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On the Choice of the Regional Location of Infrastructure Investments in Portugal (*)

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Abstract

In this paper we deal with the issue of identifying empirically the best location for infrastructure investments. We define the best location for investment as the one that maximizes the benefits for the whole country, that is, across all regions, in terms of output, or employment or private investment. 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. We can summarize our results as follows. When we consider the issue of the best overall alternatives in terms of infrastructure investments and locations, we find that the largest output effects come from infrastructure investments in ports (except for North) and education (except for Lisbon). Investments in education are also very important in terms of both the employment and private investment effects (except again for Lisbon). In addition, investments in all airports have important private investment effects as do investments in ports in North and Center and municipal roads in Alentejo and Algarve. On the other hand, as to the question of how far the actual effects of infrastructure investments have been from their potential, as defined by the best location, our results suggest that the infrastructure assets that have actual long term effects closer to the potential effects are airports, education, and health. On the flip side, the actual long-term effects of investments in railroad are very far from the potential effects.

Keywords: Infrastructure Investment, Economic Performance, Regional Location, VAR, Portugal.
JEL Classification: C32, E22, H54, O52, R15, R42, R53

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On the Choice of the Regional Location of Infrastructure Investments in Portugal

1. Introduction

In this paper we deal with the issue of identifying empirically the best location for infrastructure investments. We define the best location as the one that maximizes the benefits for the whole country, i.e., across all regions, in terms of output, or employment or private investment. To address this issue we use a new regional 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 discussion is centered on four intertwined research questions. First, we want to determine for each infrastructure asset the best regional location for investments. This allows us given any type of infrastructure asset to determine, for any given type of infrastructure asset, in which region to invest to maximize the benefits for the country as a whole. Second, we want to determine for each region the best infrastructure investment alternatives for each region. This allows us for each region to determine, for each region, on in what infrastructure assets to invest on to maximize the benefits for the country as a whole. Third, we consider the issue of the best overall alternatives in terms of infrastructure investments and locations. This allows us in general to determine what and where to invest to maximize the benefits for the country as a whole. Finally, we compare the actual effects of infrastructure investments with their potential effects as defined by the best location decision as discussed before. This allows us to have an idea of how close or how far these investment have been from reaching their full potential in terms of their economic effects.

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 and de Haan (2007) and Pereira and Andraz (2013), for literature surveys as well as the literature review in Kamps (2005)].

The empirical evidence on the positive effects of infrastructure public 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 effects although clearly lower than the aggregate estimates [Costa *et al.* (1987), Duffy-Deno and Eberts (1991), Eberts (1990), Garcia-Mila and McGuire (1992), Merriman (1990), Moomaw and Williams (1991), Munnell with Cook (1990), and Munnell (1993)]. Later studies, however, find that after controlling for region and state specific unobserved characteristics, public capital effects are not significant [Andrews and Swanson (1995), Eisner (1991), Evans and 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 that for the US. In general, output elasticities are positive and relatively large in Japan [Merriman (1990)], Spain [Cutanda and Patricio (1992) and Mas *et al.* (1996)], Belgium [Everaert and 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 and 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 and Paul (2004), and Pereira and 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 and Andraz (2006)] and Spain [Pereira and 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. In addition, it deals with issues that are virtually absent in the literature, the issue of the empirical determination of the best regional location of for infrastructure investment.

In this paper, to address the issue of the best location for infrastructure investments, 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 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).

In terms of the scope of the analysis, we consider the five NUTS II regions at the NUTS IIof continental Portugal 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 and Pereira (2015a)], including investments in twelve different assets for the period 1978-2011 with regionalization at the NUTS II level for 1980-2011 for eight of these infrastructure assets. The different infrastructures cover five main groups of 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). For all of these there is information at the regional level. In addition, the data set includes three types of utilities (water and wastewater, electricity and gas, petroleum refineries), and telecommunications for which there is no information at the regional level.

We estimate region and asset specific models. For each of the five regions we estimate eight models one for each of the 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 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. Or, looking at it from our perspective, infrastructure investments in each region affecting economic performance in all of the regions in the country.

It should be pointed out that although our approach is eminently empirical, it is not a-theoretical. Indeed, our analysis is grounded in a dynamic model of the economy which helps understand the effects of infrastructure investments on labor productivity. In this model, the economy uses a production technology based on the use of capital and labor, as well as infrastructure, to generate output. Given market conditions and the availability of infrastructures, private agents decide on the level of input demand and the supply of output. In turn, the public sector engages in infrastructure investment based on a policy rule that relates infrastructure to the evolution of the remaining economic variables. The estimated VAR system can be seen as a dynamic reduced form system for a production function and three input demand functions – for employment and private investment as well as infrastructure investment [a policy function]. This framework captures the direct role of infrastructures as inputs in production as well as the indirect role through their effect on the demand for the other inputs.

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 in turn each one of the four 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, gross 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[IT1]. 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. Regional output, private investment and employment data are only available in a consistent manner after 1980. Output and private investment are in millions of 2005 Euros, and 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 1990 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 most importantlargest regions in terms of their share on the country's economy. Over the sample period North accounted for 30.58% of the country's output, 37.84% of investment and 35.68% of employment while Lisbon accounted for 27.21%, 40.22% and 29.02%, respectively. Centre is a middle sized region with 20.06% of output, 21.16%, of investiment, ande 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.[IT2]

Of these regions, North, Centre and Alentejo experience a decreasing trend in terms of their shares of output the opposite being truewhile in Lisbon and to a lesser extent in Algarve show an increasing trend. The same is true in terms of employment although there has been a rebound in the case of 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 availability limitations in the availability of the 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. 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 investments. 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 was national road investment, amounting to 0.52% of GDP. What is most striking, however, is the substantial increase in investment in highways since 2000. In the last decade, highway infrastructure investment amounted to 0.59% of GDP and surpassed national road infrastructure investment in importance. In contrast, the past thirty years have seen a steady decline in municipal road infrastructure investments.

Other transportation infrastructures include railroads, airports and ports. These investment reached their peak in the nineties with the modernization of the railroad network and port expansion projects with a substantial growth in investment in airports in the last ten years. In absolute terms this reflects 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. Investment in railroad infrastructures amounted to 0.29% of GDP over the sample period, reaching 0.35% of GDP during 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 last decade with investment volumes reaching 0.08% of GDP, nearly double that seen in the 1980s.

