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On the Economic and Fiscal Effects of Investments in Road Infrastructures in Portugal *

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Abstract

The objective of this paper is to investigate the economic and fiscal impact of road infrastructure investment in Portugal, focusing on the effects for each administrative region of both local investments and investments in other regions. We estimate VAR models for the national economy as well as for each of the five regions and using the associated impulse-response functions we find that investment in road infrastructures has been a powerful instrument to increase private investment, to create new permanent jobs and to promote long-term growth in all regions. More importantly, investment in road infrastructure, both at the aggregate level and for each one of the five regions, generates fiscal effects that largely exceed the initial investment itself. Accordingly, there is no trade-off in the long-term between the potentially positive economic effects and the potentially negative budgetary effects of such investments, i.e., both economic and budgetary effects are positive. As a corollary, policies that would reduce current road investment as a response to the current budgetary concerns will result in lower long-term growth as well as worse budgetary conditions in the future.

JEL Codes: C32, H54, and R53
Keywords: public investment, road transportation infrastructures, regional spillovers, Portugal.

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1. Introduction

There is currently a raging policy debate in Portugal over public investments in general and investments in road infrastructures in particular. In recent years, this debate has been mostly centered on two specific programs. The first is the new toll-free highways constructed and operated under private-public partnerships and financed by shadow tools, the so-called SCUT freeways. The second, the so-called Plan for Investments in Priority Infrastructures, is a plan of, among other things, road investments presented in 2005 by the government. More recently, under the current economic recession, there has been a renewed interest in road investment and its potential role in helping Portugal out of this situation.

The debate itself reflects two sharply conflicting economic policy needs. On one hand, there is the long-term strategic need to promote the fundamentals of long-term growth. The efforts of the last two decades to build a comprehensive network of transportation infrastructures have changed the landscape of the country. However, available statistical data, naturally reflecting short-term business cycle effects and economic difficulties in other areas, seems to show limited success in promoting long-term growth and convergence to EU standards of living. Clearly, from the perspective of long-term growth, the argument can be made that the effort to develop an infrastructure network needs to be continued.

On the other hand, there is the shorter-term need of increasing budgetary restraint, in the context of the Stability and Growth Programs associated with the European Monetary Union and much more so under the current need for budgetary consolidation in the aftermath of the policy response to the current economic crisis. The public budget in Portugal has been notoriously bloated and the public deficit notoriously persistent. This means that the financing of public investments will face in the foreseeable future an environment of increasing scarcity of public funds. The situation is made worse by the fact that while the country in the last two decades has relied heavily on EU structural funds to finance such public infrastructure investments, such funds are now becoming increasingly scarce due a new focus of the EU on the new member states. Clearly, from the perspective of budgetary restraint, the argument can be made that engaging in large scale public projects in this budgetary environment is not reasonable.

The corollary is that the public debate on infrastructure investment is completely framed by the perceived trade-off between promoting long-term growth and achieving short-term budgetary consolidation. The proponents of these investment plans often focus on the potential economic benefits without the consideration of the potential budgetary effects while conversely the detractors of these programs focus on the potentially negative budgetary effects without recognizing the potentially positive economic effects.

The critical question, however, is whether or not this perceived trade-off between long-term growth and short-term budgetary restraint is an actual trade-off or even the right potential trade-off to consider. Conceptually it does not have to be either. Indeed, to the extent that public investment increases output in the long-term, it also expands the tax base and, therefore, tax revenues in the long term. It is conceivable that public investment has such strong effects on output, that over time it generates enough additional tax revenues to pay for itself. It is equally plausible that the effects on output although positive are not strong enough for the public investment to pay for itself. In the first case, cuts in public investment hurt long-term growth and make the future budgetary situation worse. In the second case, cuts in public

investment hurt the long-term economic performance without hurting the future budgetary situation. In both cases it makes sense to consider the potential trade-off between long-term growth and the long-term, not the short-term, budgetary impact. More importantly, the existence of this trade-off is a matter to be empirically determined.

And here we come to a critical junction. The debate in Portugal has been conditioned by the absence of any empirical evidence on the economic and fiscal effects of road infrastructure investments. The purpose of this paper is to fill this gap. We do so from three different perspectives. First, we consider the regional decomposition of the aggregate effects of road investments, distinguishing between direct effects from investments in each region and spillover effects from investments elsewhere. Second, we analyze for each region the relative effects of investments of the same magnitude in the region and elsewhere. Finally, we identify the impact of road investments by point of origin, i.e., the regions where road infrastructure investments generate the largest aggregate effects for the whole country. The ultimate goal is to provide a first answer as to the actual nature of the potential trade-off between the long-term growth and budgetary effects of road investment in Portugal.

There is large body of literature dealing with the analysis of the effects of public investment stemming mostly from the seminal work of Aschauer (1989a, 1989b, 1989c). The earlier literature focused mostly on univariate production function estimates with all the ensuing problems [see, for example, Munnell (1992), Hulten and Schwab (1993), Gramlich (1994), and Sturm *et al*. (1998) for comprehensive surveys of this early literature as well as the whole array of its econometric criticisms]. More recent contributions have evolved to a more comprehensive and robust methodological approach, mostly in a vector autoregressive [VAR] framework greatly inspired by the macroeconomic literature in particular after the seminal contribution of Blanchard and Perroti (2002) [see, Kamps (2005) and Perotti (2004) for a detailed discussion of the literature on the effects of public investment in a VAR context].

In this paper, we follow the approach developed in Pereira (2000, 2001), and Pereira and Andraz (2003) to evaluate the effects of investment in public infrastructures in the United States and adopt a VAR methodology. As is typical in this literature, our multivariate dynamic analysis relates private-sector variables - output, employment and investment - and public investment in road infrastructures. This approach highlights the relevance of dynamic feedbacks among the variables, as well as the possible endogeneity of road investment. Indeed, while the evolution of road investment is allowed to affect private sector variables through time, the evolution of these variables is also allowed to affect road investment. Accordingly, this approach fully accommodates, by design, the possibility of reverse causality in the standard sense of Granger-causality. Furthermore, following Pereira and Andraz (2004, 2006), we estimate separate VAR models for the aggregate Portuguese economy and for each of the five regions in the country, relating private output, employment and investment, and road public investment, both in the region and elsewhere. This allows us to identify the regional effects of road investment in a framework that makes it possible to identify the importance of regional spillovers and that is methodologically consistent with the evaluation of the aggregate effects.

It should be noted that, although our approach is exclusively empirical in nature it is not a-theoretical. Indeed, we have in the background of our analysis a dynamic model of the economy. In this model, the economy uses a production technology based on the use of private inputs, capital and labor, as

well as road infrastructure, to generate private output. For each region, output is affected by road infrastructure located in the region itself, as well as road infrastructures located elsewhere in the country. Given the market conditions and the availability of road infrastructure, the private sector decides on the appropriate level of input demands. In turn, the public sector decides on the evolution of road investment, using a policy rule that relates investment in road infrastructure to the evolution of the private sector variables. The estimated VAR models can be thought of as a reduced form for the production function, input demands and policy function [see, for example, Pereira and Flores (1999) for a detailed elaboration on these theoretical foundations].The literature on the analysis of the macroeconomic effects in Portugal of public investment in general and road investment in particular is scant [see, for example, Lighart (2000), Pina and St. Aubyn (2005) and Afonso and St. Aubyn (2008)]. This paper differs from previous contributions at the aggregate level [see, for example, Pereira and Andraz (2005)] at the regional level [see, for example, Pereira and Andraz (2006)] and at the industry level [see, for example, Pereira and Andraz (2007)], in that it focuses specifically on road infrastructures, addresses a much wider variety of issues as presented above, and has as its main purpose to establish the nature of the policy trade-off that lies at the core of the current debate.

Finally, although this paper is applied to Portugal and it certainly has important implications for the policy debate in this country, its interest is not merely parochial. This is because the problems currently faced by Portugal are or could soon be also shared by the most recent EU members and many other emerging economies, where infrastructures are scarce but funding to finance such infrastructures is also scarce.

This paper is organized as follows. In section 2, we present the data as well as the preliminary statistical results. In section 3, we discuss the issue of identification of exogenous changes in road investment. In section 4, we present the aggregate effects of road investment. In section 5, we address the regional effects of road investment, including the regional decomposition of the effects as well as the importance of spillover effects. Finally, section 6 provides a summary, concluding remarks and directions for future research.

