Is All Infrastructure Investment Created Equal? The Case of Portugal (*)

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Abstract

In this paper we analyze the effects of infrastructure investment on economic performance in Portugal using a newly developed data set. We employ a vector autoregressive approach to estimate the elasticity and marginal products of investments on twelve different types of infrastructure investment on private investment, employment and output. We find that the largest long-term accumulated effects come from investments in railroads, ports, airports, health, education, and telecommunications. For all of these infrastructures, the output multipliers are sizable enough to suggest that these investments would pay for themselves in the form of additional tax revenues. We find also that for investments in airports and health infrastructures the bulk of the effects are short-term demand side effects while for railroads and health the bulk of the effects come from long-term supply side effects. Finally, investments in health and airports show a clear pattern of decreasing marginal returns with railroads, ports, and telecommunications showing a relative stable pattern. In terms of the other infrastructure assets, we find that the economic effects of investments in municipal roads, highways, and electricity and gas are not significant or relevant. Investments in national roads, waste and waste water, and refinery infrastructures have positive economic effects but not large enough to also have a positive budgetary effects. Clearly, not all infrastructure investments are created equal along several and rather relevant dimensions from a policy perspective.

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JEL Classification: C32, E22, E62, H54, H60, O47, O52

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1. Introduction

Any mention of infrastructure investment in Portugal nowadays is met with scorn and criticism both from large areas of the political spectrum and maybe even more so from the general public. Infrastructure investment has entered the Portuguese lexicon as evoking excess, wastefulness and special interests. And yet it was not always like this. Quite the opposite.

In fact, since 1986, with the accession of Portugal to the EU, economic policies to promote growth have focused, in no small measure, on investment in infrastructures, with a heavy focus on road infrastructure. EU structural funds were a major source of financing through the late 1990s and the burden on the domestic public budget was therefore limited. These were the glorious days of infrastructure investment. These investments were viewed as the cure to all economic problems. In practice, these efforts literally changed the landscape of the country.

After the late 1990s, however, things started to change. With fewer EU funds available for infrastructure investment the government resorted to the widespread use of public-private partnerships as a mechanism to transform investments that would otherwise be an immediate burden on the public budget into commitments to annuities to be paid from the public budget over time. These partnerships turned out to be poorly understood, their implementation problematic and they soon became very unpopular among the general public.

The recent sovereign debt crisis and austerity in the quest for budgetary consolidation resulted in an ongoing economic recession coupled with persistently high public debt levels. In the public mind, infrastructure investments were a major factor triggering these events – something that can arguably be showed to be totally off the mark. Furthermore, due to the distribution of potential benefits and costs through time and the diffusion of these benefits over the population, infrastructure investments are often perceived of as the most politically expedient areas for budgetary cuts. Indeed, as the current crisis reached its peak, infrastructure investment led the pack as the category with the largest decline in the public budget. Not surprisingly, infrastructure investment reached in recent years their lowest levels in decades.

And so here we are. Criticisms of and suspicions about infrastructure investment are widespread. Certainly, there are ample reasons to be cautious. Many white elephant infrastructure investment projects are easy to name and mismanagement and corruption in public-private partnerships are a matter of great concern. Long gone are the days when infrastructure investment was seem as a panacea and certainly the idea that the country does not need more roads and highways has its appeal.

And yet, the dual needs for public policies to promote economic performance and debt consolidation remain. As the country seems to start emerging from very significant economic woes, with a persistent need to improve employment conditions and labor productivity, the question again arises as to how to define priorities to achieve these goals. From our perspective, the central issue is the role that infrastructure investment could or should play in achieving these goals.

So the critical questions remain: Is it still worth to invest in infrastructures? And if so which types? What are the effects of infrastructure investment on labor productivity, employment, private investment, and output? What is the relative importance of more short term demand effects versus the long term supply side effects of these investments? What are the ramifications for the long term prospects of fiscal consolidation? Ultimately, we want to answer the question: when it comes to their economic and budgetary impact are all types of infrastructure investment created equal? Which ones should be sidestepped in agreement with the popular conventional wisdom and which ones should be encouraged despite negative popular views?

In this paper we analyze the impact of infrastructure investment on economic performance in Portugal and address the questions above, first at the aggregate level and then considering twelve types of infrastructure investments – three types of road transportation infrastructures (national roads, municipal roads, and highways), three types of other transportation infrastructures (railroads, ports, and airports), two types of social infrastructures (education and health infrastructures), and four types of utilities (water and wastewater, electricity and gas, petroleum refineries, and telecommunications). In doing so we intend to bring a level of clarity to the debate on defining specific strategic priorities as far as infrastructures investments are concerned. A clarity based on empirical evidence that will allow the debate to be based on facts not preconceived notions.

Conceptually, the ultimate objective of this paper is to estimate the long-term multipliers for the different types of infrastructure investment. The magnitudes for the estimated marginal products are a good indicator of the relative economic relevance of these investments. Equally important their magnitude will also determine if the investments will pay for themselves or not over the long term in the form of additional tax revenues. While a positive marginal product by itself suggests a meaningful investment from an economic perspective, a sufficiently large marginal product suggests also a meaningful investment from a budgetary perspective.

From a taxonomic perspective, we can expect infrastructure investments to potentially fall into one of three categories. First, these investments may present negative or small positive marginal products. In this case, these infrastructure investments are not important for the economy and have a detrimental effect on the budget and as such can be eliminated without significant economic or budgetary concerns. Second, the effects of these investments may be positive but not sufficiently large to generate positive budgetary effects. These infrastructure investments are important for the economy but still have a detrimental effect on the public budget. Eliminating these investments although useful from a budgetary perspective is hurtful in economic terms. Third, the effects of infrastructure investments may be sufficiently large that they are self-financing. In this case these infrastructure investments have positive economic and budgetary effects. Eliminating these investments hurts both the economy and the public budget.

We use a multivariate dynamic time series methodological 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 relationship between infrastructure and the economy. It does so at three distinct levels: i) it explicitly addresses the contemporaneous relationships in the innovations in each variable; ii) it incorporates the dynamic intertemporal feedback structure among the variables; and, iii), it accommodates the possible existence of long-run equilibrium cointegrating relationships among the variables. Built into the approach is the identification of a causal relationship among the variables rather than simple correlations.

In addition, 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. In this model, the economy uses a production technology based on the use of capital and labor, as well as public infrastructure, to generate output. Given market conditions and the availability of public infrastructure, private economic 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 public 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 role of public infrastructure investment as a direct input to production and as an externality in production. Infrastructures further affect output indirectly through their effect on the demand for labor and private capital.

In this context, our 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]. 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.

Finally, and since this is clearly not the first paper dealing with infrastructure investment in Portugal it is important to highlight its novelties. First, we use a new and recently completed comprehensive data set for infrastructure investment in Portugal covering the period between 1978 and 2012 [see Pereira and Pereira (2015)]. In doing so, this is the first paper to enlarge the scope of the analysis of the effects of infrastructure investments by considering six types of non-transportation infrastructures mentioned above. At the same time this is also the first treatment of the six transportation infrastructure types using data after the late 1990s. From a more conceptual perspective, this is the first contribution that decomposes the marginal products between the sort-term demand effects on impact and the long term supply side effects and that maps the evolution of the marginal products over time to identify patterns of decreasing marginal returns. From a policy perspective, and in response to the economic conditions developing over the last decade, this is the first time the above taxonomy is introduced and applied and the policy implications of the results are framed in terms of the economic and budgetary dilemma.

This paper is organized as follows. Section 2 presents the economic and infrastructure 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 evidence as to the economic impact of infrastructure investment as well as their policy implications. Section 5 provides some international comparisons for the results in this paper. Section 6 presents a summary and concluding remarks.

2. Data Sources and Description

We use annual data for Portugal from 1978 to 2011. The economic data are obtained from Instituto Nacional de Estatística. The data for infrastructure investment are from a new data set developed by Pereira and Pereira (2015). Gross domestic product (GDP), private investment, and infrastructure investment are measured in millions of constant 2005 Euros while employment is measured in thousands of employees.

We consider total infrastructure investment as well as twelve individual types of infrastructures grouped in four main types of infrastructure investments: road transportation infrastructure, other transportation infrastructure, social infrastructures, and utilities infrastructure.

Table , **Table** , **Table 3** and **Table 4** present some summary information for infrastructure investment effort, as a percent of GDP, as a percent of total infrastructure investment, as well as the growth rates.

Road transportation infrastructures include national roads, municipal roads and highways and account for 28.2 percent of total infrastructure for the sample period. Investment efforts and the extension of motorways in Portugal grew tremendously during the 1990s with the last ten years marked by a substantial increase in highway investment made possible due to public private partnerships. This corresponds in absolute terms to an increase from 0.75% of the GDP in the 1980s to 1.56% in the last decade.

