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ORIGINAL ARTICLE

Infrastructure investment and employment: Evidence for Portugal

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ABSTRACT

We estimated how investment in 12 infrastructure types affects employment in Portugal. Using a vector-autoregressive specification at the industry level, we found a double dividend associated with ports and airports: investing in either delivers the greatest bang per euro, both on impact and in the long run. One million euros invested in ports and airports creates 717.1 and 290.5 jobs in the long run, respectively, and 535 and 253.3 jobs in the short run, respectively. Regarding long-term employment effects, these are followed by municipal roads, telecommunications, national roads, health structures, education facilities, refineries, railroads, and highways. Water infrastructures and electricity and gas infrastructures have negligible effects. With the long-term effects decomposed, sizable supply-side employment effects for health and education facilities exist, while demand-side effects dominate for airports, ports, municipal roads, and telecommunications. Employment following the investment in national roads is balanced across demand and supply channels. We found no significant employment-related location effects of infrastructure investments. Also, investing in either health facilities or in education buildings entails non-negligible job losses in the short run. These results suggest that the magnitude and the timing of job creation crucially depend on the type of infrastructure investment. Policymakers in Portugal need to be aware of this in choosing between countercyclical or structural targets.

Keywords: *infrastructure investment; employment; vector autoregression; countercyclical policy; structural policy; Portugal*

1. Introduction

Infrastructure investment in Portugal averaged 4.3% of GDP from 1980 through 2018. From just 3.2% of GDP in the 1980s, it gained momentum until the European sovereign debt crisis, tallying 5.4% of GDP in the 2000s. In the extraordinary setting of persistent public budgetary restraint and disappointing macroeconomic performance, it has since decelerated to 3.9% of GDP.

Through consecutive Community Support Frameworks, Portugal's very significant infrastructure investment over the past forty years has been mostly linked to EU structural policies aimed at improving long-

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term international competitiveness and closing the gap in persistent differences in standards of living among EU member states (European Commission, 1990; Gurría, 2014).

From an economic policy perspective, there are two reasons to advocate public investment (Eisner, 1986). First, in the context of endogenous growth mechanisms (see, for example, Barro (1990), Glomm and Ravikumar (1997), Futagami, Morita, and Shibata (1993), and Greiner and Hanusch (1998)), to strengthen an economy's structural capacity to produce, bottlenecks on its long-term performance need to be addressed. A policy of planned infrastructure investment adds to productive assets that enhance the long-term productivity of private sector inputs, such as labor and the stock of capital (see, for example, Aschauer (1989a, 1989b)).[1] Second, in addition to these supply-side effects, as a countercyclical policy instrument, for their short-term demand-side effects, infrastructure projects can also be justified. Keynes long argued that public investment should also be in the macroeconomic stabilization toolkit, in raising wage income, and in reducing the gap between saving and investment by making up for the immediate shortfall in the latter's private component (Brown-Collier and Collier, 1995). In a post-pandemic setting, such as the one we now experience, where it is urgent to jumpstart the economy, these concerns are even more pressing.

In this paper, we studied how infrastructure investment in Portugal affects employment. To best inform the ongoing policy debate, operating at the industry level, we estimated the number of net jobs created from 12 types of infrastructure investments.

We used a multivariate dynamic time-series approach that estimated industry- and infrastructure-specific vector autoregression (VAR) models. These models considered investments in 12 types of infrastructure assets of transportation, utilities, and social infrastructures and included industry-specific output, employment, and private investment for 22 industries that, together, spanned the whole spectrum of economic activities. This approach, developed in Pereira and Flores de Frutos (1999) and Pereira (2000, 2001), was subsequently applied to the US in Pereira and Andraz (2003, 2004), and to Portugal in Pereira and Andraz (2005, 2007, 2011) and Pereira and Pereira (2018, 2019, 2020). It is an econometric approach that not only highlights the dynamic and simultaneous relationship between infrastructure investments and the rest of the economy but furthermore accounts for such dynamic interactions in all relevant time frames: contemporaneously, over time,

1. For literature surveys on the key contribution of public capital to long-term economic performance, see Munnell (1992), Gramlich (1994), Kamps (2005), Romp and de Haan (2007), Pereira and Andraz (2013), and Bom and Ligthart (2014).

and in the long term.[2]

This empirical evidence allowed us not only to identify the relative importance of demand- and supply-side channels and their respective timings, but also to gain important insights into the industry-by-industry incidence of the employment effects of 12 infrastructure investments. Those are the two main contributions of this paper.

Crucially, we found that different types of infrastructure investments entail net job creation at different rhythms. As such, our results suggest that policymakers must choose wisely, depending on the horizon in which they seek maximum effects. This is key in the choice between countercyclical and structural policies.

This empirical analysis required a rather comprehensive dataset on infrastructure investments in Portugal between 1978 and 2011 (see Pereira and Pereira (2016))[3] that includes information on 12 types of infrastructure investments: national roads, municipal roads, highways, railroads, airports, ports, water and waste, electricity and gas, refineries, telecommunications, health facilities, and education buildings. Although this dataset has recently been partially updated through 2018 by the Gabinete de Estratégia e Estudos of the Portuguese Ministry of the Economy,[4] the results in this paper were obtained using data through 2011. This horizon was warranted for two reasons. First, regarding data on infrastructure investment, the most sensitive component in our analysis, several important methodological questions remained surrounding the internal consistency of these updates with the earlier dataset. Obtaining a comprehensive dataset for infrastructure investment for any economy for a reasonably long enough period is a rather challenging undertaking. The second reason had to do with the circumstances of the Portuguese economy in the 2010s. Following the Great Financial Crisis and then the European sovereign debt turbulence, there have been both extraordinary public budgetary restraint and persistently disappointing macroeconomic performance in Portugal since 2011. In this setting, infrastructure investment flows came to an almost screeching halt. As this period breaks with ongoing long-term economic trends, it is hardly typical in any meaningful structural way. Also, the adequate treatment of this structural break would require much longer time series than what is currently available.

To conclude, this study is both relevant and timely. Promoting long-term economic growth through public investment in a setting of fragile public budgets has long been acknowledged as a quest among international organizations (see, for example, European Central Bank (2016), European Commission (2014a, 2014b), Tressel et al. (2014), and International Monetary Fund (IMF) (2015)). More recently, with the need to first accelerate and then consolidate the post-COVID-19 economic recovery, there is also a growing chorus calling for infrastructure investment to play a stabilization

2. Our work also relates to the literature on fiscal multipliers, i.e., on the macroeconomic effects of taxes and government purchases (see, for example, Mineshima, Poplawski-Ribeiro, and Weber (2014) and Ramey (2011), for recent surveys of this literature). In fact, it is very much in the spirit of the approach pioneered by Blanchard and Perotti (2002), which is based on a VAR approach and uses the Cholesky decomposition to identify shocks in government spending. We focused, however, on a specific type of public spending—infrastructure investment—as opposed to aggregate spending, as is traditional in this literature. In this sense, our focus of this article is closer to Leduc and Wilson (2012).

3. This dataset was the result of a research project developed under the auspices of the *Fundação Francisco Manuel dos Santos* (FFMS), with the purpose of developing a comprehensive dataset on infrastructure investments in Portugal. This dataset was made available to the public in March of 2016 and, in the interim, the Portuguese Ministry of the Economy has acquired the rights to this dataset and has started the process of setting up the procedures for both maintaining and updating it as part of the official set of public statistics.