Social infrastructures include health facilities and educational buildings. These investments showed a slowly declining pattern over time in terms of their relative importance in total infrastructure investment. In absolute terms, however, they remained stable over the last two decades representing just over 1.0% of the GDP.

Investment in health facilities amounted to 0.46% of GDP while investment in educational facilities amounted to 0.50% of GDP. While both are comparable in terms of their relative magnitude over the sample period, their evolution was markedly different. Investment in health facilities increased steadily as a percent of GDP, the opposite being the case in general terms for investment in educational buildings. Indeed, investment in educational facilities reached their highest level in the nineties with 0.60% of the GDP while investment in health facilities reached its greatest volumes in the last decade also with 0.60% of GDP.

Public utilities include electricity and gas infrastructures, water supply and treatment facilities, and petroleum refining plants. Investment in public utilities reached a high level in the 1980s, driven by substantial investment in coal powered power plants and in refineries. More recently, investments in renewable energies and natural gas network have contributed to sustained growth in investment in utilities. In absolute terms, the importance of these investments increased from 0.70% of the GDP in the eighties to 1.44% in the last decade. Finally, investment in **telecommunications** amounted to 0.57% of GDP. In the nineties with the expansion of mobile communications networks they reached their peak with 0.70% of GDP.

Overall, infrastructure investments grew substantially over the past thirty years, averaging 2.88% of the GDP in the 1980s, 4.40% in the 1990s and 5.05% in the 2000s. 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 asand for the start of the different community support frameworks, 1989, 1994, 2000, and 2006, 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 infrastructures are presented in Table 5.

Over the sample period, North concentrates the higher proportion of infrastructure investment, 30.81%, followed by Centre, with 26.24%, Lisbon with 24.48%, 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 as well as the Zivot-Andrews 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 to be included in the regressions, and we include deterministic components, as well as the, a constant and/or a trend, as well as dummies for the potential structural breaks to be includedstructural breaks if they are statistically significant. We find that stationarity in first differences is a good approximation for all the time 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 in growth rates 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 and the Gregory-Hansen test. 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. In all of the tests, the optimal lag structure is chosen using the BIC, and deterministic components and structural breaks are included if they are statistically significant. As a general rule our tests cannot reject the null hypothesis of no co-integration. This is consistent with the view that it is rather unlikely to find co-integration with variables at a more disaggregated the regional level when we fail to find co-integration at the aggregate level.

The absence of cointegration is neither surprising nor problematic and is, in fact, consistent with results in 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 the level of its peers in the European Union. 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.

The absence of co-integration is not problematic conceptually and is, in fact, consistent with results in 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]. Furthermore, in the case of economies in a transition stage of their development, as it is the case of the Portuguese economy, not finding co-integration, i.e., not finding in the data evidence of convergence to the so-called great ratios among the aggregate variables in the economy, is hardly surprising.

Having determined that all of the variables are stationary in first differences and that they do not seem to be co-integrated, we follow the standard procedure in the literature and determine the specifications of the 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.

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3.33.2 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 investment variables are endogenous in the context of the VAR models, the central issue in determining the economic 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 and Evans (1996, 1998), and Rudebusch (1999)] 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.

At the national levelW, 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 two 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 decisions. 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 even moreparticularly p plausible at the regional level. This is because most of the regional infrastructure investment is financed by government funds, and therefore, 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 the regional modelswe consider both infrastructure investment in the region and infrastructure investment outside the regionelsewhere. 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 relatively smaller than compared to the infrastructure investments undertaken in the rest of the country. Besides,outside. 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.

3.53.3 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 the levels of these variables. 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 as well as the corresponding 90% bands that characterize the likelihood shape 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 described above. 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 and 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 presented in Tables 6, 7, and 8, for road transportation infrastructures, other transportation infrastructures and social infrastructures, respectively. These elasticities are the total accumulated percentage point long-term change in the other variables in the region per one-percentage point accumulated long-term change in infrastructure investment either 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.

Finally, these region-infrastructure specific marginal products with respect to investments in the region and elsewhere are used to construct the effects reported in Tables 9, 10, and 11. In these tables we present the overall effects for the country from each type of infrastructure investments in each region. The measurement of the total effect for the country is based on the idea that each infrastructure assets affects not only the region where it is located but the whole country. This is the flip side from what we discussed above that each region benefits from investment in the region itself as well as investments elsewhere. Accordingly, the total effect for the country from investments located in a given region is the sum of the direct marginal product for the region where the investment takes place plus the marginal product of these investments for the other regions.

4. On the Regional Effects of Infrastructure Investment

4.1 Preliminary Conceptual Remarks

To help frame the regional effects of infrastructure investments it is useful to understand the different mechanisms through which these investments and the related assets affect economic performance. In general terms, infrastructures fall in the category public goods or of externalities - they provide services that although being necessary for private sector activity, would not be available or would be in short supply if totally left to private sector mechanisms. As such their provision is either public or done through close public tutelage.

In this context, we can see infrastructure investments and the assets they generate affecting economic activity through different channels each with rather different impact on what one would expect in terms of the regional incidence of the effects depending on location, industry make up etc. First, there is what we could call a functional channel. Infrastructures fulfill a role as production inputs directly relevant for the activity in question. Transportation services for example, need a good road and other transportation network, while sectors that are either more labor intensive or rely more on skilled labor, such as finance or telecommunications, professional services, will have their productivity affected directly by the network of social infrastructures. This is, therefore, essentially a supply side channel. The ultimate effects are going to depend on the direct relevance of the infrastructure as an additional input to production as well as on the nature of the relationship between infrastructure and private inputs – labor and private capital.

While the functional channel is the most recognized and often the only recognized channel it is neither the only channel nor necessarily the most important. A second channel is what we could call the construction channel. These investment projects inevitably use vast pools of resources, engage the rest of the economy in the process itself of constructing these assets. Making available a road, or a port, a hospital or a waste management facility, directly engages the construction industry and through it the rest of the economy - construction materials, etc. These are demand side effects on output and employment that although reverberating throughout the economy are expected to be short-lived.

A third channel through which infrastructures affect economic performance is the operation and maintenance channel. Operating and maintaining existing infrastructures creates needs for use of resources - goods and services and labor. While the effects of the economic effort involved in operation and maintenance of a road infrastructures, for example, could easily be neglected, the same cannot be said about operating and maintaining a port, an airport, a hospital or a school. This is also a demand side effect but unlike the previous one it is more long lasting.