The largest component of **road transportation** investments for the sample period was national road investment, amounting to 0.61% of GDP and 12.21% of total infrastructure investment. What is most striking, however, is the substantial increase in investment in highways since 2000. In fact, the extension of freeways in Portugal increased by more than a third since 2000. In the last decade, highway infrastructure investment amounted to 0.73% of GDP and surpassed national road infrastructure investment in importance, with highway investment amounting now to 11.70% of total infrastructure investment. In contrast, the past thirty years have seen a steady decline in municipal road infrastructure investment volumes.

Other transportation infrastructures include railroads, airports and ports. Other transportation infrastructure investment accounted for 9.0 percent of total infrastructure investment between 1980 and 2011. Investment in social infrastructures reached its greatest levels, as a percent of total infrastructure investment, with the modernization of the railroad network and port expansion projects in the context of the second community support framework during the 1990s. The last ten years has also brought with it substantial growth in investment in airports with the renovation and expansions of the airports in Lisbon and Oporto. In absolute terms this reflects an increase from 0.22% of the GDP in the 1980s to 0.48% in the last decade.

Railroads represent the bulk of investment in other transportation infrastructures, nearly 75% of total investment in other types of transportation infrastructures. Investment in railroad infrastructures amounted to 0.34% of GDP over the sample period, reaching 0.45% of GDP during the 1990s in the context of the community support frameworks. Investment in ports and airports over the past thirty years has represented relatively smaller investment volumes due to the rather limited number of major airports (3) and ports (12) in the country. Nonetheless, very substantial investments in the airports of Lisbon and Oporto were undertaken in the last decade with investment volumes reaching 0.08% of GDP, nearly double that seen in the 1980s, a period in which major investments were directed towards the Lisbon airport, and 1990s. During the last decade, investments in airports accounted for 1.21% of total infrastructure investment.

Social infrastructures include health facilities and educational buildings. Social infrastructures have accounted for 23.8 percent of infrastructure investment and shown a slowly declining pattern over time in terms of their relative importance in total infrastructure investment. In absolute terms, however, these investments remained stable over the last two decades representing just over 1.0% of the GDP in average.

Investment in health facilities and educational buildings both figure heavily in investment in social infrastructures with health facilities accounting for 10.7% and educational buildings accounting for 13.0% of total infrastructure investment. Investment in health facilities amounted to 0.55% of GDP and investment in educational facilities amounted to 0.60% of GDP over the sample period. While both relatively important, their evolution through time is marked distinct. In particular, investment in health facilities has been increasing steadily both as a percent of GDP but also a percent of total infrastructure investment. In contrast, investment in educational buildings has been declining steadily in relation to the remaining infrastructure types. In addition, investment in educational facilities reached their highest levels, as a percent of GDP, in the 1990s, amounting to 0.73% of GDP. In turn, investment in health facilities reached its greatest volumes in the last decade and amounted to 0.75% of GDP.

Utilities include electric power generation, transmission and distributions, water supply and treatment, petroleum refining and telecommunications infrastructures. Together these account for 39.1 percent of total infrastructure investment in the sample period. In terms of their relative importance, investment in utilities reached a relatively high relevance in terms of total infrastructure investment in the 1980s, driven by the expansion of the telephone network, substantial investment in the major coal powered generating units in Sines in the 1980s and investment in the two refineries in Portugal, in Matosinhos and Sines, following the oil price shocks of the 1970s. More recently, the expansion of mobile communications networks as well as investments in renewable energies have contributed to sustained growth in investment in utilities since 2000. In absolute terms, we witnessed a constant increase in importance from 1.13% of the GDP in the 1980s to 2.09% in the last decade.

Investment in electricity and gas infrastructures, followed closely by investments in telecommunications, represent the largest components of investment in utilities. The pattern on investment over time for these infrastructure assets, however, is quite distinct and reflective of both the state and development of technologies as well as international economic dynamics. Specifically, investment in electricity and gas infrastructures accounted for a relatively large share of total infrastructure investment, 15.97%, in the 1980s, due to the construction of the Sines thermoelectric power plant, a coal fired plant with four large generating units that supply nearly 20% of the electricity consumed in Portugal. The decision to invest in expanding electricity generating capabilities at the time was a direct product of the oil price shocks of the 1970s. Similarly, the last decade has seen very pronounced efforts to increase the production of electricity from renewable energies, primarily through investment in wind turbines, and from natural gas and expand the natural gas distribution network. As such, investment volumes reached 1.09% of GDP and accounted for 17.53% of total infrastructure investment. Investment in telecommunications amounted to 0.67% of GDP over the sample period. The largest investment volumes were associated with the development of the telephone network in the late 1980s and developments in digital and information technologies in the late 1990s. Indeed, in the 1990s investment in telecommunications amounted to 16.12% of total infrastructure investment

Overall, investment levels have grown substantially over the past thirty years, averaging 2.92% of the GDP in the 1980s, 4.45% in the 1990s and 5.17 over the last decade. The increase in infrastructure investment levels is particularly pronounced after 1986, the year in which Portugal joined the EU, and in the 1990s when EU transfers within the context of the Structural and Cohesion Funds stimulated a substantial increase in investment levels (Community Support Framework 1, 1989-1993; Community Support Framework 2, 1994-1999). The investment effort decelerated substantially during the last decade during the Community Support Framework 3, 2000-2006, and the QREN, after 2007. These landmark dates for joining the European Union as well as the start of the different community support frameworks are all considered as potential candidates for structural breaks in every single step of the empirical analysis that follows.

3. Preliminary Data Analysis

3.1. Unit Roots, Cointegration, and VAR specification

We start by using the Augmented Dickey-Fuller as well as the Zivot-Andrews t-test to test the null hypothesis of a unit root in the different variables, without any structural breaks and with endogenously determined break points, respectively. We use the Bayesian Information Criterion

(BIC) to determine the number of lagged differences to be included in the regressions, and we include deterministic components, a constant and/or a trend, as well as structural breaks in the regressions if they are statistically significant.

For both tests and for the variables in log-levels, the t-statistics are lower, in absolute levels, than the 5% critical values and, therefore, the tests cannot reject the null hypothesis of a unit root. In turn, for the tests applied to the first differences of the log-levels, i.e., the growth rates of the original variables, all critical values are greater, in absolute value, than the 5% critical value. Therefore, we can reject the null hypothesis of unit roots in the growth rates of the variables. We take this evidence as an indication that stationarity in first differences is a good approximation for all the time series under consideration.

It should be pointed out that this empirical evidence is consistent with the conventional wisdom in the macroeconomics literature that private investment, output, employment, and infrastructure investment are stationary in first differences. Although our public investment series is more disaggregated, the same pattern is not surprising.

We now test for cointegration among output, employment, private investment, and infrastructure investment for each of the twelve infrastructure investment variables. We use the standard Engle-Granger approach to test for cointegration and the corresponding Gregory-Hansen test with an unknown breakpoint. We have chosen the Engle-Granger procedure 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 cointegration 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 cointegration when it does not exist.

Following the standard approach, we perform four tests in each case. This is because it is possible that one of the variables will enter the cointegrating relationship with a statistically insignificant coefficient. We do not know, a priori, whether or not this will happen. If it does happen, however, a test that uses such a variable as the endogenous variable will not pick up the cointegration. Therefore, a different variable is endogenous in each of the four tests. We apply the test to the residuals from the regressions of each variable on the remaining variables. 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.

The value of the t-statistics is lower, in absolute value, than the 5% critical values in all but 25 of the 128 cases considered – four for each of the twelve infrastructure investment variable for each of the two tests. In six of these cases, two of the four cases indicate cointegration and in one case, for telecommunications, three of the four tests, with a structural break indicated in 1996, are indicative of the presence of a cointegrating relationship. Moreover, in all but 8 of the tests, the test statistics are lower, in absolute value, than the 1% critical values. In each of these eight instances, a single endogenously determined break point is indicated. Thus, our tests cannot reject the null hypothesis of no cointegration.

The absence of cointegration is neither surprising nor problematic. On one hand it is not surprising to find lack of evidence for long-term equilibrium relationships for an economy that is still clearly in the process of converging to the level of its peers in the European Union. On the other hand it 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.

We have now determined that all of the variables are stationary of first order and that they do not seem to be cointegrated, either at the aggregate level or at the more disaggregated level. Accordingly, 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 twelve VAR models for each of the different infrastructure types and four for each of the infrastructure composites, road transportation, other transportation, social infrastructures and public works. Each VAR model includes output, employment, and private investment. In addition, it includes a different infrastructure investment variable – one for each of the four aggregate infrastructure composites and one for each of the twelve different types of infrastructure investment. 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 whether the exogenous structural breaks and deterministic components, the constant and trend, should be included in the VAR system.

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 for each system. The identification of the structural breaks is very meaningful as it shows the relevance of the inception of the first three community support frameworks but the lesser importance of the most recent one, the QREN.

Finally, it should be pointed out that the estimated variance-covariance matrices for the the residuals display, in general, a strong block-diagonal pattern in which the innovations in the private economic variables show low correlations with the infrastructure investment variables. The existence of this block diagonal pattern is relevant in that it suggests that our estimates of the effects of innovations in the infrastructure investment variables have a low contemporaneous correlation with innovations in the other variables, a matter to be further discussed below.