4. Available at https://www.gee.gov.pt/pt/publicacoes/indicadores-e-estatisticas/base-de-dados-de-infraestruturas.

role (see, for example, IMF (2020), Basdevant, Chaponda, Gonguet et al. (2020), and Wu (2021) or, in the wake of the Great Financial Crisis, relative to the US economy, Auerbach and Gale (2009), Bivens (2014), and, more recently, Haughwout (2019)).[5]

The rest of this paper is organized as follows. Section 2 presents a historical overview of the economic data in Portugal on both infrastructure investment by type of asset and industry-specific employment and GDP. Section 3 presents a preliminary data analysis involving nonstationarity, identification, and measurement issues. Section 4 exhibits a summary of the core econometric results. Section 5 concludes with a few policy implications.

2. Data sources and description

2.1. Infrastructure investment dataset

The data on infrastructure investment by type of asset were from a recently available set, first developed by Pereira and Pereira (2016), which goes back to 1978. Infrastructure investment is measured in millions of 2005 euros. We consider 12 types of infrastructural assets, which can be grouped into four main categories: road transportation, other transportation, utilities, and social infrastructures. **Table 1** summarizes the evolution of infrastructure investments in Portugal, measured 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 22.1% of total infrastructure investment between 1980 and 2018, averaging just under 1% of GDP during this period. Between 1990 and 2009, the motorways network was greatly extended. In absolute terms, infrastructure investment in road transportation increased from 0.75% of GDP in the 1980s to 1.4% in the 2010s. Since then, the relative importance of road transportation in total infrastructure investment has fallen to 9.1%, averaging just 0.36% of GDP between 2010 and 2018.

Between 1980 and 2018, the largest component of road transportation investments was national road investment, amounting to 0.4% of GDP and 9.1% of total infrastructure investment. What is most striking, however, is the substantial increase in investment in highways in the 2000s, when this type of infrastructure investment amounted to 0.5% of GDP, which was very close to national road infrastructure investment in importance, with highway investment amounting to 9.3% of total infrastructure investment compared with 9.9% for national roads. In contrast, the past forty years have seen a steady decline in the share of municipal roads in total infrastructure investment. However, in the 2010s, until 2018, municipal roads lost much less of their share than did national roads and highways, where each lost around 80%, compared with those in the 2000s.

Other transportation infrastructures include railroads, ports, and airports, accounting for 7.4% of total infrastructure investment and averaging 0.33% of GDP between 1980 and 2018. These investments reached their apex (almost 10% of total infrastructure investment) in the nineties with the modernization of the railroad network and port expansion projects. In the 2000s, investment in airports registered substantial growth. Similar to what happened with road transportation, the

[5] For a definitive assessment of both the theory and the empirics of the macroeconomic impact of infrastructure investment, especially in the short run, see Ramey (2020).

Table 1. Infrastructure investments by type of asset

	1980–2018	1980–89	1990–99	2000–09	2010–18
			Percent of GDP		
Infrastructure Investment	4.30	3.24	4.65	5.39	3.85
Road Transportation	0.97	0.75	1.31	1.40	0.36
National Roads	0.40	0.35	0.60	0.53	0.08
Municipal Roads	0.33	0.34	0.41	0.37	0.20
Highways	0.24	0.07	0.30	0.49	0.08
Other Transportation	0.33	0.22	0.47	0.47	0.15
Railroads	0.25	0.15	0.37	0.35	0.10
Ports	0.04	0.03	0.06	0.05	0.03
Airports	0.04	0.03	0.03	0.06	0.03
Utilities	1.97	1.46	1.86	2.40	2.19
Water and Waste Facilities	0.44	0.34	0.45	0.52	0.43
Petroleum Refining	0.14	0.09	0.18	0.15	0.13
Electricity and Gas	0.62	0.46	0.36	0.82	0.87
Telecommunications	0.78	0.56	0.86	0.92	0.74
Social Infrastructures	1.02	0.81	1.01	1.13	1.14
Health Facilities	0.44	0.28	0.45	0.53	0.52
Educational Buildings	0.58	0.53	0.57	0.60	0.62
			Percentage of Total Infrastructure Investment		
Infrastructure Investment	100.00	100.00	100.00	100.00	100.00
Road Transportation	22.09	23.42	28.45	26.07	9.10
National Roads	9.08	10.69	13.07	9.85	1.98
Municipal Roads	7.95	10.45	8.93	6.93	5.19
Highways	5.06	2.28	6.45	9.29	1.93
Other Transportation	7.36	6.73	9.96	8.69	3.70
Railroads	5.41	4.61	7.87	6.53	2.31
Ports	1.01	1.06	1.33	0.99	0.64
Airports	0.94	1.05	0.76	1.17	0.76
Utilities	45.99	44.67	39.71	44.18	56.44
Water and Waste Facilities	10.19	10.28	9.88	9.72	10.97
Petroleum Refining	3.06	2.86	3.80	2.60	2.98
Electricity and Gas	14.75	14.17	7.63	15.35	22.66
Telecommunications	17.98	17.36	18.41	16.51	19.83
Social Infrastructures	24.56	25.18	21.87	21.06	30.76
Health Facilities	10.50	8.79	9.57	9.89	14.11
Educational Buildings	14.06	16.40	12.30	11.17	16.65

2010s was a decade where, together, railroads, ports, and airports lost almost 60% of their share in total infrastructure investment. In absolute terms, this group, labeled as “other transportation”, rose from 0.22% of GDP in the 1980s to 0.47% between 1990 and 2009, and then dropped to just 0.15% between 2010 and 2018.

Railroads represent the bulk, nearly 76%, of investment in other transportation infrastructures. Investment in railroad infrastructure averaged 0.25% of GDP between 1980 and 2018, reaching 0.37% of GDP in the 1990s. Investment in ports and airports represented relatively smaller investment volumes due to the rather limited number of major airports and major ports in the country. Nonetheless, very substantial investments in the airports of Lisbon and Porto were undertaken in the first decade of the 21st century, with investment volumes reaching 0.06% of GDP, roughly double that seen in other decades between 1980 and 2018.

Utilities include water supply and waste treatment facilities, petroleum-refining plants, and electricity and gas infrastructures, together accounting for around 28% of total infrastructure investment, and averaging 1.19% of GDP between 1980 and 2018. Investment in utilities reached a nadir in relative terms in the 1990s, when their share collectively fell to 21.3% of total infrastructure investment, and in absolute terms in the 1980s at 0.9% of GDP. Utilities were at their zenith in relative terms in the 2010s with a share of 36.6% of total infrastructure investment, and in absolute terms in the 2000s at 1.48% of GDP. While investments in coal-powered power plants and refineries were the norm in the 1980s, more recently, investments in renewable energies and natural gas networks have contributed to the sustained growth in investment in utilities. In absolute terms, infrastructure investment in utilities had risen in trend from 0.9% of GDP in the 1980s to almost 1.5% of GDP in the 2010s.

