.76% but with a low in the nineties with 24.40%, Lisbon with 16.12% but with a great decline in the 2000s with 8.64%. Alentejo and Algarve capture 14.13% and 6.65% and show a clearly increasing trend. In turn for investments in both other transportation infrastructures and social infrastructures, Lisbon is in the lead with 35.37% with an increasing trend over time for other transportation and 31.96% with a decreasing trend for social infrastructures. For these two types of infrastructure investment North captures the second largest share with an increasing tendency followed by Centre with relative stable shares. Alentejo shows a collapse in other transportation investments in the last decade while Algarve has a small but increasing share of social infrastructure investments.

3. Preliminary Data Analysis

3.1 Unit Roots, Co-integration, and VAR Specification

We start by using the Augmented Dickey-Fuller t-tests to test the null hypothesis of a unit root in the different variables. We use the Bayesian Information Criterion (BIC) to determine the number of lagged differences, the deterministic components, as well as the dummies for the potential structural breaks to be included. We find that stationarity in first differences is a good approximation for all series under consideration. This evidence is consistent with the conventional wisdom in the macro literature that aggregate output, employment, and private investment are I(1). Although our series are more disaggregated, the same pattern of stationarity is not surprising.

We test for co-integration for each region among output, employment, private investment, and infrastructure investment for each of the different infrastructure types. We use the standard Engle-Granger approach. We have chosen these procedures over the often used Johansen approach for two reasons. First, since we do not have any priors that suggest the possible existence of more than one co-integration relationship, the Johansen approach is not strictly necessary. More importantly, however, for smaller samples based on annual data, Johansen's tests are known to induce strong bias in favor of finding co-integration when it does not exist (although, arguably, the Engle Granger approach suffers from the opposite problem). Again, we use the BIC to determine the number of lagged differences, the deterministic components as well as dummies for the potential structural breaks to be included. As a general rule our tests cannot reject the null hypothesis of no co-integration. This is consistent with the view that it is unlikely to find co-integration at a more disaggregated level when we fail to find co-integration at the aggregate level.

The absence of cointegration is neither surprising nor problematic and is consistent with the relevant literature (see, for example, Pereira (2000) and Pereira and Andraz (2003) for the US case, Pereira and Roca (1999) for the Spanish case, and Pereira and Andraz (2005) and Pereira and Andraz (2006) for the Portuguese case). On one hand, it is not surprising to find lack of evidence for long-term equilibrium relationships for an economy that has a long way to go in its process of converging to European Union levels. This is so at a more aggregated level and even more so when we consider the data at the regional level and its interaction with aggregate infrastructure investment variables. On the other hand, the absence of cointegration is not problematic as it only implies that a less simultaneous and dynamic approach based exclusively on OLS univariate estimates using these variables' would lead to spurious results. Specifically, the existence of cointegration means that two variables tend to a fixed ratio that is that in the long-term they grow at the same rate. Absence of cointegration suggests that they do not grow at the same rate, that is, there are differentiated effects of infrastructure investments on the levels of the each of the other variables.

Having determined that all of the variables are stationary in first differences and that they are not co-integrated, we follow the standard procedure and estimate VAR models using growth rates of the original variables. We estimate five region specific VAR models for each of the different infrastructure types. Each VAR model includes output, employment, and private investment in the region as well as the relevant infrastructure investment variables, both infrastructure investment in the region and infrastructure investment elsewhere. This means that, consistent with our conceptual arguments, the infrastructure investment variables are endogenous variables throughout the estimation procedure. We use the BIC to determine structural breaks and deterministic components to be included. Our test results suggest that a VAR specification of first order with a constant and a trend as well as structural breaks in 1989, 1994, and 2000 is the preferred choice in the overwhelming majority of the cases. Not surprisingly, most exceptions occur for Lisbon, region which was specially in the last decade less of a focus for the EU structural funds policies and for which, accordingly, several of the structural breaks are not significant.

One important point to mention in terms of the VAR estimates is that the matrices of contemporaneous correlations between the estimated residuals display typically a block diagonal pattern. Specifically, the contemporaneous correlations between innovations in infrastructure investments and the other variables tend to be substantially smaller, if significantly different from zero, than the correlations between the different pairs of innovations among the other variables. As a corollary, the effects of the innovations in infrastructure investment are very robust to the orthogonalization mechanisms, a matter that we further discuss below.