3.2. Identifying Exogenous Innovations in Infrastructure 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 the infrastructure investment variables. This means that we need to identify the shocks to infrastructure investment variables that are not contemporaneously correlated with, i.e., that are orthogonal to shocks in the other variables. These exogenous shocks allow us to identify the effects of innovations in infrastructure investment that are not contaminated by other contemporaneous innovations as they 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 (1998)] and adopted by Pereira (2000) in the context of the analysis of the effects of infrastructure investment.

Ideally, the identification of shocks to infrastructure investment which are uncorrelated with shocks in other variables would result from knowing what fraction of the government appropriations in each period is due to purely non-economic reasons. The econometric counterpart to this idea is to imagine a government policy function which relates the rate of growth of public infrastructure investment 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 public infrastructure investment and are uncorrelated with innovations in other variables.

In the central case, we assume that the relevant information set for the policy function includes past but not current values of the economic variables. This is equivalent in the context of the standard Choleski decomposition to assuming that innovations in investment lead innovations in economic variables. This means that while innovations in infrastructure investment affect the economic variables contemporaneously, the reverse is not true.

We have two reasons for making this our central case. First, it seems reasonable to believe that the economy reacts within a year to innovations in infrastructure investment 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.

The central results we report in this paper are the ones obtained under our preferred orthogonalization strategy, assuming that investment in infrastructures affects all other variables contemporaneously. These are the results to focus upon. These tables also include ranges of variation over all possible statistical orthogonalization strategies under the Choleski decomposition approach. These ranges should not be understood as confidence intervals; they simply and literally report the range of variation for all conceivable strategies including therefore all alternatives that are mechanically possible even if not meaningful from an economic perspective. They just measure the level of ambiguity that could conceivably be introduced by the well-known problem of the dependency of impulse response function in a VAR framework to the contemporaneous correlations among the estimated residuals.

The policy functions for aggregate infrastructure investment as well as the different types of infrastructure investment relate the evolution of infrastructure investment to the evolution of the economic variables with a one-year lag. The specification of these policy functions was tested. In no case were variables lagged more than one period statistically significant. More importantly, in no case were the contemporaneous values of the economic variables statistically significant. This confirms our assertion that our central case scenario is the most plausible also from an econometric perspective.

The results for the estimates of the different policy functions are presented in *Table* , *Table* , *Table* , and *Table* . For aggregate infrastructure investment, as well as for each of the four individual infrastructure types, the policy functions suggest that there is no feedback from the other variables to the infrastructure investment variable. This also means that these variables do not Granger-cause infrastructure investment, and infrastructure investment is truly an exogenous variable. The exogeneity of infrastructure investment decisions in Portugal is easily explained by the fact that for most of the sample period infrastructure investment decisions have been closely related to EU structural and cohesion policies.

3.3. Measuring the Effects of Innovations in Infrastructure Investment

We consider the effects of one-percentage point, one-time random shocks in the rates of growth of the different types of infrastructure investment on output, employment, and private investment. We expect these temporary shocks in the growth rates of the different types of infrastructure investment to have temporary effects on the growth rates of the other variables. They will, however, have permanent effects on the levels of these variables. All of these effects are captured through the impulse response functions and accumulated impulse response functions associated with the estimated VAR models. In all cases standard deviation bands were calculated to ascertain the statistical significance of the results.

The accumulated impulse response functions are presented in Figure 1 through Figure 4. All of them show a smooth pattern of evolution with convergence within a teen-year period. Furthermore, estimated standard deviation bands always fall in the positive range of results suggesting that the effects we identify are significantly different from zero. The only exception although marginal is the case of the effects on employment and output from road infrastructure in which case the standard deviation bands although falling mostly on positive range also overlap with the negative range. The significance of these results is therefore less robust as they are too close to not being statistically different from zero.

To measure the effects of public infrastructure investment 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. However, these concepts are used in a way that departs from conventional definitions because they are not based on *ceteris paribus* assumptions, but include all the dynamic feedback effects among the different variables. That is, they measure both the direct and dynamic effects of infrastructure investment on the economic variables and the indirect dynamic effects of infrastructure investment through changes in the evolution of these variables. This while considering the dynamic feedbacks from these variables to the evolution of infrastructure investment. Naturally, these are the relevant concepts from the standpoint of policy making.

Table, Table , Table and Table present the elasticities of private investment, employment and output with respect to infrastructure investment, both at the aggregate level and disaggregated by type of infrastructure. These long-term accumulated elasticities are to be interpreted as the total accumulated percentage point long-term change in the other variables per one-percentage point accumulated long-term change in infrastructure investment.

Table , Table 3, Table and Table present the marginal products for private investment, employment and output with respect to infrastructure investment, both at the aggregate level and disaggregated by type of infrastructure. The long-term accumulated marginal products of public infrastructure investment measure the dollar change in private investment and output, and the number of permanent jobs created, for each additional dollar of investment in public infrastructures. The marginal product figures are obtained by multiplying the average ratio of each variable to public investment by the corresponding elasticity. Accordingly, the marginal product figures are the most interesting from a policy perspective as they capture the effects of scarcity in addition to the effects of the coupling of infrastructure investment and the 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 product figures 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. In addition, to measure the effects on the marginal products of evolution of the relative scarcity, we also calculate the marginal product figures using rolling ten year averages starting for the beginning of the sample period onwards.

Finally, Table, Table , Table and Table present the annual rate of return of each type of infrastructure investment. The rate of return is calculated from the marginal product figures by assuming a useful life schedule for railroad capital assets consistent with its observed implicit depreciation rate. The rate of return is the annual rate at which an investment of one dollar would grow over the lifetime of the asset to yield its accumulated marginal product.

4. On the Impact of Infrastructure Investment by Individual Asset Type

4.1 Long-Term Elasticities and the long-term effects on labor productivity

Each type of infrastructure investment has a positive effect on private investment except for investments in ports. The positive elasticities are within a relatively narrow range – from 0.4321 and 0.3000 for health infrastructures and national roads to 0.0177 for refineries. The same is true in terms of the effects on employment, in which case the only negative effect comes from investment in national roads. All positive employment elasticities range again from 0.0587 for health infrastructures, 0.0268 for education and 0.0295 for telecommunications to 0.0031 to refineries and electricity and gas infrastructures. Accordingly, our estimates suggest that in the overwhelming majority of the cases infrastructure investments crowd in, albeit with different intensity, both private investment and employment.

Naturally, the effects infrastructure investments of the different types on output are all positive. The strongest coupling effects come from investments in health infrastructures and telecommunications infrastructures with elasticities of 0.1166 and 0.0707, respectively. The lowest elasticities are for municipal roads, ports, petroleum refineries, and electricity and gas all with elasticities around 0.0050.

To put things is a statistical context, the overwhelming majority of the accumulated long-term elasticities are statistically different from zero as implied by the standard deviation bands around the accumulated impulse response function estimates. The exceptions are the elasticity of private investment with respect to investments in national roads as well as the elasticities of private investment, employment, and output with respect to investments in municipal roads. All of the remaining elasticities, even when very small, are statistically different from zero.

The effects of infrastructure investment on labor productivity can be obtained from the values of the elasticities, as the sign of the change in the output to labor ratio is the same as that of the difference between the elasticities of output and employment. We start by observing for all of the four main types of infrastructure, investments lead to improvements in labor productivity. The effects for road infrastructures being somewhat more subdued that the effects from other transportation infrastructures, social infrastructures and public utilities. The impact of different types in infrastructure investment on labor productivity, however, is the first instance where getting to really disaggregated effects proves to be very informative from a policy perspective.

The disaggregated results, presented in Figure 5 confirm several of these ideas and fine tune others. First, the moderate effect of **road infrastructure** investment actually hides a very large effect from national road investment and reflects a negative effect from municipal roads and a medium size effect from highway investment. Second, the important effect of **other transportation** infrastructure investment on labor productivity is mostly due to railroad infrastructure investment, the effects of infrastructure investment in airports being medium size and the effects from port investments actually being essentially null. Third, the strong effects of **social infrastructure** investment come mostly from health infrastructure investment as the effect of education is moderate. Finally, impact of investment in **public utilities** on labor productivity comes primarily from investments in telecommunications as the effects from water and waste water are moderate and the effects from refineries and electricity and gas are negligible.

4.2 Long-Term Marginal Products and Rates of Return

We now turn our attention to the marginal product of private investment, employment and output with respect to each type of public infrastructure category. The marginal product figures are a better measure of the relative effects of different types of public infrastructure investments and the relevant measure from a policy perspective. This is because they reflect the relative scarcity of the different types of public investment at the margin of the sample period. The values for the marginal products are depicted in Figure 6 to Figure 9.