2 Data and Preliminary Empirical Results

In this section we present the data sources and the basic aspects of the data and test the data for unit roots and cointegration. This is important since the VAR estimates should be performed on stationary variables and if they are of the same order of integration testing for cointegrating restrictions is appropriate. Then, we determine the appropriate VAR model specification, both at the aggregate level and at the regional level. Finally, we discuss the issue of the identification of innovations in road investment and the measurement of their effects. For the sake of brevity, details of the test results are not presented in the paper but are readily available from the authors upon request.

2.1 Data sources and description

We use annual data on private-sector variables - output, employment, and investment - and on road

investment for the period 1980-98. These are the standard variables considered in the literature on the evaluation of the economic impact of infrastructure investment back to the seminal work of Aschauer (1989) [see, for example, Gramlich (1994), Kamps (2005), and Pereira and Andraz (2010) for extensive lists of such contributions]. These variables go with an explicit or implicit theoretical framework of modeling a production technology and the corresponding input demand system. In more recent work using a VAR approach the use of investment data as opposed to capital stock data has become standard since capital stocks typically have two unit roots while the corresponding investment flows only have one – as typically do the rest of the variables [see, for example, Perroti (2004, 2005)].

The relatively small size of our sample is dictated by the availability of road investment data [see more details below]. It should be noted, however, that this exact data set has been extensively used in directly-related literature [see, for example, Pereira and Andraz (2005, 2006, and 2007)] and that , for the very same reason, relatively small samples are not unusual in the relevant international literature [see, for example, Ford and Poret (1991) for an earlier example of application to OECD countries and Kamps (2005) for a recent survey of more recent literature and application also to OECD countries.] From an econometric perspective this is not a major issue since in the absence of cointegration or any cross equation restrictions a VAR model can be estimated using single-equation OLS techniques.

We consider aggregate data and regional data for the five administrative regions in the country - North, Center, Lisbon, Alentejo, and Algarve. If we think about the country as a rectangle, the long sides being the western Atlantic Ocean front and the eastern Spanish border, these five regions are five contiguous segments from the north to the south of the country.

Data on output and employment come from annual issues of the Regional Accounts published by the National Institute of Statistics. Regional private investment data, which is not available from official sources, was constructed as aggregate investment weighted by the region's output share. Summary statistics are provided in Table 1. In terms of their share of the private sector variables, Lisbon and North are by far the most important regions. They account for 46.1% and 31.4% of the output and investment and 36.3% and 36.7% of employment, respectively. The Center region accounts itself for 14.5% of output and investment and 18.3% of employment while Alentejo and Algarve combined account for just 8.1% of output and investment and 8.6% of employment.

Data for public investment in road infrastructures – both aggregate and at the disaggregate levels - comes from Pereira and Andraz (2001). This data is composed of public investment in national roads, municipal roads and highways and is available for the period 1980-98. Summary statistics for investment in road infrastructures are provided in Table 2. The overall evolution of public investment in Portugal has been closely related to the existence of EU structural transfer programs in the form of Community Support Frameworks (CSFs). These programs have been important tools to support public investments in transportation infrastructures. The sample period covers nineteen years, ten of which are covered by the first program (1989-93) and the second program (1994-99). The possibility of structural breaks due to the two CSFs, is fully incorporated into the analysis.

The importance of the CSFs in the dynamics of road nvestment is reflected in the increase of its share on GDP. Investment in road infrastructures averaged 1.2% of GDP for the sample period. It represents, however, an increasing trend from 0.9% in the period 1980-88 to 1.4% in the period 1989-98.

Furthermore, it is possible to detect changes from the first to the second CSFs in that the share of road investment on private output increased from 1.3% during the first CSF to 1.6% during the second.

In terms of the regional allocation of road investment, the North concentrated the highest proportion of investment during the sample period, 34.2%, followed by Center with 27.2%, Lisbon with 22.2%, Alentejo with 9.9%, and Algarve with 6.4%. The shares of road investment located in Lisbon, Alentejo and Algarve increased with the CSFs, i.e., from the first to the second half of the sample period while the shares of the other two regions decreased accordingly. In addition, North, Lisbon and Alentejo, show an increase in their shares of public investment from the first to the second CSF.

2.2 Unit-root tests

To determine the order of integration of the variables, we use the Augmented Dickey-Fuller (ADF) test. We use the Bayesian Information Criterion (BIC) to determine the optimal number of lagged differences in the regressions. Deterministic components and dummies for periods of the two CSF programs are included when they are statistically significant.

We start by applying the ADF t-tests to aggregate and regional output, employment, private investment and public investment, in log-levels. The test results suggest overwhelmingly that these variables are non-stationary. We then test for stationarity of the different variables in growth rates. The results of the corresponding ADF t-tests suggest that at the aggregate level the null hypothesis of a unit root in the growth rate can be rejected for all variables at the level of significance lower than 5%. Also, for virtually all of the regional level variables, the values of the t-statistics are smaller than the 5% critical values. We take this as a strong indication that stationarity in growth rates is a good approximation for all variables. This evidence is consistent with the conventional wisdom in the macroeconomics literature that aggregate output, employment, and private investment are stationary in first differences [private capital stationary in second differences]. Although we also include investment in road infrastructures and most of our series are more disaggregated, the same pattern of stationarity is not surprising.

2.3 Co-integration analysis

We now test for co-integration at both the aggregate and regional levels, among output, employment, private investment and public investment. Due to our relatively small sample we use the Engle-Granger procedure, which is less vulnerable than the Johansen procedure to the small sample bias toward finding co-integration when it does not exist [see, for example, Gonzalo and Lee (1998) and Gonzalo and Pitarakis (1999)].

Following the standard Engle-Granger approach, we performed four tests in each case. This is because it is possible that one of the variables enters the co-integrating relationship with a statistically insignificant coefficient and a test that uses such a variable as the endogenous variable will not pick up the co-integration. Therefore, a different variable is endogenous in each of the four tests. We apply the ADF t-test to the residuals from the regressions of each variable on the remaining variables. The optimal lag structure is chosen using the BIC, and a deterministic component and dummies for periods of the two CSF programs are included when they are statistically significant. At the aggregate level as well as for all

tests at the regional level, the values of the t-statistics are all larger than the 5% critical values. Thus, we cannot reject the null hypothesis that the variables are not co-integrated.

The absence of cointegration is consistent with results in the relevant literature [see, for example, Pereira (2000, 2001), and Pereira and Andraz (2003) for the US case and Pereira and Andraz (2005, 2006, 2007) for the Portuguese case]. Furthermore, the absence of cointegration is not problematic conceptually either. In fact, in the case of economies in a transition stage of their development, such as the Portuguese economy, not finding cointegration is hardly surprising. This means that the data does not show evidence of convergence in the so-called great ratios among the aggregate variables in the economy. Indeed, the whole essence of the CSFs, that are so important in the second half of our sample period, is to promote growth by changing the great ratios in the economy.

2.4 VAR specification and estimates

We have now determined that all the variables are stationary in first differences and that they are not cointegrated. Accordingly, we follow the standard procedure in the literature and proceed to estimate VAR models in growth rates. The estimates are carried on in RATS using variations of the VAR.SRC source code routines as available from www.estima.com – the RATS software website. In the absence of cointegration and any other cross-equation restrictions the VAR estimates are tantamount to a series of single-equation OLS estimates.

We estimate two different sets of VAR models. First, a model for the whole country that includes aggregate road investment, in addition to aggregate private sector variables – output, employment, and investment - and is designed to provide the overall picture on the effects of road public investment in Portugal. Second, we estimate region-specific VAR models with region-specific private-sector variables and road investment, as well as a variable that reflects road investment in the rest of the country. Accordingly, these models take into account the existence of spillover effects produced by the public investment in other regions [see, for example, Pereira and Andraz (2004, 2006) for the justification of this approach]. This also means that, for each region, the effects of road investments are estimated, distinguishing the effects of investments in the region itself, the direct effects, and the effects of road investments in other regions, the *spillover* effects captured by each region.

We confine the search for the best model to first order specifications due to the relatively small sample size available. This strategy, however, is not likely to be problematic. Indeed, at the aggregate level, for which a much larger data sample is available, the first order specification is consistently selected over specifications up to the fourth order.