3.2 Identifying Exogenous Innovations in Infrastructure Investment

We use the impulse-response functions associated with the estimated VAR models to obtain the effects of innovations in infrastructure investment on output, employment, and private investment. While the infrastructure investments are endogenous in the context of the VAR models, the central issue in determining the impact of infrastructure investment is the identification of exogenous shocks to these variables. These exogenous shocks represent innovations in infrastructure investments, both in the region and elsewhere, that are not contaminated by other contemporaneous innovations and, therefore, avoid contemporaneous reverse causation issues.

In dealing with this issue we draw from the approach typically followed in the literature on the effects of monetary policy (see, for example, Christiano, Eichenbaum, & Evans, 1996, 1999; and Rudebusch, 1998) and adopted by Pereira (2000) in the context of the analysis of the effects of infrastructure investment.

Ideally, the identification of shocks to infrastructure investment, which are uncorrelated with shocks in other variables would result from knowing what fraction of the government appropriations in each period is due to purely non-economic reasons. The econometric counterpart to this idea is to consider a policy function, which relates the rate of growth of infrastructure investment in the region to the information in the relevant information set; in our case, the past and current observations of the growth rates of the economic variables. The residuals from this policy functions reflect the unexpected component of the evolution of infrastructure investment and are, by definition, uncorrelated with innovations in other variables.

We assume that the information set for the relevant policy makers includes past values but not current values of the aggregate private sector variables. This is equivalent in the context of the standard Choleski decomposition to assuming that innovations in infrastructure investments lead innovations in the other variables. Therefore, while innovations in infrastructure investment affect the other variables contemporaneously, the reverse is not true.

We have several reasons for making this our central assumption. First, it seems reasonable to assume that the economy reacts within a year to innovations in infrastructure investments. Second, it also seems reasonable to assume that the public sector is unable to adjust infrastructure investment decisions to innovations in the economic variables within a year. This is due to the time lags involved in information gathering and public decision-making. Moreover, this assumption is particularly plausible at the regional level. This is because most of the regional infrastructure investment is financed by at the national level. We would expect innovations in national funding decisions to be even less correlated with innovations in regional economic variables than innovations in aggregate infrastructure investment with innovations in aggregate economic variables.

This assumption is also adequate from a statistical perspective. Indeed, invariably, the policy functions point to the exogeneity of the innovations in infrastructure investment, i.e., the evolution of the different infrastructure investments does not seem to be affected by the lagged evolution of the remaining variables. This is to be expected because infrastructure investments were very much linked to EU support programs and therefore not responsive to the ongoing economic conditions and regardless we would not expect any single economic sector to have an impact on decision making for infrastructure investments at the national level. Furthermore, and in a more technical vein, when we added to the policy functions contemporaneous values for the economic variables in addition to the lagged values, again, invariably, the estimated coefficients' were not significant. This is consistent with the block diagonal patterns we found for the matrices of contemporaneous correlations among the estimated residuals.

The identification of exogenous innovations in infrastructure investment has an additional dimension at the regional level as we consider both infrastructure investment in the region and infrastructure investment elsewhere. Indeed, we need to consider the contemporaneous relationship between innovations in infrastructure investment in the region and innovations in infrastructure investment outside the region. Here our assumption is that innovations in infrastructure investment outside any given region lead innovations in infrastructure investment in the region. This means that innovations in infrastructure investment outside the region affect contemporaneously innovations of infrastructure investment in the region but the reverse is not true.

This assumption is justified by the fact that, despite the small number of regions, the fraction of infrastructure investment undertaken in any given region is always substantially smaller than the infrastructure investments undertaken in the rest of the country. Besides, the alternative assumption of having investments in a given the region leading would not only be clearly inaccurate as a general matter but would also lead to contradictions across regions, as naturally not all regions could be leading simultaneously.

3.3 Measuring the Effects of Innovations in Infrastructure Investment

We consider the effects of one-percentage point, one-time shocks in the rates of growth of the different types of infrastructure investments both in the region and elsewhere, on output, employment, and private investment in the region. We expect these temporary shocks to have temporary effects on the growth rates of the other variables and, therefore, to have permanent effects on their levels. Since the temporary effects are different for different variables, the level effects will also be different. This implies changes in the long-term observed ratios between the different variables, which is consistent with the absence of evidence of co-integration.