Starting with the marginal products of **road infrastructure investment** we estimate at the aggregate level small effects across the board, on investment €3.18, on labor 34 full-time long term jobs, and an output multiplier of €2.75. These low aggregate effects are consistent with generally low effects for national roads, municipal roads and highways when considered individually. The only sizable effects are the impact of national roads on private investment, €0.69, the impact of municipal roads on employment, 148 full time jobs, as well as the output multiplier of national roads, €5.69. The remaining effects namely all the effects of highway infrastructure investment are very small. The corresponding 30 year rates of return all low even for national roads, 5.97%, and investments in national roads are the only ones that could come close to paying for themselves in the form of future tax revenues.

The economic impacts of **other transportation infrastructure** investments, however, are much more significant. At the aggregate level, these investments crowds in private investment with a marginal product of €12.62, employment with a marginal product of 271 jobs, and an output multiplier of €14.99. When more disaggregated types of investments are considered these large effects are also almost universally observed although naturally to different degrees. The only exception is that investment in ports seems to have no statistically significant effect on employment in the long term. On the flip side, investments in ports have a very large effect on labor in the long term with 482 jobs, actually the largest effect among the twelve infrastructure types. In turn, airports have also large private investment and employment effects with marginal products of €17.9 and 400 jobs. The output multipliers are very large, €11.36, €9.75, and €26.52 for railroads, ports, and airports, respectively. The thirty-year rates of return are very competitive, the lowest being 7.89% for ports which is still greater than highest rate of return for road infrastructure investments. Furthermore, given the magnitude of the output multipliers, investments in all of the three types of other transportation infrastructures could be expected to pay for themselves in terms of increased future tax revenues they induce.

The economic impact of **social infrastructure** investments is also very significant. These large effects can be identified at the aggregate level as well as for both health and education although the results tend to be larger for health infrastructure investments than for education. The effects on investment and employment are €15.34 and €14.02, and 306 and 231 jobs, for health infrastructure and education infrastructure investments, respectively. The output multipliers are 15.54 for health care infrastructure investments and €10.04 for education infrastructure investment, which imply thirty year rates of return of 9.8% and 8.0%, respectively. In both cases, the magnitude of the output multiplier suggests that from a budgetary perspective these investments would pay for themselves over the long term.

Finally, the aggregate effects of **public utilities** investments are relatively low and in fact of the same order of magnitude as the effects of aggregate road infrastructure investments. Here, however, the aggregate results hide some very important distinctions. In fact, while the effects of investments in water and waste water, petroleum infrastructures and in particular electricity and gas are small, the effects of investments in telecommunication infrastructures are very sizable. The marginal products of these investments on private investment and employment are €8.60 and 164 jobs. In turn, the output multiplier is €10.70 which translates into a thirty-year annual rate of return of 8.22%. Of all of the investments in public utilities only the ones in telecommunication infrastructure could be expected to pay for themselves from a public budgetary perspective.

4.3 Long-term Marginal Products versus Effects on Impact

The analysis of the short-term effects infrastructure investments by main type of asset reveals that in absolute terms only other transportation and telecommunications, having large accumulated long-term effects also have significant short-term effects. The short-term effects of social infrastructure investment are either much smaller or even significantly negative in terms of employment – social infrastructure investments crowd out employment in the short-term. At the most disaggregated level, that is, considering the twelve individual types of assets, we get, naturally, the most informative results from a policy perspective in terms also of the decomposition of the long-term accumulated effects between their short-term and long-term components.

In Table , Table , Table 4 and Table , we report the decomposition of the marginal products of infrastructure investment in a way that in addition to the total accumulated long-term effect, it shows how much of this effect is due to a demand side impact effect, the difference being naturally the longer-term supply-side effect.

In terms of ***road transportation***, the bulk of the effects on private investment and output, 59% specifically, are on impact, that is, in the year of construction. This suggests that the declining pattern of small and decreasing marginal products have pretty much eroded the long-term supply side benefits of these infrastructures and most of what is left is short-term demand side effects related to construction. An exception to this pattern is the employment effects. The short term employment effects are a very small part of what is anyway a very small accumulated long term effect.

These patterns can be better understood when we consider the three individual components of the road infrastructure assets. For national roads we observe that most of the effects on private investment and all of the effects on output are short-term effects. Actually, the short term effects on output exceed the long term accumulated effects which suggests a small negative long-term effect. For municipal roads, whose effect are generally small they are also mostly on impact for investment and employment while the small long term positive effect on output hides a negative effect on impact. Finally for highways we observe that most of the effects, actually all of the employment effects, are long-term effects. The most important bit of information form a policy perspective is that the moderately large long-term output multiplier for national roads is deceiving since the effects are exclusively short term effects.

For ***other transportation***, the short term effects are about one-third of the total effects. This means that aside from the short-term demand side effects related to construction there are also quite sizable long-term supply side effects to the economy.

Again, looking at the three different other transportation types is particularly informative. For investments in railroad infrastructures the short-term versus longer term decomposition follows pretty much the aggregate, with about one-third of the effects being short-term effects. For port infrastructure investment the positive employment effects are short-term and about half of the long-term output multiplier effects is also short term. This is even more so for airport infrastructure investment in which case consistently about two-thirds of the long term effects are on impact. The most important bit of information from a policy perspective is that infrastructure investments in railroads is more desirable that the numbers may suggest as its effects derive less from demand side factors and mostly from long term supply side effects.

In the case of ***social infrastructures***, the other area of significant economic and budgetary potential, the short term effects are also moderate, about 45% for private investment, 26% for employment and 35% for output. This means that the long term supply-side effects dominate. This is particularly so in the case of health infrastructures as the short term effects are well below one-third of the total long-term accumulated effects. For education, on the other hand around two-thirds of the effects on private investment and output are observed in the short-term. The most important bit of information from a policy perspective is that the effects of investments in health infrastructure are not only large but mostly long-term supply side effects.

Finally, for ***utilities***, we find that the short-term demand side effects tend to be stronger than for other transportation and social infrastructure but less than road transportation. Again, this hides a wide variety of patterns when we consider the individual assets. Investments in electricity and gas infrastructure are in one extreme as the very low effects observed are mainly short-term effects. On the other extreme, the effects of investments in petroleum refining are mostly long-term supply side effects, with very little effects on impact. The effects of investments in water and wastewater and in telecommunications are more evenly distributed and in the case of investment and output with more of a long-term relevance. Furthermore, employment effects for telecommunications are mainly long-term as well. The most important bit of information from a policy perspective is that the effects of investments in telecommunication infrastructure are not only large but mostly long-term supply side effects.

4.4 Long-Term Marginal Products and the Relative Scarcity of Infrastructure Capital

Economic theory suggests that a pattern of diminishing marginal return to infrastructure capital should be expected, meaning that with a more developed stock of infrastructure incremental additions through investment will have progressively smaller economic effects. In this context, it is important to recall that the marginal products with respect to infrastructure investment presented in this work are computed using infrastructure investment and the other relevant economic data for the last ten years. This recent period is chosen to reflect the most recently available data and accurately reflect the effect of infrastructure scarcity on the economic impact of infrastructure investment at the margin. A ten year period is chosen to ensure that the results are not overly affected by business cycle fluctuations.

To assess the evolution of the effects of scarcity on the measurement of the marginal products with respect to infrastructure investment throughout the sample period, we present now the marginal products using alternative time periods. Specifically, we consider 10-year moving averages beginning in 1978 thereby tracing the evolution of the marginal products as reflecting the evolution of the relative scarcity of the infrastructure asset. This information is particularly useful in depicting the specific patterns of diminishing marginal productivity of infrastructure investment in the different cases and specifically how fast it is decreasing. This is fundamental in evaluating the potential for policies to encourage the development of additional infrastructures.

The evolution of the marginal products for the four main types of infrastructure assets as well as the twelve individual assets are presented in Figure 10 through Figure 13. As a point of reference, the values for the marginal products we have presented and discussed above are the very last points in the different figures, that is, are the points where each curve ends using averages for the last ten years of the sample.

For **road transportation**, we see a pattern of steady decline of marginal products, one that is more pronounced earlier in the sample period than over the last ten years. Indeed, the marginal products at the end of the sample are just 50%, 34%, and 47%, for investment, employment, and output, of the values observed earlier in the sample.

Further disaggregation of the road infrastructure assets - national roads, municipal roads and highways – shows that this pattern hides a meaningful variety of situations. In the case of national roads we see a pattern of decline similar to the aggregate road infrastructure, while for municipal roads we do not see significant changes throughout the period. For highways, however, the decline in marginal products is extremely steep. To illustrate the long term output multiplier which is now €3.55 would be at about €25 if measured by the scarcity standards of the late 1980s. The same steep change can be observed in terms of the effects of investment and employment. This is consistent with an enormous effort in highway infrastructure in the last few decades..