Finally, there is what we could call a site location channel. The existence of certain infrastructures such as certain transportation infrastructures, schools, and hospitals serve as an attractor for populations and business. Naturally, the opposite is true for airports, waste and wastewater facilities or power plants and refineries which have a negative effect on the desirability of where they are located.

It should be added that the issue of the ability of a region to capture spillovers from infrastructure investments in other regions, or on the reverse for investments in any region to have spillovers effects on other regions, is transversal to all of these channels. Indeed, the functional channel may mean making, for example through a better transportation network elsewhere, a region more accessible to economic activity and markets in other regions. The construction and the maintenance and operation of infrastructures in a region will likely mobilize resources in other regions as many firms really have a national dimension. Even the location channel may be active as desirable locations may attract people and resources to neighboring areas and undesirable locations may induce the shift of people and resources to other region.

4.2 Where to invest for each infrastructure asset

In this section, we address of the issue of identifying for each infrastructure asset the location that maximizes its the benefits of investment for the country as a whole. One can think about a decision to invest in a given infrastructure asset and wanting to the determination ofe where to locate such investment efforts. Empirical results are reported in Tables 9 to 11.

We consider first investments in **road transportation infrastructures**. For **national roads** the largest output effect occurs with investments in North, with a multiplier of €16.76. The output effects for investments in the other regions are much smaller and actually negligible for investments in Lisbon. In turn, investments in North and Center have also important effects on private investment and employment as do investments in Alentejo and Algarve in terms of private investments. Investments in Lisbon, Alentejo and Algarve have negative albeit small effects on employment. For **municipal roads**, investments in Lisbon lead to the largest output benefits with a multiplier of €45.54, with important output effects from investments in North and Alentejo with €13.45 and €21.27. The effects on private investment are large, in particular for Centre and Alentejo as are the effects on employment, except for Centro. Finally, for **highways** the effects are typically small across the board for private investment, employment as well as output (again with relatively important spillover effects). The largest output effects are for investments in North with a multiplier of €4.29.

We consider now the effects of investments in **other transportation infrastructures**. We see that the largest output effects for **railroads** are for investments in North with a multiplier of €10.75 and in Lisbon with a multiplier of €14.37. On the flip side, for investments in Centre we actually see a large negative effect. In turn, for private investment there are large effects from investments in Lisbon and the effects for employment are all very small. Investments in **airports** shows very favorable results in the three regions with major airports the largest being in the North, followed by Lisbon, and Algarve, with output multipliers of €33.90, €24.63, and €15.33, respectively. There are important private investment effects from investments in the three regions and important employment effects from investments in North. For **port** infrastructure, we observe as well very sizable effects particularly so in Centre with a multiplier of €62.97, followed by North, Alentejo and Algarve all with very large effects. We also find, across the board quantitatively important effects on both private investment and employments.

Finally, for **social infrastructures** we observe large effects across the board. In terms of **education** infrastructures, the largest effects are from investments in Centre, Lisbon and Algarve with multipliers of €47.57, €40.63, and €41.36. Very sizable effects across the two remaining regions, €12.35 for investments in North and €25.94 for investments in Alentejo. For private investment and employment are quantitatively very important leading to very large effects in both cases, especially, private investment effects from investments in Centre and Algarve and employment effects from investments in Centre and Alentejo. In turn, for **health** care infrastructures the largest effects come from investments in North and Alentejo with multipliers of €11.27 and €1.78, respectively. Moderate size effects occur for private investment and employment from investments in all regions.

4.3 What to invest for each region

We consider now the issue of the choice of location for investments from a different perspective. The issue is to identify for each region the best investments. One could think about a political decision to invest in one given region and wanting to determine which infrastructure assets to invest ion to maximize the overall benefits for the country. Empirical results are also reported in Tables 9 to 11.

For investments located in **North**, the largest output effects come from investments in airports and ports with multipliers of €33.89 and €30.10. There are still large output effects from investments in national roads, municipal roads, railroads and education. In terms of the effects on private investment and employment, we see again a great importance of investments in airports, ports, and education.

For investments in **Centre**, the best effects across the board for private investment, employment, and output come from ports and education. The largest output effects come from investments in ports and education with multipliers of €62.97 and €47.57, respectively. On the other hand, we do not find output benefits from investments highways while investments in railroads in the region are to be avoided.

For infrastructure investments located in **Lisbon**, the best output results come from investments in municipal roads, airports and education, with multipliers of €45.54, €24.63 and €40.63, respectively, with sizable effects from investments in railroads and ports. The effects from investments in national roads, highways are negligible. In terms of the effects on private investment, there are important effects from investments in municipal roads, railroads, airports, and education while for employment the largest effects come from investments in municipal roads, ports and education.

For **Alentejo**, the best investments in terms of the output effects are in municipal roads, ports, and education with multipliers of €21.27, €30.10 and €25.94, respectively, with important effects from investments in health infrastructures. In turn, the largest effects in terms of private investment, come from investments in municipal roads and education while for the employment effects the largest effects are from investments in municipal roads, ports, and education.

For **Algarve**, the best benefits come from ports and education, with multipliers of €26.42 and €41.63, with sizable effects from investments in airports. Important effects on private investment are induced by investments in airports and education and on employment by investments in municipal roads, ports, and education.

4.4 The best overall infrastructure investment options

We consider now the best investment options. The idea is to determine what are the best uses overall across all regions and all infrastructure assets. For each infrastructure asset there is the possibility of locating it in one of five regions. Accordingly, there are a total of forty outcomes. We want to identify the infrastructure-region combinations that maximize the national benefits in terms on their effects on private investment, employment, and output. One can think about a political decision to invest in infrastructures and wanting to determine what to invest on and where. Once again, the empirical results are reported in Tables 9 to 11.

For **private investment**, the largest effects come from airport and education investments in the North, municipal roads, ports and education in the Centre, municipal roads and airports in Lisbon, education in Alentejo, and airports and education in Algarve. Clearly, investments in airports and educational infrastructures seem to dominate these effects. Centre concentrates three of the top ten effects and Alentejo only one.

For **employment**, the largest effects come from investments in airports, ports, and education in the North, ports and education in the Centre, education in Lisbon, municipal roads and education in Alentejo and in both Algarve. In this case investments in educational infrastructures seem to dominate these effects with five of the top ten effects with a significant role for municipal roads and ports. North concentrates three of the top ten effects and Lisbon only one.