We compute the accumulated impulse-response functions and the corresponding 90% standard deviation bands for each of the five regions and for each of the eight infrastructure assets, i.e., forty region-infrastructure specific cases. These figures show the cumulative effects of shocks on infrastructure investments based on the historical record of thirty-two years of data as filtered through the VAR and the reaction function estimates**.** We observe that without exception the accumulated impulse response functions converge within a relatively short time period suggesting that most of the growth rate effects occur within the first ten years after the shocks occur. Accordingly, we present the accumulated impulse response results for only a twenty-year horizon.

The error bands surrounding the point estimates for the accumulated impulse responses convey uncertainty around estimation and are computed via bootstrapping methods. We consider 90% intervals although bands that correspond to a 68% posterior probability are the standard in the literature (Sims & Zha, 1999). Employing one standard deviation bands narrows the range of values that characterize the likelihood shape and only serves to reinforce and strengthen our results. Further evidence exists that nominal coverage distances may under represent the true coverage in a variety of situations (Kilian, 1998). Similarly, placing too great a weight on the intervals presented in evaluating significance in unwarranted in all but the most extreme cases. Thus, the bands presented are wider than the true coverage would suggest. From a practical perspective, when the 90% error bands for the accumulated impulse response functions include zero in a way that is not marginal (to allow for the difference between the 90% and 68% posterior probability) we consider that the effects are not significantly different from zero.

To measure the effects of shocks in infrastructure investment both in the region and elsewhere, we calculate the long-term elasticities and the long-term marginal products of the different economic variables with respect to each type of infrastructure investment. These concepts depart from the conventional understandings because they are not based on *ceteris paribus* assumptions, but rather include all the dynamic feedback effects among the different variables. Naturally, these are the relevant concepts from the standpoint of policy making.

The estimates of the long-term accumulated elasticities of regional private investment, employment and output with respect to infrastructure investment in the region and elsewhere are obtained as the ratio of the total accumulated percentage point long-term change in a variable and the percentage point accumulated long-term change in infrastructure investment in the region or elsewhere.

Based on these elasticities we calculate the long-term accumulated marginal products for regional private investment, employment and output with respect to infrastructure investment in the region and elsewhere. These marginal products measure the euro change in regional private investment and output, and the number of permanent jobs regionally created, for each additional dollar of investment in infrastructures either in the region or elsewhere. The marginal product figures are obtained by multiplying the average ratio of each regional variable to infrastructure investment in the region or elsewhere, by the corresponding elasticity. Accordingly, the marginal product figures are the most interesting from a policy perspective as they capture both the effects of scarcity and the effects of the structural coupling of infrastructure investments and the regional economy as reflected in the elasticities figures.

In computing the marginal products, we use the average ratio of the economic variable to the level of infrastructure investment over the last ten years of the sample. This allows the marginal products to reflect the relative scarcity of the different types of infrastructures at the margin of the sample period without letting these ratios be overly affected by business cycle factors or other incidental regional factors in any given year.

The marginal product figures at the regional level are weighted figures. This means that the raw marginal products for each region are multiplied by the average share of regional infrastructure investment in aggregate infrastructure investment for the last ten years. This allows us to interpret the sum on the regional marginal products as the combined effect of one euro in aggregate infrastructure investment given the regional decomposition of infrastructure investment. Therefore, the sum of the disaggregated figures obtained from the regional-specific models is directly comparable to the marginal product figure for the whole country.

4. On the Regional Effects of Infrastructure Investment

4.1 Framing the Empirical Effects of Infrastructure Investments

We start by framing the regional effects of infrastructure investments by addressing the issue of the aggregate effects for the whole country as measured by the sum of the direct effects for each region from investments in the region and the spillover effects for each region from investments elsewhere. These results for each assets are reported in the total rows of Tables 6, 7, and 8 for road infrastructures, other transportation infrastructures, and social infrastructures, respectively.

We find that the largest aggregate effects for the country are from infrastructure investment in municipal roads, airports, ports, and education, with long-term output marginal products of 15.437, 27.069, 40.787, and 35.363, respectively. More moderate effects accrue to investments in national roads and health with 9.167 and 11.111, while the effects of investments in highways and railroads are clearly smaller, with 4.505 and 2.619.