For **other transportation** infrastructures as well as for ***social infrastructures*** we also see an overall pattern of decreasing marginal returns although less pronounced and indeed with a small inflection point after the early 2000s. The levels of marginal productivity measured at the end of the sample period are actually remarkably close to the levels as measure at the end of the 1990s. This is consistent with the idea that these infrastructures were the focus of attention mostly in the latter part of the sample but even then they did not play center stage. Looking at the different assets we seem a similar picture in the sense that the marginal products we estimate are between one-third and one-half of what the estimates would have been by the later 1980s. In addition, the relative stability after the early 2000s is also similar for railroads and ports, with the case of airports showing a somewhat decreasing pattern.

In the case of **social infrastructures** we observed that the marginal products have been consistently relatively high somewhat declining early in the sample years but remarkably stable after the early 2000s. This pattern is similar to what we observe in the case of health infrastructures. The case of education, however, is sharply different in that the marginal products have actually increased in the last decade reflecting an increasing relative scarcity of these infrastructures.

The case of **public utilities** the evolution at the aggregate level is similar both qualitatively and quantitatively to the case of road transportation we just described above. At a more disaggregated level however, we see a rather stable evolution of marginal products around rather low values for refineries and around high values for telecommunication In turn, for water and wastewater infrastructure we see an extremely sharp decline in marginal products with very low effects at the end of the sample. Finally, **for electricity and gas we see** a pattern of extreme decline of marginal products after the late 1990s.

We have showed that investments in railroads, ports, and airports, health and education, and telecommunications have the largest output multipliers. We have also showed that the effects of investment in railroads, health, are telecommunications are mostly long-term supply side effects while those of investments in ports, airports, and education are more short-term demand side impact effects. We now can add to this mix the idea that the long-term output multipliers of railroads, ports, airports, and health show clear decreasing patterns of marginal returns while there seems to be an increasing scarcity of educational infrastructures and there are no clear patterns of decreasing marginal returns for investments in telecommunications.

4.5 Policy Implications of the Evidence on the Effects of Infrastructure Investment

The wealth of information presented above and suggests that a targeted approach to the design of infrastructure investment policy is absolutely necessary. Specifically, different types of infrastructure may be better suited to address different policy objectives, such as increasing labor productivity, encouraging private investment, creating job, or generating output. In addition, different investments regardless of their long-term accumulated effects may have rather different short-term effects on impact. Finally, in some cases we observe sharply decreasing marginal returns in the last decade of the sample, that is, the 2000s, while in other cases the evolution of the marginal products seem to be much more stable. When choosing where to invest all of these are aspects to be considered. In *Table* , *Table* , *Table* and *Table* we present a scoreboard of the results by type of infrastructure asset that is, we distill the impacts of the different types of infrastructure investments in a way that makes their policy implications apparent.

The main public policy implication that follows from our results is the recommendation that the government should invest or in some way promote investments in railroads, ports, and airports, health and education, and telecommunications, as these investments have the largest output multipliers. These are not only the infrastructure assets with the highest effects on output but also the ones with high enough returns to imply that they would very likely pay for themselves in the form of future tax revenues generated by improved economic conditions. Cutting back in these types of investments would, therefore, have detrimental effects on economic performance as well as on the public budget. This also means that these investments may be good vehicles to promote not only economic growth but also budgetary consolidation. Investments in these infrastructure assets are – in general terms - a good idea.

In addition, we have showed that the effects of investment in railroads, health, are telecommunications are mostly long-term supply side effects while those of investments in ports, airports, and education are more short-term demand side impact effects. From a public policy perspective, this makes ceteris paribus, the investments on the former more desirable than on the later, as the main motivation for infrastructure investments should generally be to create conditions for long-term growth. This also means that the later are actually likely to be more desirable if the policy objective is to generate immediate short-term economic benefits.

We also found that the long-term output multipliers of railroads, ports, airports, and health, show clear decreasing patterns of marginal returns. Accordingly, a strategy of promoting investments in these assets can only go so far as additional investment reduces the scarcity factor and will bring marginal products to clearly lower levels. In turn, there are no clear patterns of decreasing marginal returns for investments in telecommunications which may be due to the relatively recent nature of the technologies involved. For investments in education infrastructures there is a pattern of increasing marginal effects likely due to a clear disinvestment and decommissioning of educational facilities over the last decade.

On the flip side and as we consider the remaining infrastructure assets, in terms of their output effects, investments in municipal roads, highways, and electricity and gas infrastructures do not have meaningful or significant effects. Accordingly, cutting back on these investments would not particularly hurt the economy and would certainly have favorable effects on the public budget. In the middle of our taxonomic distribution are investments in national roads, water and wastewater, and telecommunication infrastructures. In this case, although the long-term output multipliers are big enough to suggest some relevant economic effects, they are not large enough to be advantageous from a budgetary perspective. They would likely not pay for themselves in the form of future additional tax revenues.

5. International Comparisons

There is a wide body of literature dealing empirically with the economic effects of infrastructure investment [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)]. Accordingly, making general and merely qualitative comparisons is easy although not particularly interesting. More relevant quantitative comparisons are, however, surprisingly difficult. This is because of wide differences in the temporal and typological scope and definition of the data sets used, the great different in econometric approaches, and their implications in terms of the interpretation of such trivial terms as elasticities and marginal products.

Although difficult, meaningful international comparisons are not impossible. We focus here on comparisons with the evidence on the output multipliers of infrastructure investment in Portugal [see, Pereira and Andraz (2005, 20011)] and Spain [Pereira and Roca (2003, 2007)] on one hand and

Ontario, Canada [see Pereira and Pereira (2014)] and the U.S. [see Pereira (2000)] on the other hand. In all cases the results are based on the same methodological approach and therefore more directly comparable to the ones developed in this paper. Canada and the U.S. provide for a comparison with an economy at a greater level of development and with arguably a lower level of infrastructure scarcity. In contrast, Spain provides for a comparison at a similar level of development and scarcity in the infrastructure stock. Naturally, the most interesting comparisons will be with previous evidence for Portugal itself.

In most cases the data sets end in the middle to late 1990s. The exception is for the case of Ontario, Canada where data covers 1976 to 2011 and is therefore close to the time frame used in this paper. The studies for the US use data from 1956 to 1997 while the Portuguese case uses info from 1978 to 1998 and the Spanish case from to 1970-1995. Finally, comparisons with the results for Portugal and Spain are more limited in that the Portuguese and Spanish cases only consider transportation infrastructure – roads, highways, ports, airports, rail - and in the Spanish case communications. The studies for Ontario, Canada and the U.S. are more generally comparable in terms of scope of the data base used, which is more comprehensive, considering infrastructure types beyond transportation. For Ontario, Canada, the study considers government, administrative and other infrastructures, health infrastructures, education infrastructures, road infrastructures, and water and waste water infrastructures. For the U.S., the study considers road infrastructure, electric and gas facilities, water and sewage, education, hospital and other buildings, and a residual category.

The estimates the output multipliers of ***road infrastructure*** investments for the US is 1.97, the smallest of all multipliers for the U.S., while for Ontario, Canada the multiplier is actually negative. Our estimate of the output multiplier for aggregate road infrastructure is 2.75, while for each of the individual assets they are 1.02 for municipal roads, 3.55 for highways and 5.70 for national roads. They are accordingly in the same range but more importantly are also among the smallest effects we estimate.

In terms of the multipliers for ***other transportation*** infrastructure investments, the closer category for the U.S. core infrastructure which includes transit and airfields – but also electricity and gas, is 19.79 and is the largest multiplier. For Ontario, Canada, the largest multiplier is also for transit with 29.19. Our estimate for Portugal including airports, ports and railroad infrastructure is also the largest at 14.99. Each one of the individual assets has equally important effects albeit to different degrees: 11.36 for railroads, 9.75 for ports and 26.52 for airports.

The evidence Spain contemplating total transportation infrastructure – road and other transportation - is 5.50. This figure compares directly to the evidence for Portugal for a comparable time horizon, a multiplier of 9.54. The natural conclusion is that the marginal benefits of further investments in transportation infrastructure were greater at the time for Portugal than Spain, reflecting a pattern of greater scarcity in Portugal. In turn, the figure for just road transportation for Portugal for the same period is 18.06, suggesting therefore an even greater marginal product and an even greater scarcity at the time when only road infrastructure is considered.

In turn, for the U.S. the multiplier for the infrastructure type that most resembles ***social infrastructure*** – but also includes administrative buildings, is 5.53, and is in the middle of the range of results, while for Ontario, Canada the estimate of the multiplier for education infrastructure is 14.17 and health infrastructure is 23.46 and are among the largest for that regions. Our estimates for social infrastructure of 16.54 for health and 10.04 for education are of the same order of magnitude and also among our largest estimates.

Finally, for ***public utilities***, the estimates for the U.S. for water and water systems are 6.35 while for Ontario, Canada the same multiplier is 8.29. Our corresponding multiplier is 4.80, which although smaller is of the same order of magnitude.

We now turn our attention to the comparisons with precious estimates of the output multipliers for Portugal using data until the late 1990s. This is the most direct comparison we can make and the differences will be important not only to frame our new results but even more so from a policy perspective.