Investment in electricity and gas supply infrastructure, the most significant of the utility assets in terms of the investment effort, averaged 0.62% of GDP or 14.75% of total infrastructure investment between 1980 and 2018. In the 2010s, it reached 0.87% of GDP and accounted for 22.66% of total infrastructure investment. In turn, water supply and waste treatment investment averaged 0.44% of GDP or 10.19% of total infrastructure investment between 1980 and 2018, with a clear increasing trend until the 2000s, while investment in refineries averaged 0.14% of GDP or 3.06% of total infrastructure investment, with a clearly declining trend since the 1990s. Finally, investment in telecommunications averaged 0.78% of GDP or 17.98% of total infrastructure investment between 1980 and 2018. The 1990s and 2000s registered a continuous expansion of mobile communications networks, and hence investment in telecommunications grew from 0.56% of GDP in the 1980s to a peak of 0.92% of GDP in the 2000s. In the 2010s, it tapered off slightly to 0.74% of GDP. As a share of total infrastructure investment, a peak of 19.83% was reached between 2010 and 2018.

Social infrastructures include health facilities and educational buildings, and accounted for 24.6% of total infrastructure investment, averaging just over 1% of GDP between 1980 and 2018. Until the 2010s, these investments showed a slowly declining pattern over time in terms of their relative importance in total infrastructure investment. By the end of the sample period, the share of social infrastructures in total investment reached 30.76%. In absolute terms, however, it remained relatively stable over the last two decades, at just under 1.15% of GDP, up from an average of 0.81% in the 1980s.

Between 1980 and 2018, investment in health facilities averaged 0.44% of GDP, or 10.5% of total infrastructure investment, while investment in educational facilities amounted to 0.58% of GDP or 14.1% of overall investment over the same period. While both are reasonably similar in terms of their relative magnitude over the sample period, their evolution was markedly different. Investment in health facilities increased steadily, with a very significant boost in the 2010s, ending that decade with 14.11% of total infrastructure investment, up from 8.79% in the 1980s. On the other hand, the three-decades-long downward trend in investment in education buildings from the 1980s to the 2000s was reversed only in the 2010s, having recently surpassed the 1980s' average. In absolute terms, investment in health facilities plateaued at 0.53% of GDP in the 2000s, up from 0.28% of GDP in the 1980s, while investment in education buildings was consistently at its 1980–2018 average of 0.58% of GDP.

Overall, infrastructure investments grew substantially over the past 39 years, from 1980 to 2018, averaging 4.3% of GDP over this period. These investments averaged 3.24% of GDP in the 1980s, 4.65% in the 1990s, 5.39% in the 2000s, and just 3.85% of GDP in the 2010s. The increase in infrastructure investment levels is particularly pronounced after 1986, the year in which Portugal joined the EU (then known as the EEC), 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 infrastructure investment effort decelerated somewhat during the period of the Community Support Framework III (2000–2006) and more significantly with the Quadro de Referência Estratégico Nacional (QREN, or National Strategic Reference Framework) (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.

2.2. Industry dataset

The data on industry-specific output, employment, and private investment were obtained from different annual issues of the National Accounts published by Instituto Nacional de Estatística (Statistics Portugal).[6] Employment is measured in thousands of employees.

Spanning all economic activities, 22 industries were considered, grouped into four sectors. The different industries were grouped into two primary industries (agriculture and mining), seven manufacturing industries (food, textiles, paper, chemical and pharmaceutical, non-metallic minerals, basic metals, and machinery and equipment), ten private service industries (electricity and gas, water, construction, wholesale and retail trade, transportation, hospitality, telecommunications, finance, real estate, and professional services), and three public service industries (public administration, health, and education). In **Table 2**, we included details on what comprised each of the different sectors.

Summary statistics on the industry mix in terms of employment are provided in **Table 3**. The share of total employment in the primary sector steadily declined from a whopping 20.8% in the 1980s to just under 7% in the 2010s. On the other hand, in terms of the share of employment in the manufacturing sector, we observe a downward trend from 25% in the 1980s to 16.1% in the 2010s.

In terms of private services' contribution to overall employment, the decades-long uptrend

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6. Available at https://bit.ly/3o9ekHf from *Instituto Nacional de Estatística*.

Table 2. Industry classification grouped by sector

Primary Sector—Agriculture:	
Agriculture (S1)	Agriculture, crop and animal production, hunting, forestry, and fishing.
Mining (S2)	Mining and quarrying.
Secondary Sector—Manufacturing:	
Food (S3)	Manufacture of food products, beverages, and tobacco products.
Textiles (S4)	Manufacture of textiles, wearing apparel and leather products.
Paper (S5)	Manufacture of wood and paper products, and printing.
Chemical and Pharmaceutical (S6)	Manufacture of chemicals and chemical products. Manufacturing of basic pharmaceutical products and pharmaceutical preparations.
Non-Metallic Minerals (S7)	Manufacture of rubber and plastics products, and other non-metallic mineral products.
Basic Metals (S8)	Manufacture of basic metals and fabricated metal products, except machinery and equipment.
Machinery and Equipment (S9)	Manufacture of computer, electronic and optical products; Manufacture of electrical equipment; Manufacture of machinery and equipment; Manufacture of transport equipment; Manufacture of furniture; Other manufacturing; Repair and installation of machinery and equipment.
Tertiary Sector—Private Services:	
Electricity and Gas (S10)	Electricity, gas, steam, and air-conditioning supply.
Water (S11)	Water, sewerage, waste management and remediation activities.
Construction (S12)	Construction.
Wholesale and Retail Trade (S13)	Wholesale and retail trade, repair of motor vehicles and motorcycles.
Transportation and Storage (S14)	Transportation, warehousing and storage, and postal and courier activities.
Hospitality (S15)	Accommodation, and food and beverage service activities.
Telecommunications (S16)	Telecommunications.
Finance (S17)	Financial and insurance activities.
Real Estate (S18)	Real estate activities.
Professional Services (S19)	Publishing, audiovisual and broadcasting activities; Computer programming, consultancy and related activities; Information service activities; Legal and accounting activities; Activities of head offices; Management consultancy activities; Architecture and engineering activities; Technical testing and analysis; Scientific research and development; Advertising and market research; Other professional, scientific and technical activities; Veterinary activities; Administrative and support service activities; Arts, entertainment and recreation; Rental and leasing activities; Security and investigation; Other services activities.
Tertiary Sector—Public Services:	
Public Administration (S20)	Public administration and defense; Compulsory social security.
Education (S21)	Education.
Health (S22)	Human health activities; Residential care; Social work activities.