Table 6. Marginal Product with respect to Road Transportation Investment

	Private Investment			Employment			Output		
	In the region	In other regions	Total	In the region	In other regions	Total	In the region	In other regions	Total
National Roads									
North	3.184	1.879	5.064	0.153	-0.031	0.122	3.006	0.817*	3.823
Centre	-0.056*	1.205	1.149	0.044	-0.055	-0.011	-0.828*	0.035*	-0.793
Lisbon	-0.571*	4.759	4.188	-0.009*	0.126	0.116	0.160*	5.340	5.499
Alentejo	0.515	0.902	1.418	-0.013	-0.028	-0.041	0.412	0.704	1.116
Algarve	-0.028*	-0.306*	-0.333	0.000*	-0.027	-0.028	0.005*	-0.483	-0.478
	3.046	8.439	11.486	0.175	-0.016	0.159	2.755	6.413	9.167
Municipal Roads									
North	-2.407*	4.630	2.223	0.014*	0.127	0.141	-4.603*	4.863	0.259
Centre	2.131	5.647	7.778	-0.103	0.123	0.020	0.295*	8.566	8.861
Lisbon	3.918	0.873*	4.790	0.017*	0.120	0.137	4.121	2.001*	6.123
Alentejo	0.952	1.953	2.905	-0.009*	0.015	0.006	0.168*	0.496*	0.664
Algarve	-0.710	0.510	-0.200	-0.011*	0.034	0.024	-1.136	0.766	-0.370
	3.883	13.613	17.497	-0.092	0.420	0.328	-1.156	16.692	15.537
Highways									
North	0.477	0.787	1.264	0.020	0.011*	0.031	0.684	0.603	1.286
Centre	-0.667	0.354	-0.313	-0.015	0.002*	-0.013	-0.982	0.626	-0.356
Lisbon	0.205*	1.160	1.365	0.000*	0.024	0.023	0.243*	1.051	1.294
Alentejo	-0.008*	0.410	0.403	0.000*	-0.008	-0.009	-0.015*	0.410	0.395
Algarve	0.016*	0.127	0.143	0.000*	-0.002*	-0.002	0.017*	-0.017*	-0.001
	0.024	2.838	2.861	0.005	0.027	0.031	-0.054	2.673	2.619

(*) The estimates marked with asterisk are not significantly different from zero as implied by the standard deviation bands around the accumulated impulse response functions.

Of the total effects, it is informative to consider the part that reflects for each region, spillovers from investments in other regions. Our results indicate that these spillovers are very important across the board, although naturally with important nuances. For example for the output effects, spillovers correspond to 100% of the observed effects for municipal roads and highways while for railroads they correspond to 85.0%. On the lower range, for national roads, airports, ports, education, and health, the spillovers are 69.9%, 45.1%, 65.7%, 63.9%, and 58.9%, respectively. As a general statement for employment, private investment, and output, spillovers are particularly relevant for municipal roads and highways. On the flip side, investments in national roads and airports show relatively low spillover effects.

Table 7. Marginal Product with Respect to Other Transportation Investment

	Private Investment			Employment			Output		
	In the region	In other regions	Total	In the region	In other regions	Total	In the region	In other regions	Total
Railroads									
North	0.1205*	4.2795	4.400	0.0667*	0.0882	0.155	1.5394	1.6958	3.235
Centre	-1.3866	2.0744	0.688	-0.0469	0.0367	-0.010	-3.1057	3.0399	-0.066
Lisbon	3.4170	-3.5105	-0.093	0.0478	0.0178*	0.066	2.4780	-1.8618*	0.616
Alentejo	0.2650	1.7665	2.032	-0.0075	-0.0350	-0.042	-0.2827	0.8342	0.552
Algarve	0.0102*	-0.0336	-0.023	0.0010*	-0.0120	-0.011	0.0467*	0.1212*	0.168
	2.426	4.576	7.003	0.061	0.096	0.157	0.676	3.829	4.505
Airports									
North	4.2989	3.1296	7.428	0.1749	-0.0463*	0.129	6.6222	-0.1751*	6.447
Centre	-	4.0113	4.011	-	-0.1035*	-0.104	-	3.3040	3.304
Lisbon	5.9634	2.9037	8.867	0.1790	0.1580	0.337	7.9884	4.9526	12.941
Alentejo	-	4.8130	4.813	-	-0.0876	-0.088	-	2.5506	2.551
Algarve	0.8847	-0.3879*	0.497	-0.0148*	0.0222*	0.007	0.0384*	1.7881	1.827
	11.147	14.470	25.617	0.339	-0.057	0.282	14.649	12.420	27.069
Ports									
North	1.5570	1.0461*	2.603	0.0417	0.0330*	0.075	1.4881*	4.2738*	5.762
Centre	6.0348	7.3323	13.367	0.0884	0.1934	0.282	10.2370	7.3086	17.546
Lisbon	-4.9653*	-3.0760*	-8.041	-0.0593*	0.0331*	-0.026	2.3285*	12.1067	14.435
Alentejo	-0.7318	2.9416	2.210	-0.0061*	0.1421	0.136	-0.0811*	0.0220*	-0.059
Algarve	0.0025	1.7806	1.783	0.0008*	0.0841	0.085	0.0095*	3.0934	3.103
	1.897	10.025	11.922	0.066	0.486	0.551	13.982	26.804	40.787