Again, our results now for ***road transportation*** and for ***other transportation*** are 2.75 and 14.99, respectively, while for the combination of both that is ***total transportation***– a result not previously introduced in the paper – it is 3.18. These figures are to be contrasted with multipliers for the period ending in the late 1990s of 18.06 for road infrastructures, around 19.0 for other transportation, and 9.54 for total transportation.

The multiplier for road transportation is now 6.5 times smaller than by the late 1990s. This not only reflects a rapid decline in the marginal productivity of these investments as it could be seem from the discussion in the precious section, but even more so from a decoupling of road infrastructure investments and economic performance as reflected by the decline in the elasticity itself from 0.29 to 0.05. Overall the multiplier for total transportation infrastructure investment is now about one third of what was estimated for the late 1990s. Clearly, in terms of the output effects there is a degree of diminishing returns and even more so of increasing decoupling which is particularly large for road infrastructures investments.

When we consider the six transportation infrastructures we also see some of the same types of patterns but there are exceptions and added nuances. The decoupling of the infrastructure investment from the economy, as suggested by lower estimates of the elasticities, is particularly profound in the case of municipal roads and ports and very important although less so for national roads and railroads. In turn, the elasticities for highway investment did not change significantly while the elasticity for airports is now substantially larger. It would seem that the evolution of infrastructure investment and of the overall economy has brought the country to a place where the responsiveness of the economy to investments municipal roads and ports has greatly declined while the responsiveness to airports has increased.

When we consider the multipliers we observe that only in the case of airport investment has the estimate increased – from 19.18 in the late 1990s to 26.51 now. This is completely due to increase in the responsiveness of the economy to these investments as the reduction in scarcity in itself would imply a decrease in the long term multiplier. On the flip side we see a very sharp decline in the multiplier for municipal roads – from 22.32 to 1.02 – and for ports – from 107.00 to 9.75 - which are in both cases totally due to the decoupling effects that is a lower elasticity. In turn for national roads and railroads we find more of a mixed role of decoupling and decrease scarcity in explaining the decline in the output multipliers from 31.41 to 5.70 and from 18.47 to 11.36. Finally for highway investment the decline in the multiplier from 8.24 to 3.55 is completely due to dimished scarcity.

6. Summary and Concluding Remarks

This study analyzes the effects of infrastructure investment on economic performance in Portugal using a newly developed data set. We consider twelve types of infrastructure investments – three types of road transportation infrastructures (national roads, municipal roads, and highways), three types of other transportation infrastructures (railroads, ports, and airports), two types of social infrastructures (education and health infrastructures), and four types of public utilities (electricity and gas, water and wastewater, refineries, and telecommunications). We employ a vector autoregressive approach to estimating the elasticity and marginal product of public infrastructure investment on private investment, employment and output. This approach is consistent with the argument that the analysis of the effects of public infrastructure investment on economic variables requires the consideration of dynamic feedback effects among the different variables.

We frame our empirical results in terms of the economic policy environment, i.e., considering both the economic impacts of infrastructure investments and their budgetary implications. We find that, clearly, not all infrastructure investments are created equal along several and rather relevant dimensions from a policy perspective.

We find that the largest long-term accumulated output effects come from investments in railroads, ports, airports, health, education, and telecommunications. For all of these infrastructures, the output multipliers are sizable enough to suggest that these investments would pay for themselves in the form of additional tax revenues. We find also that for investments in airports and health infrastructures the bulk of the effects are short-term demand side effects while for railroads and health the bulk of the effects come from long-term supply side effects. Finally, investments in health and airports show a clear pattern of decreasing marginal returns with railroads, ports, and telecommunications showing a relative stable pattern.

In terms of the other infrastructure assets, we find that the economic effects of investments in municipal roads, highways, and electricity and gas are not significant or relevant. Investments in national roads, waste and waste water, and refinery infrastructures have positive economic effects but not large enough to also have a positive budgetary effects.

Because of their immediate relevance for policy making it is appropriate to include here two cautionary notes about these results. First, these results deal with general macroeconomic impacts and provide proper but general guidance. The fact that an infrastructure asset is identified as yielding important positive effects does not imply that all investment projects pertaining to the same assets are equally desirable or even desirable at all. The same reasoning applies to the assets that we have identified as less important – it does not mean that all projects in these areas would also be undesirable. To make these determinations there is no substitute for a benefit-cost analysis. Second, the macroeconomic impacts we have identified are relevant from a policy perspective and are indicative of the benefits for the country as a whole as determined by its economic fabric. These numbers are not indicative of the desirability that these projects could have for the private sector.

Our results open the door to several important avenues of future research directly relevant for policy purposes. The first, would be a finer analysis at a more disaggregated infrastructure level of the effects of investments – the more disaggregated the more relevant the policy recommendations. Second, one should consider the effects of infrastructure investment at the industry level. This is particularly relevant to identify the relative effects of these investments in traded and non-traded industries and thereby allow us to understand the interaction between infrastructure investment and general policies to promote international competitiveness in Portugal. Third, one should consider the effects of infrastructure investment at the regional level. This would be particularly important as it would shed light on the issue of inter-regional infrastructure investment spillovers and the effects of infrastructure investment in the regional concentration of economic activity.

To 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. The quest for policies that promote long-term growth in a framework of fragile public budgets is widespread. As EU structural transfers have shifted towards new members, countries such as Ireland, Greece, and Portugal have been forced to rely on domestic public policies to promote real convergence. This poses a challenge since growing public spending, pro-cyclical policies, and more recently, falling tax revenues have contributed to rapidly increasing levels of public debt and a sharp need for budgetary consolidation. How to direct the infrastructure investment efforts in a way that is friendly to both the economy and the public budget is, therefore, a question in search of an answer in many other countries facing similar difficulties.

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Table 1 Infrastructure Investment Effort and Growth – Road Transportation

	Road Transportation	National Roads	Municipal Roads	Highways
		Percent of GDP		
1978-2011	1.42	0.61	0.44	0.37
1980-89	0.89	0.39	0.40	0.09
1990-99	1.59	0.73	0.50	0.36
2000-09	1.88	0.71	0.45	0.73
		Growth Rate		
1978-2011	3.77	5.41	1.33	3.78
1980-89	3.41	6.61	1.68	0.66
1990-99	6.22	6.15	4.36	11.96
2000-09	3.47	6.55	-1.75	3.56
		Percent of Total		
1978-2011	28.20	12.21	9.32	6.67
1980-89	25.99	11.52	11.90	2.56
1990-99	30.35	14.09	9.47	6.79
2000-09	30.23	11.43	7.10	11.70

Table 2 Infrastructure Investment Effort and Growth – Other Transportation

	Other Transportation Infrastructure	Railroads	Ports	Airports
		Percent of GDP		
1978-2011	0.46	0.34	0.06	0.05
1980-89	0.26	0.18	0.04	0.04
1990-99	0.56	0.45	0.07	0.04
2000-09	0.57	0.43	0.07	0.08
		Growth Rate		
1978-2011	1.77	1.18	2.39	5.91
1980-89	2.04	0.42	-3.35	16.57
1990-99	11.16	14.69	9.79	-10.14
2000-09	-2.82	-5.24	-1.20	17.92
		Percent of Total		
1978-2011	8.98	6.72	1.23	1.03
1980-89	7.57	5.17	1.23	1.17
1990-99	10.52	8.31	1.40	0.81
2000-09	9.21	6.92	1.08	1.21

Table 3 Infrastructure Investment Effort and Growth – Social Infrastructure

	Social Infrastructures	Health Facilities	Educational Buildings
Percent of GDP			
1978-2011	1.15	0.55	0.60
1980-89	0.97	0.34	0.63
1990-99	1.30	0.57	0.73
2000-09	1.26	0.75	0.51
Growth Rate			
1978-2011	2.29	4.10	0.33
1980-89	3.18	2.34	3.75
1990-99	9.39	11.47	7.87
2000-09	-3.49	0.41	-8.65
Percent of Total			
1978-2011	23.76	10.74	13.02
1980-89	28.41	9.89	18.52
1990-99	24.52	10.73	13.79
2000-09	20.13	11.97	8.16

Table 4 Infrastructure Investment Effort and Growth – Public Utilities

	Utilities	Water	Petroleum Refining	Electricity and Gas	Telecommunic ations
Percent of GDP					
1978-2011	1.32	0.37	0.22	0.73	0.67
1980-89	0.84	0.17	0.11	0.55	0.49
1990-99	1.00	0.32	0.22	0.46	0.85
2000-09	1.78	0.52	0.18	1.09	0.75
Growth Rate					
1978-2011	3.89	9.01	-0.52	5.53	5.51
1980-89	1.53	9.34	-16.89	4.86	17.98
1990-99	10.04	10.70	25.30	7.05	3.67
2000-09	6.73	4.55	-1.36	9.80	-7.47
Percent of Total					
1978-2011	39.06	6.80	4.58	14.34	13.34
1980-89	38.04	4.90	3.22	15.97	13.94
1990-99	34.61	5.98	4.06	8.45	16.12
2000-09	40.43	8.17	2.83	17.53	11.89