Table 3. Share of employment by industry

	1980–2018	1980–89	1990–99	2000–09	2010–18
Agriculture	12.9	20.8	13.7	10.1	6.9
Agriculture (S1)	12.1	19.1	13.0	9.7	6.6
Mining (S2)	0.8	1.7	0.7	0.4	0.3
Manufacturing	20.0	25.0	21.7	17.0	16.1
Food (S3)	2.6	3.1	2.6	2.4	2.4
Textiles (S4)	6.7	8.9	7.6	5.5	4.7
Paper (S5)	2.0	2.5	2.3	1.8	1.4
Chem. & Pharm. (S6)	0.6	0.8	0.8	0.5	0.4
Non-Metallic Minerals (S7)	1.9	2.2	2.0	1.8	1.5
Basic Metals (S8)	2.2	2.6	2.2	2.1	2.0
Machinery & Equip. (S9)	4.0	4.9	4.2	2.9	3.7
Private Services	48.1	39.3	46.3	51.7	55.1
Electricity & Gas (S10)	3.2	4.6	4.2	3.9	0.2
Water (S11)	0.5	0.5	0.4	0.2	0.9
Construction (S12)	2.2	1.1	0.8	0.7	6.2
Wholes. & Ret. Trade (S13)	11.9	10.5	10.1	11.4	15.6
Transp. & Storage (S14)	11.5	12.0	14.5	15.8	3.7
Hospitality (S15)	4.2	3.8	3.3	3.4	6.3
Telecommunications (S16)	3.5	3.6	4.5	5.4	0.3
Finance (S17)	0.8	0.5	0.4	0.3	2.0
Real Estate (S18)	2.0	2.5	2.5	2.1	0.8
Professional Services (S19)	8.3	0.2	5.6	8.5	19.1
Public Services	19.1	14.9	18.3	21.2	21.9
Public Administration (S20)	7.7	7.0	8.1	9.1	6.7
Education (S21)	6.1	4.7	6.2	6.6	6.9
Health (S22)	5.3	3.2	4.0	5.6	8.3
Total	100.0	100.0	100.0	100.0	100.0

remained intact, accounting for more than 55% of all jobs in the 2010s, up from just shy of 40% in the 1980s. Here, too, the averages hide very different developments over time. While the electricity and gas industry and real estate have both been on a downtrend since the 1980s, from the 1990s onwards, wholesale and retail trade has grown in terms of its contribution to overall employment. Of all industries that comprised the private service sector, professional services were the most significant gainer, from just 0.2% in the 1980s to a very substantial 19.1% in the 2010s.

Lastly, in terms of public services' share in economy-wide employment, it has steadily increased since the 1980s, from an average of 14.9% in the 1980s to 21.9% in the 2010s. The health industry has been a major employer, almost tripling its share in employment from a low of 3.2% in the 1980s to a whopping 8.3% in the 2010s. Education has also grown in significance in terms of its employment share, albeit at a slower pace, especially since the turn of the century. As for public administration, the strong upward trend that was in place until the 2000s, reaching 9.1% of total employment, had since reversed very significantly, averaging 6.7% in the 2010s.

3. Preliminary data analysis[7]

3.1. Unit roots, cointegration, and VAR specification

We started with unit root and cointegration analyses. Having determined that stationarity seems to be a good approximation for all series, and in the absence of any evidence for cointegration, we followed the standard procedure in the literature and determined the specifications of the VAR models using growth rates of the original variables.

We estimated 12 VAR models for each of the 22 industries, one for each of the different infrastructure types, for a total of 264 models. Each VAR model included industry-specific output, employment, and private investment, as well as the relevant infrastructure-investment variable. We used the Bayesian information criterion (BIC) to determine the 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, the years of the inception of the first three community support frameworks, was the preferred choice in most of the cases.

3.2. Identifying exogenous innovations in infrastructure investment

The key issue in determining the impact of infrastructure investment is the identification of exogenous shocks representing innovations in infrastructure investments that are not contaminated by other contemporaneous innovations and that avoid reverse causation. In dealing with this issue, we drew on the approach in handling the effects of monetary policy (see, for example, Christiano, Eichenbaum and Evans (1996, 1999), and Rudebusch (1998)) adopted by Pereira (2000) in the context of the analysis of the effects of infrastructure investments.

The identification of exogenous shocks to infrastructure investment would, in general, 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 that relates the rate of growth of infrastructure investment to the relevant information set. The residuals from these policy functions reflect the unexpected component of the evolution of infrastructure investment and are, by definition, uncorrelated with innovations in other variables.

We assumed that the relevant information set for the policy function included past but not current values of the economic variables. In the context of the standard Cholesky decomposition, this is equivalent to assuming that innovations in investments lead innovations in economic variables, i.e., that while innovations in infrastructure investments affect the economic variables contemporaneously, the reverse is not true. This also means that the estimated effects of infrastructure investments are invariant to the ordering of the three economic variables.

We had two conceptual reasons for this assumption. First, it seemed reasonable to assume that the economy reacts within a year to innovations in infrastructure investments. Second, it also seemed reasonable to assume that the public sector is unable to adjust infrastructure investment decisions to

[7] For the sake of brevity, we just sketched here the different steps in the preliminary data analysis. Full documentation is available from the authors upon request.

innovations in the economic variables within the same year. This is due to the time lags involved in information gathering and public decision making.

Furthermore, this assumption was reasonable also from a statistical perspective. Invariably, the policy functions point to the exogeneity of innovations in infrastructure investments, 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. Moreover, we would not expect any single economic sector to have an impact on decision making for infrastructure investments at the national level.

3.3. Measuring effects of innovations in infrastructure investments

To measure the effects of one-percentage-point one-time shock in the rates of growth of the different infrastructure investments on employment for the different industries, we estimated the accumulated impulse-response functions for each of the VAR models. The accumulated impulse response functions typically converged within a relatively short time period. The error bands surrounding the point estimates for the accumulated impulse responses were computed via bootstrapping methods. We considered 90% intervals, although bands that correspond to a 68% posterior probability are the standard in the literature (see Sims and Zha (1999)). From a practical perspective, when the 90% error bands for the accumulated impulse response functions include zero, we considered that the effects are not significantly different from zero.[8]

To measure the effects of shocks in infrastructure investment, we calculated the total long-term accumulated elasticities and the total long-term accumulated marginal products of the different sectors' employment with respect to each type of infrastructure investment. These concepts depart from conventional understanding because they are not based on ceteris paribus assumptions, but, instead, they include all the dynamic feedback effects among the different variables.

The total long-term accumulated elasticities were to be interpreted as the total accumulated percentage-point long-term change in employment per one-percentage-point accumulated long-term change in infrastructure investment. In turn, the total long-term accumulated marginal products measured the change in employment for each additional euro of infrastructure investment. The marginal products were obtained by multiplying the ratio of average employment to infrastructure investment by the corresponding elasticity. We used the average ratio over the last ten years of the sample. Using a recent time period allowed the marginal products to reflect the relative scarcity of the different infrastructures at the margin of the sample period, while the choice of ten years prevented these ratios from being overly affected by business cycle factors.

4. Employment effects of infrastructure investments

4.1. Industry-level effects

We started by presenting our results at the industry level. The industry-specific elasticities of employment with respect to the 12 infrastructure investments are reported in **Table 4** and **Table 5**.

[8] Again, for the sake of brevity, the impulse response functions have been omitted. Full documentation is available from the authors upon request.