The VAR specification has two jointly determined dimensions - the specification of the deterministic components and the possibility of structural breaks. In order to consider possible structural changes due to the two CSFs, we distinguish three periods - the period before 1989, the period of first CSF program, 1989-93, and the period of the second CSF program, 1994-98. Therefore, we consider three alternatives in terms of the VAR specification - no structural break/no dummies, one structural break/one dummy distinguishing the periods before and after 1989, and two structural breaks/two dummies reflecting the possibility of the three different periods mentioned above.

Test results are reported in Table 3. We find that the BIC criterion leads to the selection of VAR specifications with two structural breaks for both the aggregate and the five regional models. BIC tests also suggest that both at the aggregate level and for the five regional models the best specifications include a deterministic constant and a trend. Worth noting about the VAR estimates is the fact that the matrices of variance and covariance of the estimated residuals tend to have a block diagonal structure, i.e., residuals of the road infrastructure equations have a relatively low covariance with the residuals of the remaining VAR equations. The actual VAR estimation results are available upon request.

3. Identifying and measuring the effects of innovations in road investment

We use the accumulated impulse-response functions associated with the estimated VAR models to obtain the economic effects of innovations in road investment. Our methodology allows for the consideration of both the contemporaneous correlations and the dynamic feedbacks among the different variables including road investment. This means that road investment is an endogenous variable in our analysis and that the feedbacks from the economy onto the road investment decisions are fully accounted for. In addition, both contemporaneous correlations and dynamic feedbacks are critical in the identification of innovations in investment in road infrastructures and in the measurement of the effects of such innovations on the private sector variables.

3.1 On the identification of exogenous innovations in public investment

The central issue for the determination of the effects of road investment is the identification of shocks that are not contemporaneously correlated with shocks in the private sector variables, i.e., shocks that are not subject to the reverse causation problem. 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 (1998)]. This approach was adapted to the analysis of the effects of public capital formation in Pereira (2000, 2001) and the details about its application at the regional level may be found in Pereira and Andraz (2004, 2006).

Ideally, the identification of exogenous shocks to road investment 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 estimate policy functions, which relate the rate of growth of public investment to the information relevant for policy makers. The residuals from these policy functions reflect the unexpected component of the evolution of public investment and, by definition, are not correlated with innovations in the private sector variables.

At the aggregate level we assume that the relevant information set includes past but not current values of the aggregate private sector variables. This is equivalent to assuming, in the context of the Choleski decomposition, that innovations in road investment affect private sector variables contemporaneously, while the reverse is not true [see, for example, Blanchard and Perotti (2002) for similar assumption]. Indeed, it is perfectly reasonable to assume that the private sector reacts within a year to innovations in road investment. It is also reasonable to assume that, due to the time lags involved

in information gathering and public decision-making, the public sector is unable to adjust road investment to innovations in the private-sector variables within a year. This is even more so since most of the road infrastructure investment for the sample period was undertaken under the auspices of the CSF programs.

At the regional level, we also assume that innovations in regional road investment affect regional private sector variables contemporaneously, but the reverse is not true. This assumption is even more plausible at the regional level since most road investment is financed at the central government level. We would expect innovations in central government funding to be less correlated with innovations in regional private sector variables than innovations in aggregate road investment with innovations in aggregate private sector variables. Finally, in the regional models we assume that innovations in road investment outside the region affect contemporaneously innovations of road investment in the region but the reverse is not true. This assumption is justified by the fact that the fraction of road investment undertaken in any given region is relatively small compared to the road investment undertaken elsewhere.

These arguments establish a very plausible central case for the identification of innovations in road investment that are not correlated with innovations in other variables. Nevertheless, to determine the robustness of our central case results we consider also all the possible alternatives in terms of the definition of which observations are included in the central administration information set. This is equivalent to considering all the possible orderings of the variables within the Choleski decomposition framework. The corresponding range of results is available upon request.

3.2 The estimated policy functions

The policy functions at the aggregate and regional levels are reported in Table 4. At the aggregate level, there is no feedback from the other variables to road investment, which implies that road investment is an exogenous variable. In terms of the region-specific policy functions, road investment is responsive to previous changes in region-specific private sector variables in Norte and Algarve. However, each of those regions does not carry sufficient weight to impose these regional patterns at the aggregate level.

It is interesting to contrast this result with the evidence for the US. In fact, Pereira (2000) shows that changes in public investment in road infrastructure in the US are positively correlated with lagged changes in output and negatively correlated with lagged changes in employment. Accordingly, in the US, changes in private-sector variables affect the evolution of public investment, which therefore is not an exogenous variable. The exogeneity of road investment in Portugal, however, is a natural consequence of the fact that investment decisions have long been closely linked with the Portuguese participation in the EU. Particularly after 1989, the bulk of road investment has been conducted under the two CSFs, programs which are typically negotiated between the recipient economies and the EU, and which focus on long-term goals and deliberately avoid short-term considerations.

3.3 Measuring the effects of innovations in public investment

To measure the effects of exogenous innovations in road investment we use the accumulated impulse-response functions associated with the estimated VAR models and the corresponding policy functions – see Figures 1-6. We consider a one-percentage point, one-time innovation in the rate of growth of road investment. All accumulated impulse response functions converge. Accordingly, these innovations have

temporary effects on the growth rates of the private-sector variables. Naturally, they have permanent effects on the levels of these variables. Furthermore, since the temporary effects on the growth rates of the different variables vary, the level effects will also be different. This implies changes in the long-term observed ratios between variables, a result consistent with the absence of cointegration.

We report the long-term cumulative elasticities with respect to road investment. Long term is defined as the time horizon over which the growth effects of innovations disappear. According to our estimates our accumulated impulse-response functions tend to converge rapidly, typically within the first five years after the shock. These elasticities represent the total accumulated percentage point changes in output for one long-term accumulated percentage-point change in road investment. It should be pointed out that unlike the standard definition of elasticity, the concept we use captures all feedback effects over time, it measures total effects and not ceteris paribus type of effects and it measures accumulated long-term effects – in practice over a thirty-year period - and not annual effects.

We also report the long-term accumulated marginal products of road investment. These figures measure the long-term accumulated change in private-sector variable per one Euro long-term accumulated change in road investment. We obtain each figure by multiplying the long-term elasticity by the corresponding output to road investment ratio for the last ten years of the sample. This allows us to interpret the marginal product figures as the long-term accumulated effects of policies implemented at the end of the sample measured under the conditions observed by the end of the sample period, while avoiding business cycle effects.

4. On the Aggregate Effects of Road Infrastructure Investment

We begin by presenting the aggregate effects. Aside from being important in itself, the aggregate analysis is fundamental to put in context the effects obtained from the regional models.

4.1 On the aggregate effects

The aggregate results are obtained from the impulse response functions associated to the VAR model, in which output, employment, private investment and investment in road infrastructure are related. The relevant results for each variable are presented in the upper sections of Table 5.

The elasticity of private investment with respect to road investment is 0.542. This implies that one million Euros in road investment induce, in the long term, an accumulated increase of 8.4 million Euros in private investment. This suggests that, at the national level, investments in road infrastructure and private investment are complementary. In turn, the elasticity of employment with respect to public investment is 0.217. In terms of job creation, this means that one million Euros in public investment generates, in the long term, 25 new jobs in the private sector. Therefore, at national level, there is also a complementary relation between investment in road infrastructures and employment in the private sector.

Finally, the elasticity of output with respect to public investment is 0.295. This value means that one million Euros invested in public capital generates an accumulated long-term increase in private output of 18.1 million Euros. These results imply an annual average rate of return over a thirty years

period of 10.1%. We may also interpret this marginal product by calculating the value of the tax revenues generated by the implicit increase in output. Using a reference tax rate of 21% of the GDP, the marginal product figure suggests that over thirty years the public sector would collect 3.9 Euros in tax revenues for each Euro of initial investment. This means that we estimate that road investment more than pays for itself in the form of future tax revenues.

4.2 The aggregate effects versus the aggregation of the regional effects

The main objective in this paper is to identify the decomposition at the regional level of the aggregate effects of road investment. For the regional disaggregation to be credible it is necessary that the sum of the effects from the five regional models to be in line with the effects obtained from the aggregate model.

The relation between the aggregate results and the sum of the results obtained from the regional models requires some reflection. Since capital infrastructure is a public good, when the investment occurs, the new capital assets are accessible to all regions simultaneously. In this sense, the sum of the marginal products of investments in road transport infrastructure in the different regions should equal the marginal products obtained at the aggregate level.