Table 5 Policy Functions for Infrastructure Investment – Road Transportation

	gdp_{-1}	emp_{-1}	$gfcf_{-1}$	$pinv_{-1}$	1989	1994	2000	$Constant$	$Trend$
Road Transportation	0.3147	-0.1106	0.7340	-0.1295	0.2292	0.2555	0.5058	0.1906	-0.0233
	(3.4884)	(3.0071)	(0.9454)	(0.2036)	(0.1505)	(0.2)	(0.3001)	(0.154)	(0.0138)
National Roads	2.4464	1.3826	-0.7953	-0.1813	0.0799	-0.0318	0.0322	0.0431	-0.0019
	(3.3673)	(2.9877)	(0.8712)	(0.2331)	(0.138)	(0.1869)	(0.2798)	(0.1424)	(0.0128)
Municipal Roads	-2.0069	-0.6281	2.0160	-0.3423	0.0827	0.0527	0.1491	0.1680	-0.0109
	(3.3771)	(2.9289)	(0.9069)	(0.1593)	(0.1441)	(0.1938)	(0.29)	(0.1493)	(0.0133)
Highways	21.0694	-19.8236	-1.4012	0.1162	0.0934	0.5044	0.7336	0.3520	-0.0440
	(16.0241)	(13.6648)	(4.7632)	(0.241)	(0.6842)	(0.9389)	(1.3765)	(0.7044)	(0.0627)

Standard errors in parentheses
* $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table 1 Policy Functions for Infrastructure Investment – Other transportation

	gdp_{-1}	emp_{-1}	$gfcf_{-1}$	$pinv_{-1}$	1989	1994	2000	$Constant$	$Trend$
Other Transportation	0.0419	-2.6824	0.7860	0.0279	0.0417	0.0351	-0.1265	0.0333	0.0024
	(4.1778)	(3.6803)	(1.1259)	(0.2433)	(0.1804)	(0.2463)	(0.3918)	(0.1891)	(0.0178)
Railroads	-3.1726	-1.5452	1.2664	-0.0259	0.0825	-0.0141	-0.2078	0.1218	0.0033
	(5.2918)	(4.5032)	(1.4311)	(0.2174)	(0.2221)	(0.301)	(0.4595)	(0.2291)	(0.0209)
Ports	4.7602	15.1805	1.0173	-0.3844	-0.4448	-0.2572	-1.3012	-0.7085	0.0715
	(16.506)	(14.6325)	(4.4353)	(0.2121)	(0.7031)	(0.9451)	(1.4611)	(0.7531)	(0.0677)
Airports	0.1896	-7.9443	3.0393	-0.2138	-0.0561	0.7725	1.6781	0.8326	-0.0756
	(10.3496)	(9.1176)	(2.7649)	(0.1974)	(0.4571)	(0.5952)	(0.8862)	(0.452)	(0.0407)

Standard errors in parentheses
* $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table 2 Policy Functions for Infrastructure Investment – Social Infrastructure

	gdp_{-1}	emp_{-1}	$gfcf_{-1}$	$pinv_{-1}$	1989	1994	2000	$Constant$	$Trend$
Social Infrastructures	1.9727	0.1490	0.5998	-0.1587	-0.0468	-0.0816	-0.1904	-0.0443	0.0062
	(2.6142)	(2.2437)	(0.7707)	(0.2248)	(0.1107)	(0.1493)	(0.2235)	(0.1153)	(0.0102)
Health Facilities	0.9124	1.5428	0.4890	-0.0979	0.0315	-0.0321	-0.1117	-0.0353	0.0049
	(3.1378)	(2.7029)	(0.8777)	(0.2245)	(0.1361)	(0.1806)	(0.2706)	(0.1383)	(0.0124)
Educational Buildings	3.3271	-1.1471	0.9101	-0.4551	-0.1467	-0.1581	-0.3344	-0.0429	0.0087
	(3.2557)	(2.7976)	(0.9409)	(0.1971)	(0.1387)	(0.1864)	(0.279)	(0.1437)	(0.0128)

Standard errors in parentheses
* $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table 8 Policy Functions for Infrastructure Investment – Public Utilities

	gdp_{-1}	emp_{-1}	$gfcf_{-1}$	$pinv_{-1}$	1989	1994	2000	$Constant$	$Trend$
Utilities	2.5442	5.4785	-1.6959	-0.1765	-0.4196	-0.5598	-1.1046	-0.2923	0.0491
	(5.0049)	(4.3211)	(1.3517)	(0.1922)	(0.2175)	(0.301)	(0.4471)	(0.224)	(0.0207)
Water	0.9980	2.2445	-1.8656	-0.1654	-0.3468	-0.4188	-0.8781	-0.0930	0.0399
	(8.7156)	(7.5379)	(2.3423)	(0.2095)	(0.3853)	(0.5186)	(0.7858)	(0.3888)	(0.0363)
Petroleum Refining	33.4103	35.3551	-11.4513	-0.0731	-1.2594	-2.4432	-5.8506	-2.9364	0.2964
	(27.1476)	(23.8268)	(7.3065)	(0.1815)	(1.1914)	(1.573)	(2.4043)	(1.1894)	(0.1083)
Electricity and Gas	-28.5801	23.5704	1.0159	-0.4445	0.5950	0.1816	-1.1081	0.6274	0.0356
	(20.2791)	(17.5417)	(5.4352)	(0.1687)	(0.8621)	(1.1559)	(1.7315)	(0.8871)	(0.0793)
Telecommunications	8.4375	-6.8902	-0.1589	-0.2790	-0.5175	-0.4446	-0.8938	-0.1376	0.0326
	(5.5944)	(4.664)	(1.4447)	(0.2283)	(0.2481)	(0.3333)	(0.5055)	(0.2426)	(0.0229)

Standard errors in parentheses
* $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table 9 Elasticities with respect to Infrastructure Investment – Road Transportation

	Private Investment	**Employment**	**Output**
Road Transportation Infrastructure	0.2292	0.0169	0.0496
	[-0.0803, 0.2292]	[-0.0238, 0.0169]	[-0.0381, 0.0496]
National Roads	0.3000	-0.0042	0.0442
	[-0.1680, 0.3691]	[-0.0752, 0.0115]	[-0.0996, 0.0684]
Municipal Roads	0.0618	0.0159	0.0040
	[-0.0258, 0.1160]	[0.0012, 0.0285]	[-0.0249, 0.0270]
Highways	0.0839	0.0088	0.0226
	[0.0367, 0.0849]	[0.0027, 0.0091]	[0.0101, 0.0229]

Table 10 Elasticities with respect to Infrastructure Investment – Other Transportation

	Private Investment	**Employment**	**Output**
Other Transportation Infrastructure	0.2596	0.0379	0.0772
	[0.0881, 0.2596]	[0.0130, 0.0379]	[0.0275, 0.0772]
Railroads	0.1725	0.0162	0.0433
	[0.0572, 0.1725]	[0.0024, 0.0162]	[0.0121, 0.0433]
Ports	-0.0009	0.0077	0.0057
	[-0.0804, 0.0]	[-0.0058, 0.0078]	[-0.0193, 0.0060]
Airports	0.0533	0.0081	0.0197
	[-0.0742, 0.0533]	[-0.0106, 0.0081]	[-0.0204, 0.0197]

Table 11 Elasticities with respect to Infrastructure Investment – Social Infrastructure

	Private Investment	**Employment**	**Output**
Social Infrastructures	0.3911	0.0521	0.0956
	[0.0117, 0.3911]	[0.0127, 0.0521]	[-0.0189, 0.0956]
Health Facilities	0.4321	0.0587	0.1166
	[0.1829, 0.4321]	[0.0290, 0.0587]	[0.0441, 0.1166]
Educational Buildings	0.2385	0.0268	0.0427
	[-0.2115, 0.2385]	[-0.0276, 0.0268]	[-0.0999, 0.0427]

Table 12 Elasticities with respect to Infrastructure Investment – Public Utilities

	Private Investment	**Employment**	**Output**
Utilities	0.3156	0.0547	0.0962
	[0.020, 0.3156]	[0.0024, 0.0547]	[0.0006, 0.0962]
Water Infrastructure	0.1103	0.0181	0.0296
	[0.0034, 0.1103]	[-0.0025, 0.0181]	[-0.0061, 0.0296]
Petroleum Refining Infrastructure	0.0177	0.0032	0.0066
	[0.0117, 0.0177]	[0.0021, 0.0032]	[0.0045, 0.0066]
Electricity and Gas	0.0254	0.0031	0.0050
	[-0.0259, 0.0254]	[-0.0054, 0.0031]	[-0.0107, 0.0050]
Telecommunications	0.2270	0.0295	0.0707
	[-0.0080, 0.2270]	[-0.0039, 0.0295]	[-0.0001, 0.0707]