(*) The estimates marked with asterisk are not significantly different from zero as implied by the standard deviation bands around the accumulated impulse response functions.

4.2 On the Regional Effects of Infrastructure Investments by Asset

Having presented the effects of investments on different infrastructure assets at the aggregate level, we now turn to the decomposition of these effects at the regional level. The idea is to identify for each infrastructure asset the regions that benefit the most, when we account for both the effects of investments in the region and spillover effects from investments elsewhere. We focus our discussion on the output effects although in most, but not all cases, the effects on private investment and employment show similar patterns. The results are reported in Tables 6, 7, and 8, for road infrastructure, other transportation infrastructures, and social infrastructures, respectively.

Table 8. Marginal Product with Respect to Investment in Social Infrastructures

	Private Investment			Employment			Output		
	In the region	In other regions	Total	In the region	In other regions	Total	In the region	In other regions	Total
Education									
North	1.677	8.415	10.093	0.041	0.287	0.328	1.162*	11.879	13.041
Centre	3.801	6.686	10.486	0.134	0.079	0.212	7.047	8.131	15.177
Lisbon	0.895*	4.835	5.731	0.069	0.175	0.244	4.307	1.067*	5.375
Alentejo	-1.373*	2.248	0.874	0.048	0.026	0.074	-0.495*	2.313	1.818
Algarve	0.564*	0.252*	0.816	-0.003*	0.022	0.019	0.732	-0.780	-0.048
	5.564	22.437	28.001	0.289	0.589	0.877	12.753	22.610	35.363
Health									
North	1.328	1.647	2.975	0.044	0.120	0.164	2.761	2.038	4.799
Centre	0.681	2.808	3.490	0.027	0.037	0.064	1.179	3.281	4.459
Lisbon	0.120	2.730	2.850	0.004	0.055	0.059	0.187*	1.352*	1.540
Alentejo	0.375	1.645	2.020	-0.007	0.006	-0.001	0.411	1.360	1.770
Algarve	0.015*	-0.041*	-0.026	-0.004	-0.029	-0.033	0.026*	-1.483	-1.457
	2.519	8.789	11.308	0.064	0.189	0.253	4.563	6.548	11.111

(*) The estimates marked with asterisk are not significantly different from zero as implied by the standard deviation bands around the accumulated impulse response functions.

For road infrastructures, the largest effects for investments in national roads occur in North and Lisbon, with marginal products of 3.823 and 5.499. The effects for Lisbon are mostly due to spillovers from investments in other regions. For municipal roads, the largest output effects occur in Centre and Lisbon, with 8.861 and 6.123 and, here, spillovers are important in both cases, but particularly relevant in Centre. Finally, for highways the effects are small across the board.

With respect to other transportation infrastructures, the only region that benefits in a meaningful way from railroad investments is North with 3.235. Output spillovers effects are very important for both North and Centre. In the case of Centre they offset detrimental effects from investments in the region itself. As to investments in airports, the largest benefits occur in North and Lisbon with 6.447 and 12.941. Spillovers are relevant in Lisbon as well as in Centre and Alentejo where no major airports are located. Finally, for investments in ports the largest effects occur in Centre and Lisbon with 17.546 and 14.435, with the effects in North and Algarve very important as well. Spillover effects are relevant for all regions except Alentejo and are the bulk of the effects for North, Lisbon, and Algarve.

Finally, for social infrastructures, investments in education benefit both the North and Centre with 13.040, and 15.177, and to a lesser extent Lisbon with 5.375. Output spillover effects are particularly important for North and Centre as well as Alentejo. In terms of infrastructures in health the largest effects occur in North and Centre as well with marginal products of 4.799 and 4.459, respectively. In both cases as well as in Alentejo, spillovers are very significant.