For **output**, the largest effects come from infrastructure investments in airports and ports in North, ports and education in Centre, municipal roads and education in Lisbon, and ports and education in both Alentejo and Algarve. Investments in ports and education are the two most important types of investment concentrating together eight of the top ten output effects.

4.5 How Far are the Actual Effects from the Potential Effects of Infrastructure Investments?

One last issue we want to address is to compare the potential with the actual effects of investments for each infrastructure asset. The idea is to determine how far the actual effects are from the potential effects and thereby to identify areas of relative strength and weakness in terms of the patterns of infrastructure investments followed in the past.

The potential effects for each infrastructure asset are defined and the largest regional marginal product for each asset, thereby reflecting the best location alternative for each infrastructure investment. In turn, the actual effects, are taken from Pereira and Pereira (2015b) where the same data set and the same methodological approach are used to provide a regional decomposition of the aggregate effects of investments in the different types of infrastructure assets considering both the direct effect in the region as well as the spillover effects captured by each region. These actual effects are, therefore, directly comparable to the potential effects we identify in this paper. Table 12 reports the actual effects from Pereira and Pereira (2015b), the best effects as identified in this paper, and the ratio between the two which gives an indication of how far or how close the actual investments have been from their full potential.

Our results suggest that in terms of the output effects, the infrastructure assets that have actual long term effects closer to the potential are airports, education, and health all with ratios of actual to potential above 70%. The same is true for highways, airports, education and health for private investment and ports and health in terms of the employment effects. On the flip side, railroad investments across the board, municipal roads for private investment and output and national roads and highways for employment, are all far from their potential effects, with ratios under 40%.

Overall, there is a clear pattern, as the economic effects of investments in airports and health are much closer to their potential than the remaining infrastructure assets, closely followed by education and ports. Investments in railroads faire very poorly. The case of airports is paradigmatic as being on average at 80% of their potential, something that can be understood if we consider that we are talking about three main airports. Investments in railroads, known as having been somewhat neglected over the sample period, faire very poorly on average at less than 30% of their potential.

From a different perspective we can also observe that the ratios for the different infrastructure investments are on average lowest for employment and greatest for private investment. In fact, in four of the eight infrastructure assets private investment the ratios exceed

70% while in three of the eight employment ratios the ratio is under 40%. This also goes with the perception of important rigidities in the labor markets.

5. Summary and Concluding Remarks

In this paper we deal with the issue of identifying empirically the best location for infrastructure investments. We define the best location as the one that maximizes the benefits for the whole country, that is, across all regions, in terms of output, or employment or private investment. 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.

We can summarize our results as follows. When we consider the issue of the best overall alternatives in terms of infrastructure investments and locations, we find that the largest output effects come from infrastructure investments in ports (except for North) and education (except for Lisbon). Investments in education are also very important in terms of both the employment and private investment effects (except again for Lisbon). In addition, investments in all airports have important private investment effects as do investments in ports in North and Center and municipal roads in Alentejo and Algarve.

On the other hand, as to the question of how far the actual effects of infrastructure investments have been from their potential, as defined by the best location, our results suggest that the infrastructure assets that have actual long term effects closer to the potential effects are airports, education, and health. On the flip side, the actual long-term effects of investments in railroad are very far from the potential effects.

The policy implications of our results are self-evident. This being the case, however, it is critical to understand the scope of the results, what they are informative about and what they are not. These results are meant to give very clear guidance as to the infrastructure assets and regions to pay attention to in the design of infrastructure policy. They are important inputs in determining what and where to invest in general terms and in helping identify the potential effects of specific investment projects. What they cannot do, is to be used as the only factor to justify any specific infrastructure investment project in any given region. For that there is no substitute to a serious, substantive and informative benefit-cost analysis.

The results in this paper open the door to several important research avenues, technical and yet directly relevant for policy making. An important next step would be going more in the direction of the fiscal multiplier literature and to explore how non-linearities may affect the effects of infrastructure investments. In particular, it would interesting to consider the issue of regime switching, i.e., if it makes a different if the investments occur in a boom or a bust, as well as the issue of the potential differential effects between investment increases and decreases. In addition, a closer look at the timing of the effects, that is, the issue of whether most of the effects occur in the short-term or over a longer time frame would help in understanding the nature of the mechanisms behind these effects. Finally, exploring the panel dimension of the data could bring new insights into the results and obviate any concerns about relative small sample sizes so common in this literature.

TTo conclude, it should be mentioned that 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 best regional location for the infrastructure investment efforts 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.

References

1. Andrews, K. and Swanson, J. (1995), "Does public infrastructure affect regional performance?" *Growth and Change*, Vol. 26, No. 2, pp. 204-216.

2. Baunsgaard, T., A. Mineshima, M. Poplawski-Ribeiro, and A. Weber (2014), "Fiscal Multipliers," in *Post-Crisis Fiscal Policy* C. Cottarelli, P. Gerson, and A. Senhadji (Eds.). MIT Press.

3. Blanchard, O. and R. Perotti (2002), "An Empirical Characterization of the Dynamic Effects of Changes in Government Spending and Taxes on Output," *Quarterly Journal of Economics* 117, 1329-68.

2.4. Boarnet, M. G. (1998), "Spillovers and the Locational Effects of Public Infrastructure," *Journal of Regional Science,* 38, 381-400.

3.5. Boscá, J., Escriba, J., and Murgui, M. (2000), "The effect of public infrastructure on the private productive sector of Spanish regions," *Journal of Regional Science*, Vol. 42, 301-326.

4.6. Cadot, O., Roller, L. and Stephan, A. (1999), "A political economy model of infrastructure allocation: an empirical assessment," CEPR Discussion Paper Nº 2336, Wissenschaftszentrum, Berlin, December

5.7. Cohen, J. and Paul, C. (2004), "Public infrastructure investment, interstate spatial spillovers and manufacturing costs," *Review of Economics and Statistics*, Vol. 86, No. 2, 551-560.

6.8. Costa, J., R. Ellson and R. Martin (1987): "Public Capital, Regional Output, and Development: Some Empirical Evidence," *Journal of Regional Science,* 27(3), 419-437.

7.9. Christiano, L., M. Eichenbaum, C. Evans (1996), "The Effects of Monetary Policy Shocks: Evidence from the Flow of Funds," *Review of Economics and Statistics* 78(1), 16-34.

8.10. Christiano, L., M. Eichenbaum, C. Evans (1999), "Monetary Policy Shocks: What Have we Learned and to What End?" in *Handbook of Macroeconomics* Vol. 1A, Eds. John B. Taylor and Michael Woodford. North-Holland.