Table 4. Industry-specific elasticities of employment w.r.t. infrastructure investments: Road transportation and other transportation

	National Roads	Municipal Roads	Highways	Railroads	Airports	Ports
Agriculture and Mining						
Agriculture (S1)	*	0.0079	*	*	*	0.0057
Mining (S2)	-0.3374	0.3040	*	0.1125	*	0.0538
Manufacturing						
Food (S3)	-0.0456	*	*	-0.0272	*	*
Textiles (S4)	*	0.0377	*	-0.0119	0.0105	0.0124
Paper (S5)	*	0.0146	0.0183	*	0.0137	*
Chem. & Pharm. (S6)	*	0.0710	*	*	*	*
Non-Metallic Minerals (S7)	0.0977	0.0195	0.0163	-0.0279	*	0.0067
Basic Metals (S8)	0.0509	0.0935	0.0042	-0.0359	-0.0208	0.0163
Machinery & Equip. (S9)	0.1002	*	0.0103	-0.0685	0.0037	*
Private Services						
Electricity & Gas (S10)	*	*	*	-0.0592	-0.0644	*
Water (S11)	*	*	*	*	-0.0488	*
Construction (S12)	0.0000	0.0821	0.0147	0.0564	*	0.0273
Wholes. & Ret. Trade (S13)	0.0000	0.0222	0.0198	*	0.0182	0.0167
Transp. & Storage (S14)	0.0099	0.0074	0.0095	*	*	0.0102
Hospitality (S15)	0.0730	0.0200	0.0200	0.0280	0.0254	0.0027
Telecommunications (S16)	*	*	*	-0.0294	0.0218	*
Finance (S17)	*	*	*	-0.0779	-0.0106	*
Real Estate (S18)	0.1323	*	*	0.1018	*	0.0236
Professional Services (S19)	0.2600	0.0633	0.0335	0.0553	*	0.0261
Public Services						
Public Administration (S20)	0.0233	0.0609	0.0112	*	0.0263	0.0134
Education (S21)	0.0580	0.0094	0.0045	*	*	0.0061
Health (S22)	-0.0863	*	-0.0100	*	*	0.0048

*Notes: Values marked with * are not statistically significant as implied by the standard deviation bands around the impulse response functions*

Table 5. Industry-specific elasticities of employment w.r.t. infrastructure investments: Social infrastructures and utilities

	Health	Education	Water and Waste	Electricity and Gas	Petroleum Refining	Telecom
Agriculture and Mining						
Agriculture (S1)	-0.0454	-0.1546	*	-0.0145	*	0.0134
Mining (S2)	*	*	0.0941	*	0.0214	0.1754
Manufacturing						
Food (S3)	*	*	-0.0139	0.0094	*	*
Textiles (S4)	-0.0196	-0.0512	0.0074	0.0044	*	0.0276
Paper (S5)	*	*	*	*	*	0.0405
Chem. & Pharm. (S6)	0.0309	0.0187	0.0207	*	*	*
Non-Metallic Minerals (S7)	0.0633	0.0623	*	*	*	0.0384
Basic Metals (S8)	0.1021	0.0414	0.0230	0.0100	*	0.0584
Machinery & Equip. (S9)	0.0331	0.0368	-0.0539	0.0061	*	0.0280
Private Services						
Electricity & Gas (S10)	0.0502	-0.1013	*	*	*	*
Water (S11)	*	-0.1389	*	*	*	-0.0643
Construction (S12)	0.0718	0.1477	0.0186	0.0131	0.0161	0.1114
Wholes. & Ret. Trade (S13)	*	0.0592	*	0.0032	0.0024	0.0515
Transp. & Storage (S14)	0.0384	0.0588	*	*	0.0070	0.0463
Hospitality (S15)	*	-0.1155	*	-0.0170	*	0.0699
Telecommunications (S16)	-0.0410	*	*	*	*	*
Finance (S17)	0.0293	*	-0.0420	*	-0.0052	-0.0282
Real Estate (S18)	0.0596	0.1405	*	-0.0570	0.0203	0.0940
Professional Services (S19)	0.0742	0.0813	0.0279	-0.0686	0.0060	0.1509
Public Services						
Public Administration (S20)	-0.0322	0.0208	*	0.0178	0.0025	0.0253
Education (S21)	0.0131	0.0620	*	0.0041	0.0065	0.0176
Health (S22)	-0.0434	*	-0.0091	*	0.0055	0.0143

*Notes: Values marked with * are not statistically significant as implied by the standard deviation bands around the impulse response functions*

Based on these elasticities, we obtained the respective industry-specific marginal products following the procedures discussed above. These marginal products are presented in **Table 6** and **Table 7**. These tables include not only the total long-term accumulated effects of the 12 infrastructure investments but also the effects on impact, that is, considering only the effects contemporaneous with the shocks on the infrastructure investment variables.

In the last two rows of Table 6 and Table 7, we present the aggregate values of the marginal employment effects for each of the 12 infrastructure investments across all 22 industries we considered. As the objective of this paper is to determine which infrastructure investments had the most significant aggregate employment effects, as well as the nature of such aggregate effects, our focus was not on the industry dimension of such employment effects. Nevertheless, as these aggregate results were obtained by adding all statistically significant industry-level effects, these four tables provide critical background information for the analysis that follows.

4.2. Total long-term effects, short-term effects on impact, and intertemporal over-time effects

Each of the 12 infrastructure investments we considered affects employment in each of 22 distinct industries. **Table 8** summarizes the overall job creation effects, detailing the horizon in which these materialize.

We found that investing in ports entails the greatest bang per euro in terms of total long-term jobs created. Each million euros invested in this type of infrastructure generates an estimated 717.1 permanent jobs in the long run. Much further behind, we found airports with a corresponding 290.5 jobs per million euros of investment, followed by municipal roads (277.4), telecommunications (235.6), and national roads (232.5). With respect to where to invest to create the greatest number of jobs in the long run, these four types of assets make up a second tier. Next, we found health facilities (179.9) and education buildings (163.1) with employment effects that are still significant. The assets with the smallest total long-term effects, i.e., under 100 jobs created per million euros invested, are petroleum refining (85.2), railroads (72.5), highways (61.1), and water infrastructures (22.8). Electricity and gas facilities entail an estimated loss of 21.5 jobs per million euros invested.

While total long-term employment effects of infrastructure investments in ports and airports are the most sizeable, these are mostly short-term effects, with around 75% or more of the total effects being on impact. The effects of investments in national roads, municipal roads, and telecommunications, on the other hand, while still sizeable, are more evenly distributed over time. The short-term effects of these are around 30%–45% of the total effects.

The overall effects of infrastructure investments in health facilities and education buildings, while relatively smaller but still significant in size, are exclusively long-term. On impact, their effects are negative, with estimated short-term losses of 85 and 57.2 jobs per million euros of investment, respectively.

Refineries, highways, and railroads have even smaller total effects on employment. While more than 90% of the short-term effects materialize in the short run for railroads, the short-term effects for highways and refineries are around 40%–45% of the total. Both water infrastructures and electricity and gas facilities entail job losses on impact.

Table 6. Short-term versus total long-term employment effects of infrastructure investments: Road transportation and other transportation