4.3 On the Effects of Infrastructure Investments by Region

We consider now the results from a different perspective, i.e., for each region we want to identify which infrastructure assets lead to the greatest effects when we consider both the direct effects of investments in the region itself and the spillover effects captured by the region from investments in other regions. We still consider Tables 6, 7, and 8, and again focus on the output effects – the effects on employment and private investment following similar patterns.

For North, the largest output effects come from investments in education with 13.041, and to a lesser extent in airports and health with 6.447 and 4.799, respectively. This region captures sizable spillover effects from investments in education and municipal roads elsewhere.

For Centre, the largest output effects are due to investments in ports and education with marginal products of 17.546 and 15.177, respectively, and to a lesser extent municipal roads and health with 8.861 and 4.459. In each of these cases spillovers from investments elsewhere are very significant. Spillovers are also significant from investments in railroads and airports.

As to Lisbon, the best output effects come from investments in airports and ports with 12.941 and 14.435 and to a lesser extent national roads, municipal roads and education with 5.499, 6.123, and 5.375. Output spillovers are particularly strong for investments in national roads and ports and still very significant for investments in municipal roads and airports.

Finally, for Alentejo and Algarve, all effects are relatively small and the spillovers not very sizable. For Alentejo, the largest effects come from investments in airports and education and are due to spillover effects from investments elsewhere while for Algarve the largest effects are from investments in airports and ports and are also due mostly to spillovers.

4.4 On the Effects Infrastructure Investments on the Regional Mix of Economic Activity

In this section, we probe more formally into the issue of which regions benefit the most from infrastructure investments. We want to identify the effects of infrastructure investment on the regional mix of economic activity in the country.

Table 9. Effects of Road Infrastructure Investment on the Regional Economic Composition

National Roads	**North**	**Centre**	**Lisbon**	**Alentejo**	**Algarve**
Private Investment					
Share of Benefits	42.85	9.72	35.44	12.00	0.00
Share of GFCF	28.90	21.12	35.92	8.23	5.83
Ratio	1.48	0.46	0.99	1.46	0.00
Employment					
Share of Benefits	51.07	0.00	48.93	0.00	0.00
Share of Employment	35.01	24.37	30.03	6.34	4.25
Ratio	1.46	0.00	1.63	0.00	0.00
Output					
Share of Benefits	36.62	0.00*	52.68	10.69	0.00
Share of Output	29.59	19.80	39.05	6.99	4.56
Ratio	1.24	0.00	1.35	1.53	0.00
Municipal Roads	**North**	**Centre**	**Lisbon**	**Alentejo**	**Algarve**
Private Investment					
Share of Benefits	12.56	43.95	27.07	16.42	0.00
Share of GFCF	28.90	21.12	35.92	8.23	5.83
Ratio	0.43	2.08	0.75	2.00	0.00
Employment					
Share of Benefits	43.08	6.02	41.90	1.76	7.23
Share of Employment	35.01	24.37	30.03	6.34	4.25
Ratio	1.23	0.25	1.40	0.28	1.70
Output					
Share of Benefits	1.63	55.71	38.49	4.17	0.00
Share of Output	29.59	19.80	39.05	6.99	4.56
Ratio	0.06	2.81	0.99	0.60	0.00
Highways	**North**	**Centre**	**Lisbon**	**Alentejo**	**Algarve**
Private Investment					
Share of Benefits	39.81	0.00	42.99	12.68	4.51
Share of GFCF	28.90	21.12	35.92	8.23	5.83
Ratio	1.38	0.00	1.20	1.54	0.77
Employment					
Share of Benefits	57.38	0.00	42.62	0.00	0.00
Share of Employment	35.01	24.37	30.03	6.34	4.25
Ratio	1.64	0.00	1.42	0.00	0.00
Output					
Share of Benefits	43.23	0.00	43.49	13.29	0.00
Share of Output	29.59	19.80	39.05	6.99	4.56
Ratio	1.46	0.00	1.11	1.90	0.00

Table 10. Effects of Other Transportation Investment on the Regional Economic Composition