9.11. Cutanda, A. and Patrício, J. (1992), "Infrastructure and regional economic growth: the Spanish case," *Regional Studies*, Vol. 28, No. 1, pp. 69-77.

10.12. Duffy-Deno, K. and R. Eberts (1991), "Public Infrastructure and Regional Economic Development: A Simultaneous Equations Approach," *Journal of Urban Economics* 30, 329-43.

11.13. Eberts, R. (1990), "Cross sectional analysis of public infrastructure and regional productivity growth", Working Paper No. 9004, Federal Reserve Bank of Cleveland, Cleveland, May.

12.14. Eisner, R. (1991), "Infrastructure and regional economic performance: comment", *New England Economic Review*, September, pp. 47-58.

13.15. Evans, P. and G. Karras (1994), "Are Government Activities Productive? Evidence From a Panel of U.S. States," *Review of Economics and Statistics,* 76(1) 1-11.

14.16. Everaert, G. (2003), "Balanced growth and public capital: an empirical analysis with I(2) trends in capital stock data," *Economic Modelling*, Vol. 20, pp. 741-763.

15.17. Everaert, G. and Heylen, F. (2004), "Public capital and long term labor market performance in Belgium," *Journal of Policy Modeling*, Vol. 26, pp. 95-112.

16.18. Garcia-Milà, T. and T. McGuire (1992), "The Contribution of Publicly Provided Inputs to States' Economies," *Regional Science and Urban Economics,* 22, 229-41.

17.19. Garcia-Milà, T., T. McGuire and R. Porter (1996), "The Effect of Public Capital in State-Level Productions Functions Reconsidered," *Review of Economics and Statistics,* 78(1), 177-80.

18.20. Gramlich, E. (1994), "Infrastructure investment: A review essay," *Journal of Economic Literature* 32, 1176-96.

19.21. Haugwout, F, (1989), "Aggregate Production Functions, Interregional Equilibrium, and the Measurement of Infrastructure Productivity," *Journal of Urban Economics,* 44, 216-27.

20.22. Haugwout, F. (2002), "Public Infrastructure Investments, Productivity and Welfare in Fixed Geographical Areas," *Journal of Public Economics,* 83, 402-28.

21.23. Holtz-Eakin, D. (1993), "Public investment in infrastructure," *Journal of Economic Perspectives*, Vol. 7, No. 4, pp. 231-234.

22.24. Holtz-Eakin, D. (1994), "Public Sector Capital and the Productivity Puzzle," *The Review of Economics and Statistics,* 76 (1), 12-21.

23.25. Holtz-Eakin, D. and A. Schwartz (1995), "Spatial Productivity Spillovers from Public Infrastructure: Evidence from State Highways," *International Tax and Public Finance,* 2, 459-68.

24.26. Instituto Nacional de Estatística www.ine.pt

27. Kamps, C. (2005), "The dynamic effects of public capital: VAR evidence for 22 OECD countries," *International Tax and Public Finance* 12, 533-558.

28. Kilian, Lutz (1998), "Small-Sample Confidence Intervals for Impulse Response Functions," *Review of Economics and Statistics*, Vol. 80. No.2, pp. 218-230.

29. Leduc, Sylvain and Daniel Wilson (2012), "Roads to Prosperity or Bridges to Nowhere? Theory and Evidence on the Impact of Public Infrastructure Investment," *NBER Macroeconomics Annual* Vol. 27 No. 1, pp. 89-142.

25.

26.30. Mas, M., Maudos J., Perez, F. and Uriel, E. (1996), "Infrastructures and productivity in the Spanish regions," *Regional Studies*, Vol. 30, No. 7, pp. 641-650.

27.31. Merriman, D. (1990), "Public capital and regional output: another look at some Japanese and American data," *Regional Science and Urban Economics*, Vol. 20, pp. 437-458.

28.32. Mikelbank, B. A. and R. W. Jackson (2000), "The Role of Space in Public Capital Research," *International Regional Science Review,* 23 (3), 235-58.

29.33. Mikelbank, B. and Jackson, R. (2000), "The role of space in public capital research," *International Regional Science Review*, Vol. 23, No. 3, pp. 235-258.

30.34. Moomaw R. and Williams, M. (1991), "Total factor productivity growth in manufacturing: further evidence from the states," *Journal of Regional Science*, Vol. 31, No. 1, pp. 17-34.

31.35. Moomaw, R., Mullen, J. and Williams, M. (1995), "The interregional impact of infrastructure capital," *Southern Economic Journal*, Vol. 61, No. 3, pp. 830-845.

32.36. Moreno, R., López-Bazo, E. and Artís, M. (2003), "On the effectiveness of private and public capital," *Applied Economics*, Vol. 35, pp. 727-740.

33.37. Munnell, A. (1990), "Why Has Productivity Growth Declined? Productivity and Public Investment," *New England Economic Review*, January/February, 3-22.

34.38. Munnell, A. (1992), "Infrastructure, Investment and Economic Growth," *Journal of Economic Perspectives,* 6, 189-98.

35.39. Munnell, A. and L. Cook (1990), "How Does Public Infrastructure Affect Regional Economic Performance?" *New England Economic Review*, September/October, Federal Reserve Bank of Boston, 11-33.

36.40. Pereira, A. (2000), "Is all public capital created equal?" *Review of Economics and Statistics* 82, pp. 513-518.

37.41. Pereira, A. (2001), "Public capital formation and private investment: what crowds in what?" *Public Finance Review* 29, 3-25.

38.42. Pereira, A. and Andraz, J. (2003), "On the impact of public investment on the performance of US industries," *Public Finance Review* 31, 66-90.

39.43. Pereira, A. and Andraz, J. (2004), "Public highway spending and state spillovers in the USA," *Applied Economics Letters* 11, 785-788.

40.44. Pereira, A. and Andraz, J. (2005), "Public investment in transportation infrastructures and economic performance in Portugal," *Review of Development Economics* 9, 177-196.

41.45. Pereira, A. and Andraz, J. (2006), "Public investment and regional asymmetries in Portugal," *Annals of Regional Science,* Vol. 40, No. 4, pp. 803-817.

42.46. Pereira, A. and Andraz, J. (2013), "On the economic effects of public infrastructure investment: a survey of the international evidence," *Journal of Economic Development* 38 (4), 1-37.