It is likely, however, that the sum of the regional marginal products would not coincide exactly with the effects at the aggregate level. This is due to the possible existence of general equilibrium effects that are not captured at the regional level. Consider, for example, the effects of road investment of the decisions regarding private factor demands. When more transport infrastructure is accessible, greater factor quantities are demanded, simultaneously, in all regions. This simultaneous increase in factor demand is limited by restrictions in the economy. As a result, a part of the increase in demand drives an increase in factor prices and the corresponded adjustment lowers demand in various regions. In this way, it is possible that the sum of regional marginal products exceeds the aggregate effects.

Our estimation results show that the sum across regions of the effects of road investment represents 111.0%, 107.8%, and 104.3% of the estimated aggregate results for private investment, employment and output, respectively. In light of the previous discussion, these values are perfectly consistent with the results from the aggregate model. This grants a large degree of credibility to our efforts for identifying the regional patterns subjacent to the aggregate results. Beyond this, the results suggest that the general equilibrium effects do not seem to be relevant to any of the private sector variables considered in the analysis.

5. On the Regional Effects of Road Investment

We consider now the effects of investment in road infrastructures at the regional level. The results are based on the impulse response functions associated with the VAR estimates at the regional level, which include regional output, employment, and private investment as well as road investment in the region and road investment elsewhere in the country. The discussion of the results is organized according to the three questions identified in the introduction.

5. 1 On the Regional Decomposition of the Effects of Road Investment

We start by considering the regional decomposition of the aggregate effects of road investment, that is, the regional decomposition of the effects of aggregate changes in road investment following the historical pattern of regional decomposition of such investment. Accordingly, in what follows, the raw marginal products are multiplied by the average ratio between regional road investment and aggregate road investment over the past ten years. In this way, all regional marginal products reflect the effects for each region of one million Euros of investment in the country. Consequently, the sum of the marginal products obtained from the regional models is directly comparable to the value of the marginal products obtained from the aggregate model, for the entire economy. The results are reported in Table 5.

Effects on private investment

In terms of the direct effects on private investment for each region of road infrastructure in the region itself, our results suggest that the elasticities range from –0.209 for Lisbon to 0.278 for Algarve, and that road investment in the region has positive direct effects in three of the five regions considered - the exceptions are Lisbon and Alentejo. Our estimates, however, suggest that the effects of local public investment are negligible. In fact, one million Euros in road investment generates, in the long term, an increase in private investment of 1.6 million Euros. This figure corresponds to a net increase of 0.06 million Euros and to a transfer of private investment of 1.5 million Euros across regions. The regions that benefit the most are the North and the Algarve with marginal products of 1.30 and 0.28 million Euros, respectively. In turn, in terms of the spillover effects on private investment we estimate positive effects for all regions. The estimated elasticities range between 0.160 for North and 0.982 for Center. Our estimates suggest that one million Euros in road investment generate, in the long term, spillover effects of about 9.3 million Euros. The greatest beneficiaries are Lisbon, with a gain of 5.5 million Euros and Center, with a gain of 2.2 million Euros. The North, Alentejo and Algarve get lower spillover effects of about 0.8, 0.6 and 0.2 million Euros, respectively. Finally, consider the total effect, i.e., the sum for each region of the direct and spillover effects. Our results suggest that one million Euros of road investment in the country generates, in the long term, an accumulated increase in private investment of 9.36 million Euros, with positive effects in all the regions. The largest effects occur in Lisbon, with a gain of 3.96 million Euros, the Center region, with 2.22 million Euros, and the North region with 2.09 million Euros. The Alentejo and the Algarve regions get smaller effects of 0.61 and 0.48 million Euros, respectively.

Effects on employment

Empirical results suggest that road investments in a region generate positive effects on private employment in the region itself in three of the five regions. The exceptions are North and Alentejo. The estimated elasticities fall in a very narrow range between –0.037 for the North and 0.172 for the Center regions. In terms of job creation, the results suggest that one million Euros in local public investment creates, in the long term, 7.5 new private jobs. Of these, 5.8 are new jobs, while the remaining 1.7 correspond to jobs shifted across regions. The beneficiaries are the Center, Lisbon and Algarve with 3.5, 3.0 and 1.0 new jobs, respectively. In turn, road investment elsewhere affects employment positively in all regions. The elasticities vary between 0.089 in North and 0.445 in Algarve. One million Euros in road

investment generates, in the long term, spillover effects of about 20.60 new private jobs. The greatest beneficiary is Lisbon with 10.9 new jobs, followed by North and Center, with 3.7 and 3.1 new jobs, respectively. The regions that benefit the least are Algarve and Alentejo, with 1.9 and 1 new private jobs, respectively. Finally, the sum of the direct and spillover effects is positive for all the regions and reaches the national value of 26.4 new jobs for each million Euros in road investment. Once again, the largest value occurs in Lisbon, with 13.9 new jobs, and the Center, with 6.6 new jobs. The remaining regions, while still benefiting in terms of employment, capture benefits of considerably lower magnitude, specifically, 2.9, 2.1 and 0.9 new jobs, for Algarve, North and Alentejo, respectively.

Effects on output

Road investment in each region has positive effects on output in the region itself in all regions but Alentejo. The elasticities vary in a small range between –0.056 and 0.180, for Alentejo and Algarve, respectively. In terms of marginal products, the overall long-term accumulated gain is 3.97 million and output shifts across regions are negligible. The greatest beneficiaries are Lisbon and Center, with marginal products of 2.00 and 1.29, respectively. In turn, output in each region is affected positively by road investment elsewhere. The estimated elasticities vary between 0.049 for North and 0.796 for Alentejo. One million Euros in public investment generates spillover effects that amount to 14.87 million Euros in the long term. The greatest beneficiaries are Lisbon, Alentejo and Center, with gains of 8.72, 2.21 and 1.95 million Euros, respectively. The total effects for each region, the sum of the direct and spillover effects, are positive for all regions. The largest values occur in Lisbon, with a gain of 10.72 million Euros, and in Center, with 3.24 million Euros, for each million Euros of investment in the country.

Fiscal effects

The estimate of the long-term effects on output of one million Euros in road investment in the country allows us to calculate the potential fiscal revenues of such investment. Considering the sum of the effects across regions and using the average annual tax rate of 21%, we estimate that over a thirty-year period the public sector will collect 3.9 million Euros in tax revenues for each additional one million Euro in road investment. The regional decomposition of these effects, assuming the same average tax rate across regions, suggests that of the total of 3.9 million Euros, 2.2 are generated by Lisbon, 0.7 by the Center, 0.4 by both Alentejo and Algarve and 0.2 by the North.

5.2 On the Relative Importance of Direct Effects versus Spillover Effects

We now consider the relative effects for each region of road investment, i.e., the effects for each region of an investment of one million Euros in the region itself and the same investment of one million Euros elsewhere. The results are reported in Table 6.

Effects on private investment

The region that benefits most from local investment in road transport infrastructure is Lisbon, followed by Algarve and North. The results suggest that an investment of one million Euros in these regions creates an

accumulated long-term increase in total private investment of 5.58, 3.95, and 3.91 million Euros, respectively. These effects are marginally positive for Center and marginally negative for Alentejo. As to the effects for a region of road investment elsewhere, the greatest beneficiary is Lisbon with an accumulated long-term increase in local private investment of 7.54 million Euros. The benefits are substantially lower for Center and North with 2.82 and 1.19 million Euros, as well as for Alentejo and Algarve with 0.70 and 0.22 million Euros, respectively. In terms of the effects on private investment, the spillover effects are relatively more important than the direct effects in Center, Lisbon, and Alentejo.

Effects on employment

In terms of employment, the region that benefits the most from local road investment is Center, followed by Algarve and Lisbon. For these regions, one million Euros of local road investment creates, in the long term, about 16.3, 13.7 and 11.2 new private jobs. In turn, one million Euros of investment in the North and in Alentejo generates, in the long term, a reduction of 4.7 and 1.1 private jobs, respectively. At the same time, the investment of one million Euros elsewhere affects positively local employment in all regions. The largest effects are in Lisbon, North and Center with 15.1, 5.53 and 3.96 new jobs, respectively. The regions of Algarve and Alentejo capture smaller effects, 2.03 and 1.15 new jobs, respectively. In terms of the effects on employment, the spillover effects are relatively more important than the direct effects in North, Lisbon, and Alentejo.