Railroads	**North**	**Centre**	**Lisbon**	**Alentejo**	**Algarve**
Private Investment					
Share of Benefits	61.80	9.66	0.00	28.53	0.00
Share of GFCF	28.90	21.12	35.92	8.23	5.83
Ratio	2.14	0.46	0.00	3.47	0.00
Employment					
Share of Benefits	70.24	0.00	29.76	0.00	0.00
Share of Employment	35.01	24.37	30.03	6.34	4.25
Ratio	2.01	0.00	0.99	0.00	0.00
Output					
Share of Benefits	70.78	0.00	13.48	12.07	3.67
Share of Output	29.59	19.80	39.05	6.99	4.56
Ratio	2.39	0.00	0.35	1.73	0.81
Airports	**North**	**Centre**	**Lisbon**	**Alentejo**	**Algarve**
Private Investment					
Share of Benefits	29.00	15.66	34.61	18.79	1.94
Share of GFCF	28.90	21.12	35.92	8.23	5.83
Ratio	1.00	0.74	0.96	2.28	0.33
Employment					
Share of Benefits	27.20	0.00	71.24	0.00	1.56
Share of Employment	35.01	24.37	30.03	6.34	4.25
Ratio	0.78	0.00	2.37	0.00	0.37
Output					
Share of Benefits	23.82	12.21	47.81	9.42	6.75
Share of Output	29.59	19.80	39.05	6.99	4.56
Ratio	0.80	0.62	1.22	1.35	1.48
Ports	**North**	**Centre**	**Lisbon**	**Alentejo**	**Algarve**
Private Investment					
Share of Benefits	13.04	66.96	0.00	11.07	8.93
Share of GFCF	28.90	21.12	35.92	8.23	5.83
Ratio	0.45	3.17	0.00	1.35	1.53
Employment					
Share of Benefits	12.94	48.80	0.00	23.57	14.69
Share of Employment	35.01	24.37	30.03	6.34	4.25
Ratio	0.37	2.00	0.00	3.72	3.45
Output					
Share of Benefits	5.76	17.55	14.44	-0.06	3.10
Share of Benefits	14.11	42.96	35.34	0.00	7.60
Ratio	0.48	2.17	0.90	0.00	1.67

Table 11. Effects of Social Infrastructure Investment on the Regional Economic Composition

Education Infrastructures	**North**	**Centre**	**Lisbon**	**Alentejo**	**Algarve**
Private Investment					
Share of Benefits	36.05	37.45	20.47	3.12	2.92
Share of GFCF	28.90	21.12	35.92	8.23	5.83
Ratio	1.25	1.77	0.57	0.38	0.50
Employment					
Share of Benefits	37.35	24.20	27.81	8.49	2.15
Share of Employment	35.01	24.37	30.03	6.34	4.25
Ratio	1.07	0.99	0.93	1.34	0.51
Output					
Share of Benefits	36.83	42.86	15.18	5.13	0.00
Share of Output	29.59	19.80	39.05	6.99	4.56
Ratio	1.24	2.16	0.39	0.73	0.00
Health Infrastructures	**North**	**Centre**	**Lisbon**	**Alentejo**	**Algarve**
Private Investment					
Share of Benefits	26.25	30.79	25.14	17.82	0.00
Share of GFCF	28.90	21.12	35.92	8.23	5.83
Ratio	0.91	1.46	0.70	2.17	0.00
Employment					
Share of Benefits	57.04	22.35	20.61	0.00	0.00
Share of Employment	35.01	24.37	30.03	6.34	4.25
Ratio	1.63	0.92	0.69	0.00	0.00
Output					
Share of Benefits	38.18	35.48	12.25	14.09	0.00
Share of Output	29.59	19.80	39.05	6.99	4.56
Ratio	1.29	1.79	0.31	2.01	0.00

To analyze the effects of infrastructure investments on the regional mix, we need to move beyond the magnitude of the effects of infrastructure investments in absolute terms and turn to the effects in relative terms. This means, first, for each region the size of its effects relative to the total effects for all regions and, second, these shares relative to the size of the region. The point is that the small effects for certain regions, maybe just a reflection of the fact that these regions are small. Furthermore, even small effects are significant if the share of the total effects they represent exceeds the share of the region in the total economy. In this case, the marginal effects induced by the infrastructure investments exceed the average size of the region and as such infrastructure investments tend to make such region relatively more important in the regional mix. The results of infrastructure investments in the regional economic composition are reported in Tables 9, 10, and 11, for road infrastructures, other transportation infrastructures, and social infrastructures, respectively. As before, we focus our discussion on the effects on the regional output mix. The effects on the regional mix of employment and private investment are also reported in the same tables and follow in broad strokes the same patterns.