		National Roads	Municipal Roads	Highways	Railroads	Airports	Ports
Agriculture (S1)	Total	*	6.45	*	*	*	31.19
	Short-Term	*	48.26	*	*	*	41.11
Mining (S2)	Total	-6.17	8.91	*	3.42	*	10.49
	Short-Term	-4.62	5.79	*	2.90	*	7.40
Food (S3)	Total	-5.65	*	*	-5.60	*	*
	Short-Term	-1.87	*	*	-4.84	*	*
Textiles (S4)	Total	*	17.32	*	-5.67	28.55	37.90
	Short-Term	*	0.00	*	-5.27	28.17	22.68
Paper (S5)	Total	*	2.25	1.73	*	12.46	*
	Short-Term	*	3.41	0.79	*	8.79	*
Chem. & Pharm. (S6)	Total	*	2.79	*	*	*	*
	Short-Term	*	1.07	*	*	*	*
Non-Metallic Minerals (S7)	Total	9.44	3.01	1.55	-4.48	*	6.92
	Short-Term	5.62	0.00	0.50	-2.49	*	1.43
Basic Metals (S8)	Total	5.59	16.45	0.46	-6.55	-21.60	19.06
	Short-Term	0.66	7.14	0.06	-2.84	-6.34	7.99
Machinery & Equip. (S9)	Total	20.67	*	2.10	-23.50	7.29	*
	Short-Term	10.96	*	0.60	-17.43	8.12	*
Electricity & Gas (S10)	Total	*	*	*	-1.27	-7.87	*
	Short-Term	*	*	*	-0.80	-5.64	*
Water (S11)	Total	*	*	*	*	-17.96	*
	Short-Term	*	*	*	*	-10.54	*
Construction (S12)	Total	-21.04	78.72	8.68	56.07	*	173.81
	Short-Term	-57.98	8.03	0.00	6.32	*	143.35
Wholes. & Ret. Trade (S13)	Total	37.26	29.45	16.18	*	142.23	147.49
	Short-Term	43.07	0.00	7.23	*	128.70	139.56
Transp. & Storage (S14)	Total	1.79	2.14	1.69	*	*	19.70
	Short-Term	4.39	0.00	1.10	*	*	15.42
Hospitality (S15)	Total	20.58	9.02	5.57	13.13	67.69	8.12
	Short-Term	30.69	6.79	7.62	16.42	67.75	36.86
Telecommunications (S16)	Total	*	*	*	-0.85	3.59	*
	Short-Term	*	*	*	-1.17	3.45	*
Finance (S17)	Total	*	*	*	-14.26	-11.08	*
	Short-Term	*	*	*	-7.81	-11.19	*
Real Estate (S18)	Total	4.94	*	*	6.31	*	9.38
	Short-Term	5.93	*	*	12.00	*	12.97
Professional Services (S19)	Total	157.62	61.43	20.04	55.73	*	168.62
	Short-Term	46.66	28.89	9.86	72.13	*	70.32
Public Administration (S20)	Total	8.19	34.24	3.88	*	87.18	49.99
	Short-Term	0.00	3.82	0.00	*	41.97	33.76
Education (S21)	Total	20.00	5.22	1.55	*	*	22.25
	Short-Term	0.00	0.00	0.24	*	*	0.36
Health (S22)	Total	-20.77	*	-2.37	*	*	12.20
	Short-Term	-15.77	*	-1.71	*	*	1.78
Total	Total	232.45	277.41	61.05	72.48	290.49	717.13
	Short-Term	67.73	113.19	26.28	67.12	253.25	534.98

*Notes: Values marked with * are not statistically significant as implied by the standard deviation bands around the impulse response functions*

Table 7. Short-term versus total long-term employment effects of infrastructure investments: Social infrastructures and utilities

		Health	Education	Water and Waste	Electricity and Gas	Petroleum Refining	Telecom
Agriculture (S1)	Total	-52.55	-109.97	*	-4.80	*	5.70
	Short-Term	-35.34	-133.48	*	-3.45	*	6.61
Mining (S2)	Total	*	*	2.57	*	1.55	2.67
	Short-Term	*	*	1.67	*	1.56	1.02
Food (S3)	Total	*	*	-2.58	0.76	*	*
	Short-Term	*	*	-3.81	0.68	*	*
Textiles (S4)	Total	-12.78	-20.47	3.16	0.82	*	6.60
	Short-Term	-13.07	-14.62	0.00	1.20	*	3.19
Paper (S5)	Total	*	*	*	*	*	3.24
	Short-Term	*	*	*	*	*	1.92
Chem. & Pharm. (S6)	Total	1.72	0.64	0.76	*	*	*
	Short-Term	1.02	0.95	0.40	*	*	*
Non-Metallic Minerals (S7)	Total	13.89	8.39	*	*	*	3.09
	Short-Term	6.56	4.11	*	*	*	1.41
Basic Metals (S8)	Total	25.46	6.33	3.78	0.71	*	5.34
	Short-Term	14.21	0.90	1.00	0.89	*	2.03
Machinery & Equip. (S9)	Total	15.50	10.58	-16.62	0.82	*	4.82
	Short-Term	2.78	3.20	-11.86	0.92	*	1.23
Electricity & Gas (S10)	Total	1.48	-1.83	*	*	*	*
	Short-Term	1.13	-1.20	*	*	*	*
Water (S11)	Total	*	-7.54	*	*	*	-2.09
	Short-Term	*	-5.28	*	*	*	-1.16
Construction (S12)	Total	97.68	123.26	16.68	5.09	38.05	55.57
	Short-Term	-40.35	32.70	0.00	4.59	2.56	20.24
Wholes. & Ret. Trade (S13)	Total	*	68.28	*	1.70	7.95	35.47
	Short-Term	*	23.15	*	7.23	9.34	9.95
Transp. & Storage (S14)	Total	15.79	14.82	*	*	5.00	6.97
	Short-Term	6.55	9.30	*	*	4.86	1.79
Hospitality (S15)	Total	*	-45.40	*	-3.13	*	16.42
	Short-Term	*	-34.21	*	-3.23	*	18.48
Telecommunications (S16)	Total	-1.62	*	*	*	*	*
	Short-Term	-1.42	*	*	*	*	*
Finance (S17)	Total	7.33	*	-6.91	*	-2.26	-2.59
	Short-Term	1.13	*	-6.16	*	-0.55	-3.14
Real Estate (S18)	Total	5.05	7.31	*	-1.38	2.98	2.92
	Short-Term	3.82	6.17	*	-1.16	1.88	3.57
Professional Services (S19)	Total	102.08	68.72	25.26	-27.07	14.38	76.19
	Short-Term	7.64	30.78	1.46	-20.81	0.23	37.90
Public Administration (S20)	Total	-25.69	10.18	*	4.07	3.49	7.42
	Short-Term	-29.85	0.00	*	3.95	3.30	0.59
Education (S21)	Total	10.24	29.79	*	0.93	8.86	5.04
	Short-Term	8.34	20.33	*	1.75	5.49	1.17
Health (S22)	Total	-23.73	*	-3.26	*	5.23	2.86
	Short-Term	-18.20	*	-1.35	*	8.33	0.39
Total	Total	179.87	163.11	22.84	-21.48	85.23	235.64
	Short-Term	-85.04	-57.21	-18.65	-7.44	37.00	107.19

*Notes: Values marked with * are not statistically significant, as implied by the standard deviation bands around the impulse response functions*

Table 8. Employment effects of infrastructure investments (jobs per million €)

	Short-Term Effects on Impact	Intertemporal Effects Over Time	Total Long-Term Effects	Short-Term/Total (%)
Road Transportation				
National Roads	67.7	164.7	232.5	29.1
Municipal Roads	113.2	164.2	277.4	40.8
Highways	26.3	34.8	61.1	43.0
Other Transportation				
Railroads	67.1	5.4	72.5	92.6
Airports	253.3	37.2	290.5	87.2
Ports	535.0	182.2	717.1	74.6
Utilities				
Water and Waste Facilities	-18.7	41.5	22.8	Neg.*
Electricity and Gas	-7.4	-14.0	-21.5	Neg.**
Petroleum Refining	37.0	48.2	85.2	43.4
Telecommunications	107.2	128.5	235.6	45.5
Social Infrastructures				
Health Facilities	-85.0	264.9	179.9	Neg.*
Education Buildings	-57.2	220.3	163.1	Neg.*

Notes: Neg. corresponds to negative short-term effects on impact. Neg.** corresponds to both negative short-term effects on impact and negative total long-term effects.*

In complement to the foregoing analysis, the top five infrastructure investments that, over time, after an immediate impact, yield the greatest intertemporal employment effects are health facilities, with 264.9 jobs created per million euros invested, followed by education buildings (220.3), ports (182.2), national roads (164.7), and municipal roads (164.2).