43.47. Pereira, A. and Flores, R. (1999), "Public capital accumulation and private-sector performance in the U.S.," *Journal of Urban Economics* 46, 300-322.

44.48. Pereira, A. and R. Pereira (2015a), *Investimentos em Infraestruturas em Portugal: Dados e Factos Estilizados*. Fundação Francisco Manuel dos Santos, forthcoming.

45.49. Pereira, A. and R. Pereira (2015b), "On the Regional Dimension of Infrastructure Investments in Portugal," mimeo.

46.50. Pereira, A. and O. Roca-Sagales (1999), "Public Capital Formation and Regional Development in Spain," *Review of Development Economics*, 3(3), 281-294.

47.51. Pereira, A. and Roca-Sagales, O. (2003), "Spillover effects of public capital formation: evidence from the Spanish regions," *Journal of Urban Economics* 53, 238-256.

52. Pereira, A. and Roca-Sagales, O. (2007), "Public Infrastructures and Regional Asymmetries in Spain," *Revue d'Economie Regionale et Urbaine*, 503- 520.

53. Ramey, V. (2011), "Can Government Purchases Stimulate the Economy?" *Journal of Economic Literature* 49 (3), 673-85.

48.

49.54. Romp, W. and de Haan, J. (2007), "Public capital and economic growth: a critical survey," *Perspektiven der Wirtschaftspolitik*, 8, Special Issue, April, 6-52

55. Rudebusch, G. D. (1998): "Do Measures of Monetary Policy in a VAR Make Sense?" *International Economic Review*, 39(4), 907-931.

56. Sims, Christopher A. and Tao Zha. (1999), "Error Bands for Impulse Responses," *Econometrica*. Vol. 67, no. 5. pp. 1113-1155.

50.

51.57. Stephan, A. (2000), "Regional infrastructure policy and its impact on productivity: a comparison of Germany and France," *Applied Economics Quarterly*, Vol. 46, pp. 327– 356.

Table 1 Definition of Regions by NUTS II

NUTS II	NUTS III
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,
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,
Lisboa	ALCOCHETE, ALMADA, AMADORA, BARREIRO, CASCAIS, LISBOA, LOURES, MAFRA, MOITA, MONTIJO, ODIVELAS, OEIRAS, PALMELA, SEIXAL, SESIMBRA, SETÚBAL, SINTRA, VILA FRANCA DE XIRA,
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,

Table 2 Summary of Regional Composition of Economic Activity

		North	Centre	Lisbon	Alentejo	Algarve
			GDP			
1980-2011	100.0000	30.5914	20.0550	37.8427	7.2890	4.2219
1980-89	100.0000	31.3566	20.1121	36.8297	7.6442	4.0574
1990-99	100.0000	30.9163	20.2332	37.5622	7.2579	4.0303
2000-09	100.0000	29.6333	19.9236	38.8550	7.0530	4.5351
			Private Investment			
1980-2011	100.0000	27.2098	21.1647	40.2233	6.7580	4.6442
1980-89	100.0000	26.5371	21.8878	41.6967	5.7321	4.1463
1990-99	100.0000	26.4555	20.6526	42.9658	5.9801	3.9460
2000-09	100.0000	27.9919	21.2783	37.0182	7.9839	5.7277
			Employment			
1980-2011	100.0000	35.6761	25.2699	29.0247	6.3434	3.6860
1980-89	100.0000	36.0457	26.1692	27.8952	6.7912	3.0987
1990-99	100.0000	35.9548	25.3440	29.1080	5.9198	3.6734
2000-09	100.0000	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 2 Summary of Regional Composition of Economic Activity

		North	Centre	Lisbon	Alentejo	Algarve
				GDP		
1980-2011	100.0000	30.5914	20.0550	37.8427	7.2890	4.2219
1980-89	100.0000	31.3566	20.1121	36.8297	7.6442	4.0574
1990-99	100.0000	30.9163	20.2332	37.5622	7.2579	4.0303
2000-09	100.0000	29.6333	19.9236	38.8550	7.0530	4.5351
				Private Investment		
1980-2011	100.0000	27.2098	21.1647	40.2233	6.7580	4.6442
1980-89	100.0000	26.5371	21.8878	41.6967	5.7321	4.1463
1990-99	100.0000	26.4555	20.6526	42.9658	5.9801	3.9460
2000-09	100.0000	27.9919	21.2783	37.0182	7.9839	5.7277
				Employment		
1980-2011	100.0000	35.6761	25.2699	29.0247	6.3434	3.6860
1980-89	100.0000	36.0457	26.1692	27.8952	6.7912	3.0987
1990-99	100.0000	35.9548	25.3440	29.1080	5.9198	3.6734
2000-09	100.0000	35.2519	24.4907	29.7136	6.3559	4.1879

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

	Road Infrastructures	National Roads	Municipal Roads	Highways	Other Transportation Infrastructures	Railroads	Ports	Airports	Social Infrastructu
					North				
1980-2011	33.33	31.53	36.38	29.92	23.60	21.63	25.87	27.39	30.36
1980-89	34.69	34.14	37.76	19.96	24.33	20.46	35.23	24.72	29.17
1990-99	32.22	32.09	33.00	32.35	17.02	16.96	17.89	14.41	30.55
2000-09	32.14	28.71	37.86	31.14	30.19	28.70	19.74	46.28	31.42
					Centre				
1980-2011	29.76	27.81	27.27	43.91	20.44	26.30	10.62	0.00	25.20
1980-89	32.96	32.69	25.03	73.99	19.03	26.64	4.74	0.00	27.75
1990-99	24.40	25.91	24.40	20.83	21.63	27.02	3.95	0.00	24.07
2000-09	33.21	25.33	31.08	44.16	19.16	22.74	23.61	0.00	24.03
					Lisbon				
1980-2011	16.12	15.60	19.38	12.89	35.37	31.96	37.56	57.08	31.96
1980-89	16.55	16.70	18.60	6.06	32.84	28.52	35.82	57.90	32.31
1990-99	23.70	21.02	27.17	25.23	36.65	32.78	41.34	72.43	32.64
2000-09	8.63	10.16	14.03	4.18	37.79	36.60	38.33	38.91	31.01
					Alentejo				
1980-2011	14.13	17.82	9.98	10.80	15.25	15.65	24.62	0.00	8.14
1980-89	9.42	10.74	10.38	0.00	17.00	18.67	23.42	0.00	7.94
1990-99	12.82	10.57	8.81	21.49	21.27	20.06	36.34	0.00	8.54
2000-09	18.83	29.88	10.29	12.70	7.37	7.45	15.68	0.00	7.86
					Algarve				
1980-2011	6.65	7.25	6.99	2.49	5.35	4.47	1.33	15.52	4.34
1980-89	6.39	5.73	8.23	0.00	6.81	5.71	0.80	17.38	2.83
1990-99	6.87	10.41	6.63	0.09	3.43	3.18	0.48	13.16	4.21
2000-09	7.19	5.92	6.74	7.82	5.49	4.51	2.64	14.80	5.68