Effects on output

In terms of output, the greatest beneficiary from local road investment is Algarve followed by Lisbon, Center and North. One million Euros of investment in these regions drives, in the long term, to an accumulated increase in regional output of 10.04, 7.33, 5.93 and 0.42 million Euros, respectively. The same investment in Alentejo generates, in the long term, a reduction of output in the region of 1.74 million Euros. In turn, road investments elsewhere have the greatest effect in Lisbon. One million Euros of investment creates, in the long term, an accumulated increase in output of 11.99 million Euros in Lisbon. The effects are lower in Center and Alentejo, 2.49 and 2.47 million Euros, respectively, and even lower in North and Algarve, 1.43 and 1.11 million Euros, respectively. In terms of the effects on output, the spillover effects are relatively more important than the direct effects in North, Lisbon, and Alentejo.

5.3 The aggregate effects of road investments by region

We now consider the effects of road investment by region of origin. For each region we consider not only the effects of the road investment in the region itself but also the spillover effects such road investments generate for other regions. The sum of all these effects gives for each region the aggregate impact of road investments in the region. This allows us to ascertain in which regions road investment is the most productive from a national perspective. The results are reported in Table 7.

On the economic effects

Aggregate private investment, employment and output are positively affected by road investments in all regions. In terms of the country's private investment, one million Euros of road investment in the

Algarve, North and Alentejo generates, in the long term, an accumulated aggregate increase of 16.20, 15.19 and 11.71 millions Euros, respectively, while the effects of road investments in Lisbon and Center are smaller but still very significant, 10.50 million Euros and 9.70 million Euros, respectively. In terms of employment, the largest effect results from road investments in Center and Algarve. One million Euros of investment in road infrastructures in these regions generates, in the long term, 40.11 and 39.44 new private jobs in the country, respectively. In turn, road investments in Lisbon, Alentejo and North create 23.87, 25.52, and 17.54 new jobs, respectively. Finally, one million Euros of investment in Algarve, Center, North, Lisbon and Alentejo generates an accumulated long term increase in aggregate output of 28.42, 22.97, 18.47, 15.28 and 14.83 million Euros, respectively.

On the fiscal effects

The knowledge of the effects on aggregate output of road investments in different regions allows us to estimate the fiscal effects of road investments by location of such investments. Again we assume the same average tax rates across regions. One million Euros in road investments in Algarve generates fiscal revenues of 5.9 million Euros, while the same investment in Center and North generate 4.8 and 3.9 millions Euros respectively. Finally, one million Euro road investment in Alentejo and Lisbon generate 3.2 and 3.1 million Euros in tax revenues respectively. Our results suggest that although road investments in all regions pay for themselves in the form of future tax revenues, investments in Algarve and Center are particularly generous in terms of their fiscal effects.

6. Summary, Concluding Remarks, and Directions for Future Research

In this paper we estimate the economic and fiscal impact of public investment in road transportation infrastructures in Portugal with the ultimate objective of clarifying the nature of the potential trade-off between its economic and fiscal effects.

We started by estimating the aggregate effects of road infrastructure to find that in the long term, road investment crowds in private investment and employment and it has a positive impact on output. We estimate that one million Euros of public investment raises output in the long term by 18.84 million Euros. The analysis of the economic impact of road investment at the regional level was driven by three objectives. The first objective was the regional disaggregation of the aggregate economic effects of road investment. The empirical results show that the total impact on private investment, employment and output is positive in all regions. In terms of private investment, the largest benefits are captured by Lisbon, North and Center, while in terms of employment and output the largest benefits are captured by Lisbon, and to a lesser extent by Center. The second objective was the analysis of the relative importance for each region of road investments of equal value in the region and elsewhere. Regarding the effects on private investment, Center, Lisbon and Alentejo are the regions that benefit relatively more from investments elsewhere while in terms of employment and output this is the case with North, Lisbon and Alentejo. The third objective was to identify the regions where road investments generate the greatest aggregated effects. The empirical results indicate that the greatest effects on private investment result

from road investments in Algarve and North and while in terms of employment the biggest contributions come from road investments in Center and Algarve. Finally, in terms of output the greatest effects result from road investments in Algarve and Center.

The central conclusion of the paper is that there is no trade-off between long-term growth and long-term budgetary restraint. At the aggregate level, and considering an effective tax rate of 21%, the public sector will collect tax revenues that amount to 3.9 times the initial road investment and therefore, investments in road infrastructures more than pay for themselves over the lifetime of roads. The same is true for road investment in each of the administrative regions of the country. Indeed, Algarve and Center generate the largest fiscal effects with 5.9 and 4.8 million Euros for each million Euros of investment while North is at the national average with 3.9 and Alentejo and Lisbon somewhat below with 3.2 and 3.1 million, respectively. What this means is that foregoing road investment will not only jeopardize long-term economic performance but it may jeopardize the budgetary situation as well.

Despite the importance of our results and maybe even because of their importance it is appropriate to include here several cautionary notes. First, our results provide useful information for the evaluation of future transportation investment projects by providing estimates about the order of magnitude of the economic and fiscal effects of past investments. In this sense they are an important piece of information in guiding the policy debate and the general development strategy in the country. The use of these results to evaluate specific road investment projects, however, should be done carefully and always in conjunction with the appropriate idiosyncratic information. Second, our estimates of the marginal products of road investment are based on historical patterns at a time of greater scarcity of road infrastructures. While our estimates of the marginal products are comfortably large, one should expect a pattern over time of declining marginal products. This means that we would not expect the absence of a trade-off between road investment and budgetary consolidation to last forever. Third, our objective is to measure the effects of road infrastructure and not to compare such effects to the effects of other types of public investment or, for that matter, private investments. This means that while our results may suggest that road infrastructure investment is important, they do not suggest that road infrastructure investment is the best strategy for the future. Fourth, our analysis covers a period in which the bulk of the road infrastructure investment was undertaken under the auspices of the EU Structural Funds Programs. This means that not considering in the analysis the cost of financing such investments is not a matter of concern. It implies, however, that our results should be regarded as the upper bound of the effects that would be obtained if financing were to be an issue. This is important since with the dwindling of EU funding the Portuguese government will have to progressively have to rely on taxation or borrowing to finance future investment projects and therefore the costs of such financing cannot be ignored.

In a different vein, our analysis should be strengthened in two important directions. First, it has to be acknowledged that, unlike the analysis of the economic impact of road investments, the analysis of the fiscal impact of such investments is somewhat unsophisticated. This is because tax revenues are not explicitly considered in our econometric analysis and therefore our fiscal impact does not accommodate the inevitable negative efficiency effects of an added tax burden on the economy. More definite statement in this area could be established if the fiscal effects of road investment on future taxation could be identified through the VAR analysis the same way as the economic effects. Such is, however, not

possible due to the lack of readily available taxation data at the regional level. Second, the analysis and discussion of regional spillovers could be extended to consider across the border spillovers with Spain. In fact, important domestic inter-regional spillover effects were identified. It is also very well understood the growing interdependence between the Portuguese and Spanish economies. It is also understood the importance of across the border economic interactions for many regions in the country. One could only expect that for example the North and Algarve – the furthermost north and south regions of the country may have a economic connection with Spain that rivals their connection with the rest of the country. This raises interesting issues in terms of the locations of future road investments and how they may induce benefits to be captured by the Spanish economy and vice-versa to what extent the Portuguese economy is not itself benefiting from road investment across the border.

We conclude by relating our results to the bigger picture. Our analysis and discussion omits any reference to the issue of climate change and the environmental impacts of road infrastructure investment. This is important since more roads mean more traffic and therefore more emissions but to the extent that more modern roads really replace old roads which actually improves fuel efficiency. Which effect dominates is to be seen. In addition, our analysis omits any considerations about the possible effects of changes in fuel prices either directly or through the introduction of carbon taxes. Conceivably, higher fuel prices could lead to a significant reduction of road use and therefore to lower accumulated long-term benefits. A variation of this argument would apply to the introduction of tolls in many of the roads built in the last few decades. As of now about one-third of the highway network is not subject to tolls. This may change in the near future though. Ultimately, all these increases in driving costs would have to be traded off against improving fuel efficiency standards of the car fleet.