4.3. Decomposition of total long-term effects of infrastructure investments

In **Table 9**, we decomposed the total long-term employment effects of infrastructure investments into three constituent channels. The first is a demand-side channel that sums all short-term effects (on impact) across all industries, plus the intertemporal employment effects (over time) pertaining to the construction industry (S18). The second is a supply-side channel that comprises all intertemporal effects (over time), with the exception of those that materialize in the construction (S12) and real estate (S18) industries. Finally, there is a location channel that includes the intertemporal employment effects in real estate. This is an effect that is totally induced by the very presence of the infrastructure asset itself. While certain assets, such as transportation infrastructures, schools, and hospitals, serve as an attractor for economic activities and, thereby, for employment, the opposite tends to be true for airports, waste and wastewater facilities, power plants, and refineries, which have a negative effect on the desirability of where they are located.

Analyzing the total long-term employment effects by channel, the demand-side effects represent around 85% or more in petroleum refining assets and in other transportation infrastructures, such as railroads, airports, and ports, and around 45%–65% in telecommunications and in road transportation infrastructures, such as national roads, municipal roads, and highways. In turn,

Table 9. Decomposition of total long-term employment effects (% of total)

	Total Long-Term Effects (Jobs Per Million €)	Demand-Side Effects	Supply-Side Effects	Location Effects
Road Transportation				
National Roads	232.5	45.0	55.0	Neg.
Municipal Roads	277.4	66.3	33.7	0.0
Highways	61.1	57.3	42.7	0.0
Other Transportation				
Railroads	72.5	100.0	Neg.	Neg.
Airports	290.5	87.2	12.8	0.0
Ports	717.1	78.9	21.1	Neg.
Utilities				
Water and Waste Facilities	22.8	Neg.	100.0	0.0
Electricity and Gas	-21.5	Neg.	Neg.	Neg.
Petroleum Refining	85.2	85.1	13.6	1.3
Telecommunications	235.6	60.5	39.5	Neg.
Social Infrastructures				
Health Facilities	179.9	29.5	69.8	0.7
Education Buildings	163.1	20.5	78.8	0.7

Notes: Neg. corresponds to a negative number

supply-side effects correspond to over 70% of total long-term employment effects in the case of infrastructure investments in health facilities and education buildings. Of all infrastructure assets, national roads are the most balanced ones across the demand and supply channels. With respect to the location channel, we found no evidence of significant employment effects. This is unlike what Pereira and Pereira (2019) found in the case of output.

5. Policy implications and concluding remarks

In this paper, using a vector-autoregressive specification at the industry level, we investigated how each of the 12 types of infrastructure investments we considered affects employment in Portugal. Our estimates are not simply those obtained from an aggregate methodology. Instead, we explicitly considered that different types of infrastructure investments reverberate through the economy over time, generating readjustments in employment that are industry specific. Thus, the aggregate net job creation effects we present—as a result of a given type of infrastructure investment—are the sum of the statistically significant industry-specific employment effects.

We aimed to determine which infrastructure asset delivers the greatest bang per euro invested, in the sense that it creates the greatest number of jobs. Furthermore, to best inform economic policy in Portugal, in addition to the magnitude, the timing of these employment effects also matters, i.e., when do they materialize? For each of the 12 infrastructure investments under analysis, which is the dominant channel through which these effects appear? In short, which of these effects are from the demand side and which are from the supply side?

One of the strongest policy implications of our results is that investing in ports and airports produces both the most sizeable long-term employment effects and the largest immediate and demand-side-induced creation of jobs. Those are the two assets with the strongest bang per euro invested. We take this as evidence of a double dividend in Portugal, where investing in ports and airports yields significant job creation, both on impact and in the long run. In that sense, the instrument of choice for countercyclical policies coincides with that for structural policies.

Another implication of our results is that, for immediate employment effects, it is best not to invest in health facilities and in education buildings, insomuch as we estimate short-run job losses. Instead, investing in these two types of infrastructure assets is the preferred option for maximum supply-side employment effects over time. For job creation results that are still significant and more evenly distributed both over time and across demand- and supply-side channels, our results point to investing in telecommunications, as well as in road infrastructures, such as national roads and municipal roads. Highways present a similar balance, albeit with smaller overall employment effects.

These two policy implications suggest that both the magnitude and the timing of the resulting job creation depend crucially on the type of infrastructure investment. Knowing this is especially critical for employment-oriented public authorities aiming at either countercyclical or structural policies. That is the main contribution of this paper.

From a more general perspective, our results also underscore that it is shortsighted (pun intended!) to presume that the effects of infrastructure investments are mostly of a long-term supply-side nature, operating through conventional productivity channels. Short-term and other demand effects are just as important, as our results suggest. While this questions the conventional wisdom that views infrastructure investment as essentially a long-term tool to promote economic growth and to accelerate real convergence, it also reopens the question of the role these infrastructure investments can play as an effective countercyclical tool.

References

Aschauer A (1989a). "Is public expenditure productive?" *Journal of Monetary Economics*, 23(2): 177–200. https://doi.org/10.1016/0304-3932(89)90047-0

_____ (1989b). "Does public capital crowd out private capital?" *Journal of Monetary Economics*, 24(2): 171–188. https://doi.org/10.1016/0304-3932(89)90002-0

Auerbach A and Gale W (2009). *Activist Fiscal Policy to Stabilize Economic Activity* (NBER Working Paper 15407). National Bureau of Economic Research. https://doi.org/10.3386/w15407

Barro RJ (1990). "Government spending in a simple model of endogenous growth". *Journal of Political Economy*, 98(5, Part 2): S103–125. https://doi.org/10.1086/261726

Basdevant O, Chaponda T, Gonguet F, Honda J and Thomas S (2020). "Designing fiscal rules to protect investment". In: Schwartz G, Fouad M, Hansen T and Verdier G (Eds.), *Well Spent: How Strong Infrastructure Governance Can End Waste in Public Investment*, pp. 106–124. International Monetary Fund.

Bivens J (2014). *The Short- and Long-Term Impact of Infrastructure Investments on Employment and Economic Activity in the U.S. Economy* (Economic Policy Institute Briefing Paper No. 374). Economic Policy Institute.