For road transportation infrastructures, investments in national roads and highways shift the output regional mix towards North, Lisbon, and Alentejo, while investments in municipal roads have the same effects for Centre. None of the investments in road infrastructure assets shifts the composition of regional output toward Algarve.

For other transportation infrastructures the shifts in regional output composition occur in North and Alentejo for railroad investments, Lisbon, Alentejo, and Algarve for airport investment, and Centre and Algarve for port infrastructure investments. This means that every region benefits in relative terms from investments in one of the other transportation infrastructure assets.

Finally, for social infrastructures, investments in both education and health shift the regional output mix towards North and Centre, for health infrastructures, towards the Alentejo as well. Accordingly, Lisbon and Algarve do not benefit in relative terms from either education or health infrastructure investments.

If we look at this issue from the perspective of each region, the relative importance of North in the regional output mix is enhanced by investments in national roads, highways, railroads, education, and health while the relative importance of Centre is enhanced by investments in municipal roads, ports, education, and health. For Lisbon, its relative importance in the regional output mix is increased by investments in national roads, highways, and airports.

For Alentejo the relative importance increases with investments in national roads, highways, railroads, airports and health. Finally, Algarve sees its output share increased by only investments in airports and ports.

5. Summary and Concluding Remarks

In this paper we deal with the issue of identifying empirically the effects of infrastructure investments on the regional mix of economic activity in Portugal. To address this issue we use a new data set for infrastructure investments in Portugal at the level of the NUTS II regions. We use a region-specific VAR approach, which considers for each region not only the effects of infrastructure investments in the region itself but also the regional spillover effects for each region from infrastructure investments elsewhere.

Our results can be summarized as follows. First, we find that considering all of the direct and spillover effects for all regions, the infrastructure investments with the largest aggregate effects are in municipal roads, airports, ports, and education, while more moderate effects stem from investments in national roads and health and the effects of investments in highways and railroads are clearly the smallest. Regional spillovers are very important across the board, and are particularly relevant for municipal roads and highways. On the flip side, investments in national roads and airports show relatively low spillover effects.

Second, when we consider the regional effects of infrastructure investments in terms of their absolute magnitude we observe that in terms of road infrastructures, the largest effects for investments in national roads occur in North and Lisbon, the effects for Lisbon being mostly due to spillovers. For investments on municipal roads, the largest effects occur in Centre and Lisbon with spillovers particularly relevant in Centre while for investments in highways the effects are small across the board. For other transportation the only region that benefits in a meaningful way from railroad investments is North with important spillover effects. As to investments in airports, the largest benefits occur in North and Lisbon with spillovers relevant in Lisbon, while for investments in ports the largest effects occur in Centre and Lisbon, with spillover representing the bulk of the effects for Lisbon. Finally, investments in educational and health facilities benefit mostly North and Centre, in both cases with important spillover effects.

Third, when we consider the regional effects of infrastructure investments in terms of their magnitude relative to size of the region, we find that for road transportation, investments in national roads shift the output regional mix towards North, Lisbon, and Alentejo. Investments in municipal roads have the same effect for Centre and investments in highways once again in the North, Lisbon and Alentejo. For other transportation the shifts in regional output composition occur in North and Alentejo for railroad investments, Lisbon, Alentejo, and Algarve for airport investment, and Centre and Algarve for port investments. Finally, investments in both education and health shift the regional output mix towards North and Centre, and for health infrastructures, towards the Alentejo as well.

Our results have some important policy implications. The regional disaggregation of aggregate effects of infrastructure investments shows a wide disparity of effects, the prevalence of regional spillovers, and important shifts in the regional economic mix. This suggests that emphasis on road investments in the last few decades, for example, may have shifted economic activity away from Centre and even more so Algarve. These ideas are also important to keep in mind in the design of new infrastructure investments. For example, a new focus on other transportation infrastructures may have more balanced regional effects while a new focus on social infrastructures shifts the regional mix for North and Centre.

To conclude, although this paper is an application to the Portuguese case and is intended to be directly relevant from the perspective of policy making in Portugal, its interest is far from parochial. From a methodological perspective and from the standpoint of policy making, the issue of determining empirically the effects of infrastructure investment efforts on the regional economic mix provides critical information, most often than not absent, to the adequate design by any country of development strategies that rely to any meaningful extent on infrastructure investments. In fact, it is critical that improving the overall economic standing of a country should not be done at the cost of increasing the regional disparities in the country.

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