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Table 1: Shares of private sector variables (% of total)

	Output	Employment	Investment
North	31.4	36.7	31.4
Center	14.5	18.3	14.5
Lisbon	46.1	36.3	46.1
Alentejo	4.7	5.1	4.7
Algarve	3.4	3.5	3.4
Total	100.0	100.0	100.0

Table 2: Shares of road public investment

	1980-88	1989-93	1994-98	1989-98	Sample average
North	35.3	30.7	35.9	33.3	34.2
Center	33.5	24.0	19.4	21.7	27.2
Lisbon	16.6	25.5	29.1	27.3	22.2
Alentejo	9.3	8.0	13.1	10.5	9.9
Algarve	5.6	11.9	2.5	7.2	6.4
Total	100.0	100.0	100.0	100.0	100.0
% of GDP	0.9	1.3	1.6	1.4	1.2

Table 3 – VAR specification (BIC- selected specification in bold)

	Model order	Deterministic components	No dummy	One dummy (1989)	Two dummies (1989,1994)
North	1	N	-22.30123	-22.68899	-22.97660
	1	C	-23.57026	-23.65639	-23.99533
	1	CT	-23.41280	-24.12584	**-24.98138**
Center	1	N	-21.69928	-22.11522	-22.34169
	1	C	-21.64419	-22.03685	-22.30894
	1	CT	-21.65699	-22.17501	**-24.09381**
Lisbon	1	N	-22.59158	-23.04398	-23.75925
	1	C	-22.83181	-23.04104	-24.14364
	1	CT	-22.98517	-24.08433	**-25.50503**
Alentejo	1	N	-17.85129	-18.24906	-18.65689
	1	C	-17.87425	-18.32664	-18.92415
	1	CT	-18.47433	-19.68466	**-20.35699**
Algarve	1	N	-17.44967	-18.00014	-18.34575
	1	C	-17.53846	-17.99296	-18.33927
	1	CT	-17.84088	-20.11961	**-20.49454**
Portugal	1	N	-19.58056	-19.79295	-20.12231
	1	C	-19.76135	-19.86845	-20.20951
	1	CT	-19.72756	-20.32870	**-20.69073**

Table 4– Policy functions at regional level (dependent variable GPINV)

	Cons	Trend	D1989	D1994	GDP (-1)	EMP (-1)	INV (-1)	RINV (-1)	RINV1 (-1)
North	0.009	0.029*	-0.177	-0.392**	-1.63*	1.271	0.154	-0.515**	-0.112
	(0.11)	(1.89)	(-1.31)	(-2.16)	(-1.90)	(1.04)	(0.78)	(-2.29)	(-0.42)
Center	0.016	-0.010	0.184	0.166	-0.096	0.048	0.059	-0.077	0.286
	(0.09)	(-0.35)	(0.76)	(0.46)	(-0.06)	(0.02)	(0.13)	(-0.31)	(0.51)
Lisbon	-0.316**	0.075***	-0.521**	-0.983***	-0.207	-1.363	0.021	0.637***	0.147
	(-2.48)	(3.41)	(-2.61)	(-3.79)	(-0.12)	(-0.80)	(0.06)	(3.95)	(0.52)
Alentejo	-0.277	0.041	0.070	-0.081	-0.264	-0.120	0.460	-0.267	0.273
	(-1.22)	(1.12)	(0.22)	(-0.18)	(-0.26)	(-0.05)	(0.72)	(-1.20)	(0.60)
Algarve	-0.227	0.110**	-1.357**	-1.248**	-6.081*	7.414**	-0.073	0.416*	0.512
	(-0.82)	(2.08)	(-2.94)	(-2.13)	(-1.88)	(2.41)	(-0.10)	(1.91)	(1.07)
Portugal	-0.112	0.026*	-0.121	-0.323**	0.465	-0.122	0.078	-0.032	
	(-1.40)	(1.99)	(-1.07)	(-2.01)	(0.46)	(-0.11)	(0.38)	(-0.16)	

NB: t-statistics in parenthesis. *Significant at 10% level. **Significant at 5% level. ***Significant at 1% level.

Table 5: Regional effects of road investment

	Elasticities with respect to		Marginal products with respect to(*)		
	Road investment in the region	Road investment elsewhere	Road investment in the region	Road investment elsewhere	Total road investment
Effects on private investment					
Portugal	0.54173		8.43		
North	0.25831	0.16021	1.30	0.79	2.09
Center	0.00565	0.98190	0.01	2.21	2.22
Lisbon	-0.20921	0.77261	-1.52	5.48	3.96
Alentejo	-0.00824	0.88276	-0.01	0.62	0.61
Algarve	0.27781	0.35605	0.28	0.20	0.48
Total all regions			0.06	9.30	9.36
Effects on employment					
Portugal	0.21726		24.5		
North	-0.03715	0.08890	-1.60	3.70	2.10
Center	0.17165	0.15115	3.50	3.10	6.60
Lisbon	0.07154	0.26336	3.00	10.90	13.90
Alentejo	-0.01768	0.19631	-0.10	1.00	0.90
Algarve	0.13558	0.44458	1.00	1.90	2.90
Total all regions			5.80	20.60	26.4
Effects on output					
Portugal	0.29492		18.06		
North	0.00695	0.04899	0.14	0.96	1.10
Center	0.14203	0.21958	1.29	1.95	3.24
Lisbon	0.06988	0.31194	2.00	8.72	10.72
Alentejo	-0.05596	0.79550	-0.18	2.21	2.03
Algarve	0.18036	0.45768	0.72	1.03	1.75
Total all regions			3.97	14.87	18.84

(*) The marginal product of one million Euros investment in road transport infrastructures is considered according the average regional decomposition of the investment in the period considered.

Table 6: Effects of one million Euros invested in the region and outside the region(*)

	Private Investment		Employment(**)		Output	
	Road investment in the egion	Road investment elsewhere	Road investment in the egion	Road investment elsewhere	Road investment in the egion	Road investment elsewhere
North	3.91	1.19	-4.70	5.53	0.42	1.43
Center	0.06	2.82	16.30	3.96	5.93	2.49
Lisbon	5.58	7.54	11.20	15.10	7.33	11.99
Alentejo	-0.06	0.70	-1.10	1.15	-1.74	2.47
Algarve	3.95	0.22	13.70	2.03	10.04	1.11

(*) The values are marginal products. They are not weighted values. They measure the effect, in the long term, of one million Euros of investment in each region and out of the region.
(**)The marginal products represent the minimum number of job posts created by a million Euro investment at 1995 prices.

Table 7: Effects of one million Euros in road investment in each region

	Effects in the region (1)	Effects in other regions (2)	Total effects (3) = (1)+(2)
Investment			
North	3.91	11.28	15.19
Center	0.06	9.65	9.70
Lisbon	5.58	4.92	10.50
Alentejo	-0.06	11.77	11.71
Algarve	3.95	12.25	16.20
Employment			
North	-4.70	22.24	17.54
Center	16.30	23.81	40.11
Lisbon	11.20	12.67	23.87
Alentejo	-1.10	26.62	25.52
Algarve	13.70	25.74	39.44
Output			
North	0.42	18.05	18.47
Center	5.93	17.00	22.93
Lisbon	7.33	7.50	14.83
Alentejo	-1.74	17.02	15.28
Algarve	10.04	18.38	28.42

Figure 1: Cumulative Impulse-Response Function wrt Road Infrastructure Investment – Portugal

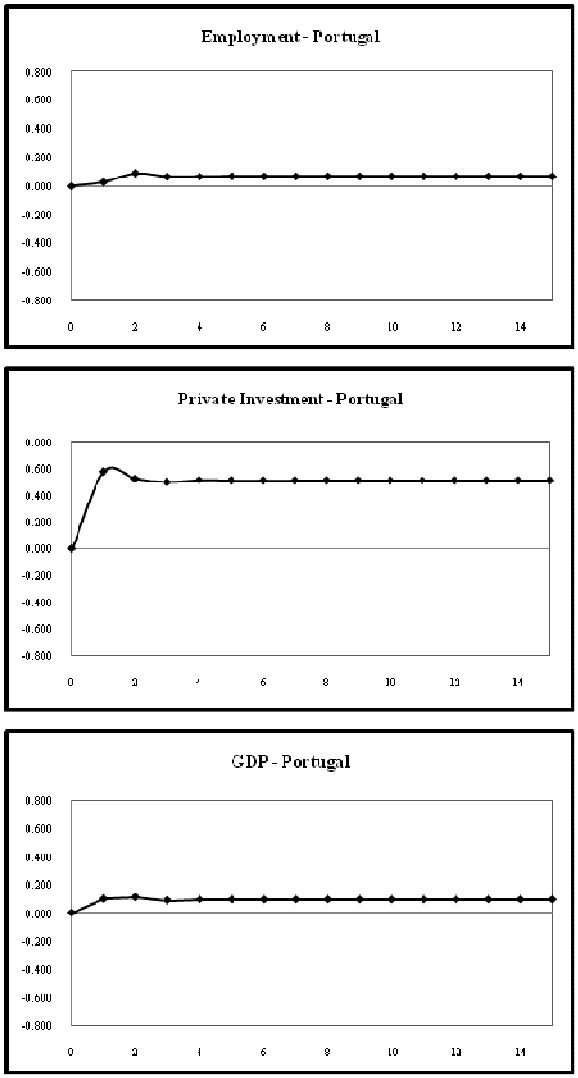

Figure 2: Cumulative Impulse-Response Function wrt Road Infrastructure Investment – North