Table 6 Elasticities with respect to Road Transportation Investment

	Private Investment		Employment		Output	
	Effect of Investment		Effect of Investment		Effect of Investment	
	In the Region	Outside the region	In the Region	Outside the region	In the Region	Outside the region
National Roads						
North	**0.3427**	**0.2017**	**0.0901**	**-0.0185**	**0.0687**	0.0186*
Centre	-0.0081*	**0.1761**	**0.0372**	**-0.0463**	-0.0282*	0.0012*
Lisbon	-0.0492*	**0.4098**	-0.0062*	**0.0861**	0.0028*	**0.0922**
Alentejo	**0.1952**	**0.3420**	**-0.0425**	**-0.0898**	**0.0398**	**0.0680**
Algarve	-0.0146*	-0.1619*	-0.0014*	**-0.1327**	0.0007*	**-0.0714**
Municipal Roads						
North	-0.1308*	**0.2525**	0.0043*	**0.0379**	-0.0531*	**0.0563**
Centre	**0.1579**	**0.4182**	**-0.0441**	**0.0525**	0.0051*	**0.1480**
Lisbon	**0.1722**	0.0381*	0.0060*	**0.0418**	**0.0363**	0.0175*
Alentejo	**0.1815**	**0.3757**	-0.0155*	**0.0252**	0.0082*	0.0243*
Algarve	**-0.1927**	**0.1370**	-0.0265*	**0.0845**	**-0.0860**	**0.0574**
Highways						
North	**0.0411**	**0.0703**	**0.0094**	0.0055*	**0.0125**	**0.0114**
Centre	**-0.0839**	**0.0411**	**-0.0110**	0.0013*	**-0.0288**	**0.0170**
Lisbon	0.0083*	**0.0856**	-0.0001*	**0.0138**	0.0020*	**0.0156**
Alentejo	-0.0028*	**0.1259**	-0.0014*	**-0.0213**	-0.0014*	**0.0321**
Algarve	0.0099*	**0.0541**	0.0023*	-0.0082*	0.0028*	-0.0020*

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

Table 7 Elasticities with respect to Other Transportation Investment

	Private Investment		**Employment**		**Output**	
	Effect of Investment		Effect of Investment		Effect of Investment	
	In the Region	Outside the region	In the Region	Outside the region	In the Region	Outside the region
			Railroads			
North	0.0068*	**0.2206**	0.0206*	**0.0249**	**0.0185**	**0.0186**
Centre	**-0.0912**	**0.1535**	**-0.0178**	**0.0157**	**-0.0476**	**0.0525**
Lisbon	**0.1473**	**-0.1474**	**0.0164**	0.0059*	**0.0214**	-0.0157*
Alentejo	**0.0429**	**0.3332**	**-0.0103**	**-0.0565**	**-0.0116**	**0.0401**
Algarve	0.0031*	**-0.0087**	0.0029*	**-0.0282**	0.0039*	0.0088*
			Airports			
North	**0.0460**	**0.0314**	**0.0103**	-0.0025*	**0.0151**	-0.0004*
Centre	**-**	**0.0562**	**-**	-0.0084*	-	**0.0108**
Lisbon	**0.0488**	**0.0242**	**0.0117**	**0.0105**	**0.0131**	**0.0083**
Alentejo	**-**	**0.1751**	**-**	**-0.0273**	**-**	**0.0236**
Algarve	**0.0410**	-0.0200*	-0.0063*	0.0104*	0.0005*	**0.0257**
			Ports			
North	**0.0125**	0.0086*	**0.0018**	0.0015*	0.0025*	0.0075*
Centre	**0.0644**	**0.0825**	**0.0055**	**0.0126**	**0.0255**	**0.0192**
Lisbon	-0.0324*	-0.0202*	-0.0031*	0.0017*	0.0030*	**0.0159**
Alentejo	**-0.0233**	**0.0830**	-0.0017*	**0.0344**	-0.0007*	0.0002*
Algarve	0.0001*	**0.0720**	0.0003*	**0.0310**	0.0001*	**0.0349**

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

Table 8 Elasticities with respect to Investment in Social Infrastructures

	Private Investment		**Employment**		**Output**	
	Effect of Investment		Effect of Investment		Effect of Investment	
	In the Region	Outside the region	In the Region	Outside the region	In the Region	Outside the region
			Education			
North	**0.1464**	**0.4116**	**0.0196**	**0.0767**	0.0215*	**0.1233**
Centre	**0.3167**	**0.5300**	**0.0644**	**0.0360**	**0.1370**	**0.1504**
Lisbon	0.0288*	**0.2688**	**0.0178**	**0.0773**	**0.0278**	0.0119*
Alentejo	-0.2486*	**0.4736**	**0.0746**	**0.0476**	-0.0228*	**0.1241**
Algarve	**0.1346**	0.0742*	-0.0076*	**0.0600**	**0.0487**	**-0.0641**
			Health			
North	**0.0871**	**0.1954**	**0.0159**	**0.0777**	**0.0384**	**0.0513**
Centre	**0.0866**	**0.3785**	**0.0201**	**0.0288**	**0.0350**	**0.1032**
Lisbon	**0.0140**	**0.1813**	**0.0035**	**0.0293**	0.0044*	0.0180*
Alentejo	**0.1501**	**0.5600**	**-0.0229**	**0.0175**	**0.0418**	**0.1179**
Algarve	0.0090*	-0.0197*	**-0.0243**	**-0.1259**	0.0044*	**-0.1969**

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

Table 9 Marginal Product with respect to Road Transportation Investments in each Region