Blanchard O and Perotti R (2002). "An empirical characterization of the dynamic effects of changes in government spending and taxes on output". *The Quarterly Journal of Economics*, 117(4): 1329–68. https://

doi.org/10.1162/003355302320935043
Bom PRD and Ligthart JE (2014). "What have we learned from three decades of research on the productivity of public capital?" *Journal of Economic Surveys*, 28(5): 889–916. https://doi.org/10.1111/joes.12037
Brown-Collier EK and Collier BE (1995). "What Keynes really said about deficit spending". *Journal of Post Keynesian Economics*, 17(3): 341–355. https://doi.org/10.1080/01603477.1995.11490034
Christiano LJ, Eichenbaum M and Evans CL (1996). "The effects of monetary policy shocks: Evidence from the flow of funds". *The Review of Economics and Statistics*, 78(1): 16–34. https://doi.org/10.2307/2109845
_____ (1999). "Monetary policy shocks: What have we learned and to what end?" In: Taylor JB and Woodford M (Eds.), *Handbook of Macroeconomics*, Vol. 1A, pp. 65–148. North-Holland. https://doi.org/10.1016/S1574-0048(99)01005-8
Eisner R (1986). *How Real is the Federal Deficit?* The Free Press.
European Central Bank (2016). "Public investment in Europe". *ECB Economic Bulletin*, 2016(2).
European Commission (1990). *Community Support Framework 1989–93 For the Development and Structural Adjustment of the Regions whose Development is Lagging (Objective 1): Greece*. European Commission.
_____ (2014a). *Infrastructures in the EU: Developments and Impact on Growth* (European Economy Occasional Papers 203). Directorate-General for Economic and Fiscal Affairs, European Commission.
_____ (2014b). *An Investment Plan for Europe* (Communication from the Commission to the European Parliament, the Council, the European Central Bank, the European Economic and Social Committee, the Committee of the Regions and the European Investment Bank). European Commission.
Futagami K, Morita Y and Shibata A (1993). "Dynamic analysis of an endogenous growth model with public capital". *The Scandinavian Journal of Economics*, 95(4): 607–625. https://doi.org/10.2307/3440914
Glomm G and Ravikumar B (1997). "Productive government expenditures and long-run growth". *Journal of Economic Dynamics and Control*, 21(1): 183–204. https://doi.org/10.1016/0165-1889(95)00929-9
Greiner A and Hanusch H (1998). "Growth and welfare effects of fiscal policy in an endogenous growth model with public investment". *International Tax and Public Finance*, 5(3): 249–261. https://doi.org/10.1023/A:1008673925024
Gramlich E (1994). "Infrastructure investment: A review essay". *Journal of Economic Literature*, 32: 1176–1196.
Gurría A (2014). *Portugal: Deepening Structural Reform to Support Growth and Competitiveness* [Remarks transcript]. Organisation for Economic Co-operation and Development.
Haughwout A (2019). "Infrastructure investment as an automatic stabilizer". In: Boushey H, Nunn R and Shambaugh J (Eds.), *Recession Ready: Fiscal Policies to Stabilize the American Economy*, pp. 129–152. Brookings Institution.
International Monetary Fund (2015). *Making Public Investment More Efficient*. IMF.
_____ (2020). *Fiscal Monitor, October 2020: Policies for the Recovery*. IMF.
Kamps C (2005). "The dynamic effects of public capital: VAR evidence for 22 OECD countries". *International Tax and Public Finance*, 12: 533–558. https://doi.org/10.1007/s10797-005-1780-1
Leduc S and Wilson D (2012). "Roads to prosperity or bridges to nowhere? Theory and evidence on the impact of public infrastructure investment". *NBER Macroeconomics Annual*, 27(1): 89–142. https://doi.org/10.1086/669173
Mineshima A, Poplawski-Ribeiro M and Weber A (2014). "Fiscal multipliers". In: Cottarelli C, Gerson P and Senhadji A (Eds.), *Post-Crisis Fiscal Policy*, pp. 315–372. MIT Press. https://doi.org/10.7551/mitpress/9780262027182.003.0013
Munnell AH (1992). "Policy watch, infrastructure investment and economic growth". *Journal of Economic Perspectives*, 6(4): 189–198. https://doi.org/10.1257/jep.6.4.189
Pereira AM (2000). "Is all public capital created equal?" *The Review of Economics and Statistics*, 82(3): 513–518. https://doi.org/10.1162/rest.2000.82.3.513
_____ (2001). "On the effects of public capital formation on private investment: What crowds in what?" *Public Finance Review*, 29(1): 3–25. https://doi.org/10.1177/109114210102900101

Pereira AM and Andraz JM (2003). "On the impact of public investment on the performance of US industries". *Public Finance Review*, 31(1): 66–90. https://doi.org/10.1177/1091142102239135

_____ (2004). "Public highway spending and state spillovers in the USA". *Applied Economics Letters*, 11(12): 785–788. https://doi.org/10.1080/1350485042000254593

_____ (2005). "Public investment in transportation infrastructures and economic performance in Portugal". *Review of Development Economics*, 9(2): 177–196. https://doi.org/10.1111/j.1467-9361.2005.00271.x

_____ (2007). "Public investment in transportation infrastructures and industry performance in Portugal". *Journal of Economic Development*, 32(1): 1–20. https://doi.org/10.35866/caujed.2007.32.1.001

_____ (2011). "On the economic and fiscal effects of investment in road infrastructure in Portugal". *International Economics Journal*, 25(3): 465–492. https://doi.org/10.1080/10168737.2011.607256

_____ (2013). "On the economic effects of public infrastructure investment: A survey of the international evidence". *Journal of Economic Development*, 38(4): 1–37. https://doi.org/10.35866/caujed.2013.38.4.001

Pereira AM and Flores de Frutos R (1999). "Public capital accumulation and private sector performance". J*ournal of Urban Economics*, 46(2): 300–322. https://doi.org/10.1006/juec.1998.2124

Pereira AM and Pereira RM (2016). *Investimentos em Infraestruturas em Portugal* [Infrastructure Investments in Portugal]. Fundação Francisco Manuel dos Santos.

_____ (2018). "Are all infrastructure investments created equal? The case of Portugal". *Journal of Infrastructure Policy and Development*, 2(1): 67–86. https://doi.org/10.24294/jipd.v2i1.145

_____ (2019). "How does infrastructure investment affect macroeconomic performance? Evidence from Portugal". *Journal of Infrastructure Development*, 11(1–2): 14–40. https://doi.org/10.1177/0974930619872083

_____ (2020). "Infrastructure investments in Portugal and the traded/non-traded industry mix". *Journal of Infrastructure Policy and Development*, 4(1): 1–26. https://doi.org/10.24294/jipd.v4i1.1124

Ramey V (2011). "Can government purchases stimulate the economy?" *Journal of Economic Literature*, 49(3): 673–685. https://doi.org/10.1257/jel.49.3.673

_____ (2020). *The Macroeconomic Consequences of Infrastructure Investment* (National Bureau of Economic Research Working Paper No. 27625). NBER. https://doi.org/10.3386/w27625

Romp W and de Haan J (2007). "Public capital and economic growth: A critical survey". *Perspektiven der Wirtschaftspolitik*, 8(S1): 6–52. https://doi.org/10.1111/j.1468-2516.2007.00242.x

Rudebusch GD (1998). "Do measures of monetary policy in a VAR make sense?" *International Economic Review*, 39(4): 907–931. https://doi.org/10.2307/2527344

Sims CA and Zha T (1999). "Error bands for impulse responses". *Econometrica*, 67(5): 1113–1155. https://doi.org/10.1111/1468-0262.00071

Tressel T, Wang S, Kang JS and Shambaugh J (2014). *Adjustment in Euro Area Deficit Countries: Progress, Challenges and Policies*. International Monetary Fund. https://doi.org/10.5089/9781498373814.006

Wu Y (2021, July 14). "State infrastructure as a countercyclical tool". *PA Times Online*. https://patimes.org/state-infrastructure-programs-as-a-countercyclical-tool/