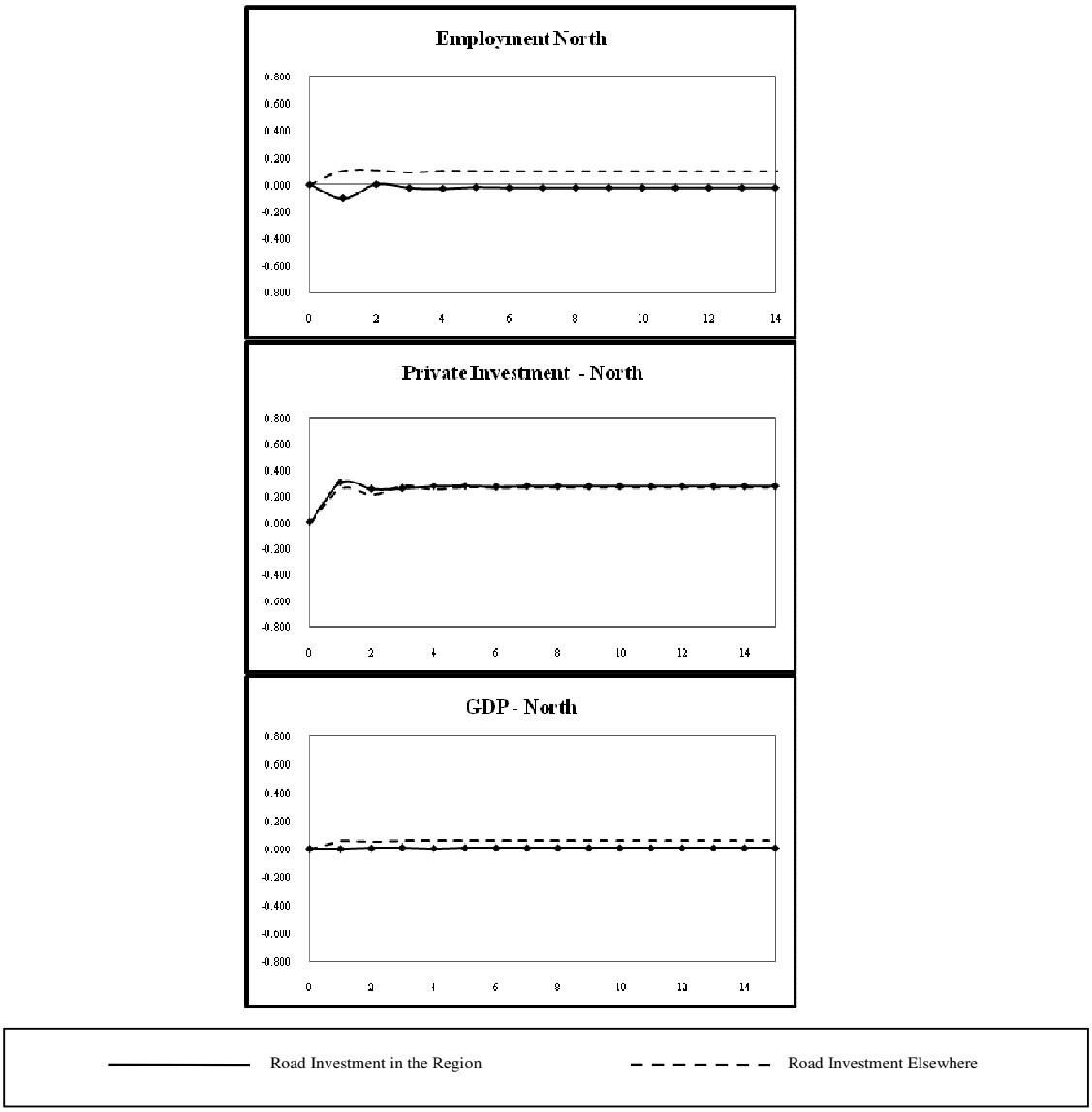

Figure 3: Cumulative Impulse-Response Function wrt Road Infrastructure Investment – Center

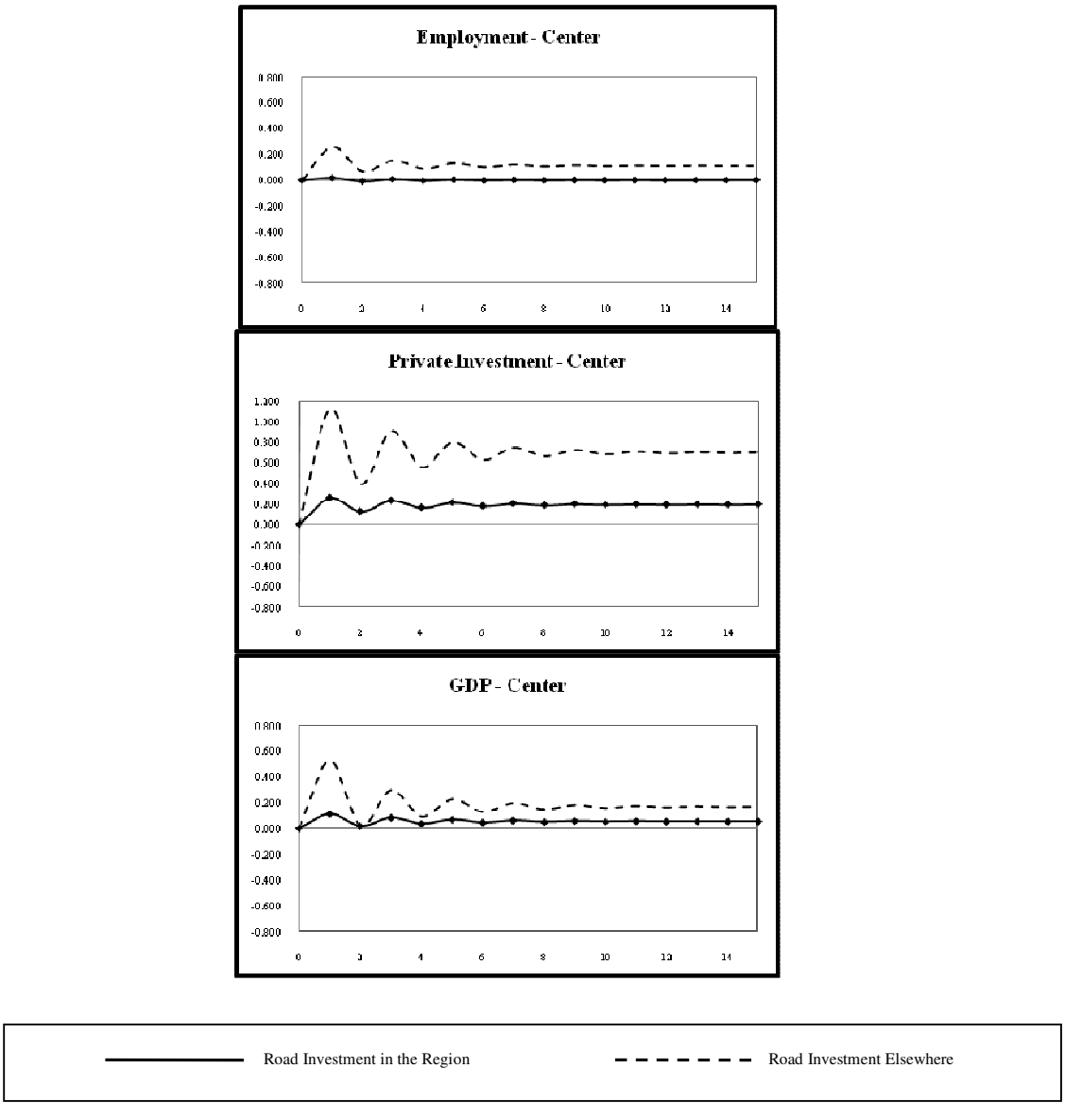

Figure 4: Cumulative Impulse-Response Function wrt Road Infrastructure Investment – Lisbon