	Private Investment			Employment			Output		
	Effect of Investment			Effect of Investment			Effect of Investment		
	On the region itself	On the other regions	Total	On the region itself	On the other regions	Total	On the region itself	On the other regions	Total
National Roads									
North	10.9415	8.1883	19.1298	0.5258	-0.002	0.5238	10.3284	6.4282	16.7566
Centre		9.2276	9.2276	0.1746	0.0269	0.2015		6.4282	6.4282
Lisbon		5.5446	5.5446		-0.1861	-0.1861		0.4872	0.4872
Alentejo	1.7399	9.5571	11.297	-0.0442	-0.0071	-0.0513	1.3913	5.4279	6.8192
Algarve		10.8392	10.8392		-0.0173	-0.0173		6.9413	6.9413
Municipal Roads									
North		11.0721	11.0721		0.3717	0.3717		13.451	13.451
Centre	6.623	10.1946	16.8176	-0.3198	0.3951	0.0753		8.6444	8.6444
Lisbon	25.4532	18.5202	51.0941		0.4391	0.4391	24.267	21.2732	45.5402
Alentejo	8.5083	16.3211	24.8294		0.5587	0.5587		21.2732	21.2732
Algarve	-10.4746	17.9728	7.4982		0.539	0.539	-16.759	20.451	3.692
Highways									
North	1.1689	2.4268	3.5957	0.049	0.0173	0.0663	1.6753	2.6108	4.2861
Centre	-1.7665	3.188	1.4215	-0.04	0.0173	-0.0227	-2.6012	2.6227	0.0215
Lisbon		2.4733	2.4733		-0.0087	-0.0087		2.4663	2.4663
Alentejo		3.3139	3.3139		0.026	0.026		3.1863	3.1863
Algarve		3.6232	3.6232		0.0173	0.0173		3.6287	3.6287

Note - The empty entries correspond to the estimates that are not significantly different from zero as implied by the standard deviation bands around the accumulated impulse response functions.

Table 10 Marginal Product with respect to Other Transportation Investment in each Region

	Private Investment			Employment			Output		
	Effect of Investment			Effect of Investment			Effect of Investment		
	On the region itself	On the other regions	Total	On the region itself	On the other regions	Total	On the region itself	On the other regions	Total
				Railroads					
North		-0.74	-0.74		-0.0012	-0.0012	5.7619	4.9826	10.7445
Centre	-5.4451	2.3165	-3.1286	-0.1841	0.0698	-0.1143	-12.1956	3.2181	-8.9775
Lisbon	9.7576	10.502	20.2596	0.1365	0.1191	0.2556	7.0762	7.2966	14.3728
Alentejo	3.4281	3.1852	6.6133	-0.0966	0.157	0.0604	-3.6568	6.3925	2.7357
Algarve		5.1351	5.1351		0.1317	0.1317		7.2966	7.2966
				Airports					
North	10.7334	14.3782	25.1116	0.4368	0.2147	0.6515	16.5343	17.3648	33.8991
Centre	0	0	0	0	0	0	0	0	0
Lisbon	12.4971	14.0448	26.5419	0.3751	-0.0876	0.2875	16.7409	7.8919	24.6328
Alentejo	0	0	0	0	0	0	0	0	0
Algarve	7.2339	19.5987	26.8326		0.2147	0.2147		15.3275	15.3275
				Ports					
North	5.9431	15.0302	20.9733	0.1593	0.5123	0.6716		30.0975	30.0975
Centre	25.0523	5.3711	30.4234	0.367	0.2575	0.6245	42.4967	20.4696	62.9663
Lisbon		15.0302	15.0302		0.5123	0.5123		12.815	12.815
Alentejo	-4.3499	11.4936	7.1437		0.3414	0.3414		30.0975	30.0975
Algarve		13.1957	13.1957		0.4257	0.4257		26.9104	26.9104

Note - The empty entries correspond to the estimates that are not significantly different from zero as implied by the standard deviation bands around the accumulated impulse response functions.

Table 11 Marginal Product with respect to Social Infrastructure Investments in each Region

	Private Investment			Employment			Output		
	Effect of Investment			Effect of Investment			Effect of Investment		
	On the region itself	On the other regions	Total	On the region itself	On the other regions	Total	On the region itself	On the other regions	Total
Education									
North	6.3753	18.7059	25.0812	0.1556	0.4261	0.5817		12.3519	12.3519
Centre	16.0476	21.3655	37.4131	0.5645	0.7122	1.2767	29.7529	17.8185	47.5714
Lisbon		22.6378	22.6378	0.1957	0.5447	0.7404	12.1581	28.4724	40.6305
Alentejo		27.6691	27.6691	0.5652	0.7864	1.3516		25.9438	25.9438
Algarve	9.299	30.1261	39.4251		0.7914	0.7914	12.0573	29.303	41.3603
Health									
North	3.3675	9.083	12.4505	0.1122	0.0978	0.21	7.0011	4.2723	11.2734
Centre	2.7463	8.0682	10.8145	0.11	0.2462	0.3562	4.7512	3.2741	8.0253
Lisbon	0.5088	8.2297	8.7385	0.0159	0.2227	0.2386		7.637	7.637
Alentejo	5.1209	10.0278	15.1487	-0.091	0.2888	0.1978	5.6052	6.1699	11.7751
Algarve		11.8029	11.8029	-0.0911	0.3257	0.2346		9.1947	9.1947

Note - The empty entries correspond to the estimates that are not significantly different from zero as implied by the standard deviation bands around the accumulated impulse response functions.

Table 12 How Far are the Actual Effects from the Potential Effects of Infrastructure Investments?

	Private Investment			Employment			Output		
	Effect of Investment		Average /Marg.	Effect of Investment		Average /Marg.	Effect of Investment		Average /Marg.
	Average	Marginal	(%)	Average	Marginal	(%)	Average	Marginal	(%)
Road Transportation									
National Roads	12.44	19.13	**65.03**	160	524	**30.53**	9.17	16.76	**54.72**
Municipal Roads	19.03	51.09	**37.25**	316	559	**69.20**	17.18	45.54	**37.73**
Highways	2.65	3.62	**73.20**	21	66	**31.82**	2.39	4.29	**55.71**
Other Transportation									
Railroads	6.87	20.26	**33.91**	71	256	**27.73**	3.72	14.37	**25.89**
Airports	26.00	26.83	**96.91**	424	652	**65.03**	27.21	33.90	**80.27**
Ports	18.92	30.42	**62.20**	550	672	**81.84**	32.75	62.97	**52.20**
Social Infrastructure									
Education	27.66	39.43	**70.15**	881	1352	**65.16**	33.63	47.57	**70.70**
Health	11.33	15.15	**74.79**	253	356	**71.07**	9.55	11.78	**81.07**