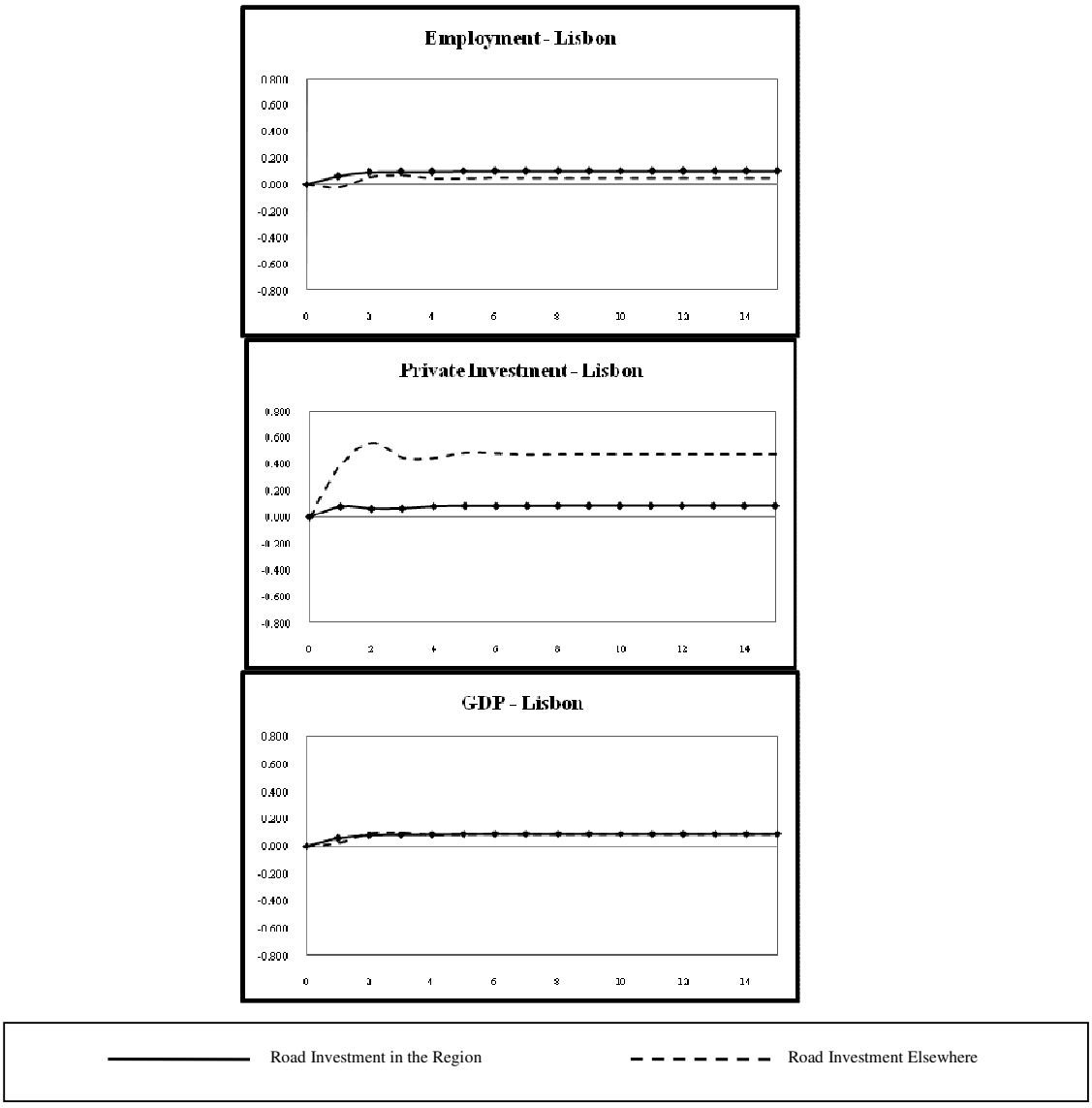

Figure 5: Cumulative Impulse-Response Function wrt Road Infrastructure Investment – Alentejo

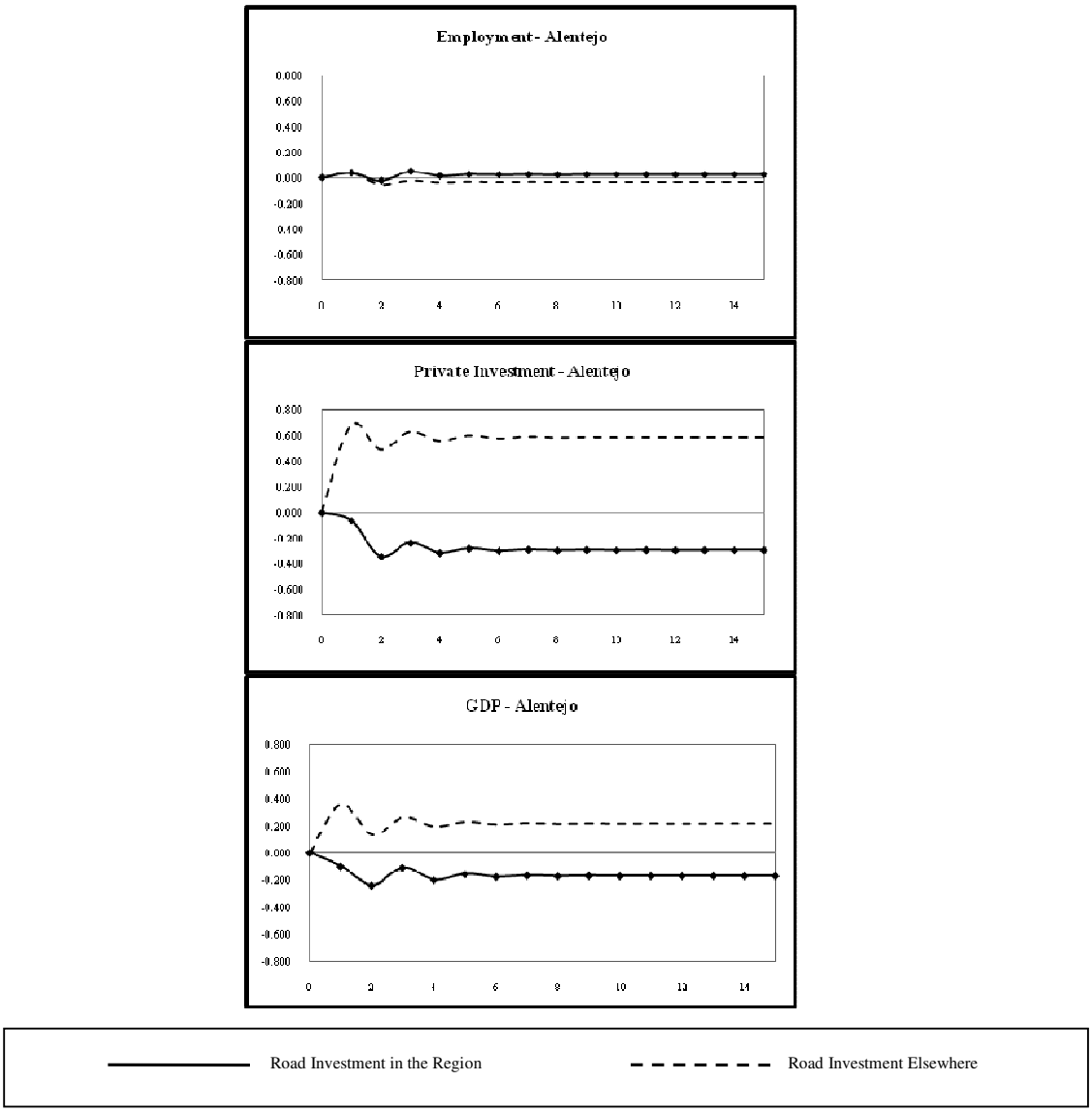

Figure 6: Cumulative Impulse-Response Function wrt Road Infrastructure Investment – Algarve