Table 13 Marginal Product of Infrastructure Investment – Road Transportation

	Private Investment	Employment	Output
Road Transportation Infrastructure	3.1801	0.0343	2.7492
	[-1.1145, 3.1801]	[-0.0484, 0.0343]	[-2.1138, 2.7492]
National Roads	9.6919	-0.0201	5.6996
	[-5.4282, 11.9241]	[-0.3562, 0.0543]	[-12.8566, 8.8247]
Municipal Roads	3.9316	0.1481	1.0177
	[-1.640, 7.3875]	[0.0111, 0.2666]	[-6.3343, 6.8731]
Highways	3.3039	0.0511	3.5490
	[1.4450, 3.3423]	[0.0156, 0.0526]	[1.5839, 3.6069]

Table 3 Marginal Product of Infrastructure Investment – Other Transportation

	Private Investment	Employment	Output
Other Transportation Infrastructure	12.6197	0.2706	14.9993
	[4.2817, 12.6197]	[0.0925, 0.2706]	[5.3426, 14.9993]
Railroads	11.3172	0.1563	11.3596
	[3.7538, 11.3172]	[0.0226, 0.1563]	[3.1668, 11.3596]
Ports	-0.3845	0.4820	9.7478
	[-34.1297, 0.0125]	[-0.3595, 0.4877]	[-32.6855, 10.1533]
Airports	17.9219	0.4002	26.5152
	[-24.9690, 17.9219]	[-0.5252, 0.4002]	[-27.4347, 26.5152]

Table 15 Marginal Product of Infrastructure Investment – Social Infrastructure

	Private Investment	Employment	Output
Social Infrastructures	8.6569	0.1692	8.4546
	[0.2594, 8.6569]	[0.0413, 0.1692]	[-1.6690, 8.4546]
Health Facilities	15.3392	0.3057	16.5441
	[6.4938, 15.3392]	[0.1511, 0.3057]	[6.2541, 16.5441]
Educational Buildings	14.0215	0.2310	10.0373
	[-12.4288, 14.0215]	[-0.2381, 0.2310]	[-23.4497, 10.0373]

Table 16 Marginal Product of Infrastructure Investment – Public Utilities

	Private Investment	Employment	Output
Utilities	2.8891	0.0735	3.5198
	[0.1828, 2.8891]	[0.0033, 0.0735]	[0.0212, 3.5198]
Water Infrastructure	4.4793	0.1077	4.7967
	[0.1393, 4.4793]	[-0.0148, 0.1077]	[-0.9934, 4.7967]
Petroleum Refining Infrastructure	2.0365	0.0536	3.0468
	[1.3418, 2.0365]	[0.0357, 0.0536]	[2.0486, 3.0468]
Electricity and Gas	0.5133	0.0092	0.4010
	[-0.5232, 0.5133]	[-0.0161, 0.0092]	[-0.8668, 0.4010]
Telecommunications	8.5996	0.1642	10.7004
	[-0.3023, 8.5996]	[-0.0218, 0.1642]	[-0.0213, 10.7004]

Table 17 Rate of Return on Infrastructure Investment – Road Transportation

	Lifespan of			
	20 years	30 years	40 years	50 years
Road Transportation	5.19	3.43	2.56	2.04
National Roads	9.09	5.97	4.45	3.54
Municipal Roads	0.09	0.06	0.04	0.04
Highways	6.54	4.31	3.22	2.57

Table 18 Rate of Return on Infrastructure Investment – Other Transportation

	Lifespan of			
	20 years	30 years	40 years	50 years
Other Transportation Infrastructure	14.50	9.45	7.00	5.57
Railroads	12.92	8.44	6.26	4.98
Ports	12.06	7.89	5.86	4.66
Airports	17.81	11.54	8.54	6.78

Table 19 Rate of Return on Infrastructure Investment – Social Infrastructures

	Lifespan of			
	20 years	30 years	40 years	50 years
Social Infrastructures	11.26	7.37	5.48	4.36
Health Facilities	15.06	9.80	7.27	5.77
Educational Buildings	12.22	7.99	5.94	4.72

Table 20 Rate of Return on Infrastructure Investment – Public Utilities

	Lifespan of			
	20 years	30 years	40 years	50 years
Utilities	6.49	4.28	3.20	2.55
Water	8.16	5.37	4.00	3.19
Petroleum Refining	5.73	3.78	2.82	2.25
Electricity and Gas				
Telecommunications	12.58	8.22	6.10	4.85

Table 21 Long-term Marginal Products versus Effects on Impact – Road Transportation

		Private Investment	Employment	GDP
Road Transportation Infrastructure	Long Term	3.18	0.03	2.75
	Short Term	1.88	0.01	1.63
	Percent	0.59	0.19	0.59
National Roads	Long Term	9.69	-0.02	5.70
	Short Term	6.52	-0.05	6.72
	Percent	0.67	2.50	1.18
Municipal Roads	Long Term	3.93	0.15	1.02
	Short Term	1.93	0.07	-1.81
	Percent	0.49	0.48	-1.78
Highways	Long Term	3.30	0.05	3.55
	Short Term	1.16	0.00	1.00
	Percent	0.35	-0.02	0.28

Table 22 Long-term Marginal Products versus Effects on Impact – Other Transportation

		Private Investment	Employment	GDP
Other Transportation Infrastructure	Long Term	12.62	0.27	15.00
	Short Term	3.75	0.09	4.07
	Percent	0.30	0.33	0.27
Railroads	Long Term	11.32	0.16	11.36
	Short Term	3.61	0.03	2.62
	Percent	0.32	0.16	0.23
Ports	Long Term	-0.38	0.48	9.75
	Short Term	-0.22	0.48	4.66
	Percent	0.57	1.00	0.48
Airports	Long Term	17.92	0.40	26.52
	Short Term	11.45	0.27	18.43
	Percent	0.64	0.68	0.69

Table 4 Long-term Marginal Products versus Effects on Impact – Social Infrastructure

		GFCF	EMP	GDP
Social Infrastructures	Long Term	8.66	0.17	8.45
	Short Term	3.87	0.04	3.00
	Percent	0.45	0.26	0.35
Health Facilities	Long Term	15.34	0.31	16.54
	Short Term	4.75	0.07	3.91
	Percent	0.31	0.23	0.24
Educational Buildings	Long Term	14.02	0.23	10.04
	Short Term	9.49	0.09	6.01
	Percent	0.68	0.39	0.60

Table 24 Long-term Marginal Products versus Effects on Impact – Public Utilities

		Private Investment	**Employment**	**GDP**
Utilities	Long Term	2.89	0.07	3.52
	Short Term	1.03	0.04	1.35
	Percent	0.36	0.55	0.38
Water Infrastructure	Long Term	4.48	0.11	4.80
	Short Term	1.52	0.07	2.11
	Percent	0.34	0.68	0.44
Petroleum Refining Infrastructure	Long Term	2.04	0.05	3.05
	Short Term	0.03	0.01	0.39
	Percent	0.02	0.15	0.13
Electricity and Gas	Long Term	0.51	0.01	0.40
	Short Term	0.40	0.01	0.35
	Percent	0.78	1.43	0.88
Telecommunications	Long Term	8.60	0.16	10.70
	Short Term	3.46	0.02	4.44
	Percent	0.40	0.12	0.41

Table 25 Infrastructure Investments: Scoreboard of Effects - Road Transportation

National Roads	
Private Investment	**Large and stable**: €9.69 [67% on impact]
Employment	**Small and stable**: negative [negative on impact]
GDP	**Medium and stable**: €5.70 [100% on impact]
Impact on the Public Budget	**Negative/Neutral**
Labor Productivity	**Large:** 0.0484
Municipal Roads	
Private Investment	**Medium and stable:** €3.93 [49% on impact]
Employment	**Medium and stable:** 148 jobs [48% on impact]
GDP	**Small and stable:** €1.01 [negative on impact]
Impact on the Public Budget	**Negative**
Labor Productivity	**Small:** negative
Highways	
Private Investment	**Small and decreasing:** €3.30 [35% on impact]
Employment	**Small and decreasing:** 51 jobs [0% on impact]
GDP	**Small and decreasing:** €3.55 [28% on impact]
Impact on the Public Budget	**Neutral/Negative**
Labor Productivity	**Medium:** 0.0178

Table 56 Infrastructure Investments: Scoreboard of Effects - Other Transportation

Railroad Infrastructures	
Private Investment	**Medium and stable:** €11.31 [32% on impact]
Employment	**Medium and stable:** 156 jobs [16% on impact]
GDP	**Medium and stable:** €11.36 [23% on impact]
Impact on the Public Budget	**Positive**
Labor Productivity	**Medium:** 0.0271
Airport Infrastructures	
Private Investment	**Large and decreasing:** €17.92 [64% on impact]
Employment	**Large and decreasing:** 482 jobs [69% on impact]
GDP	**Large and decreasing:** €26.51 [69% on impact]
Impact on the Public Budget	**Positive**
Labor Productivity	**Medium:** 0.0116
Port Infrastructures	
Private Investment	**Small and stable:** negative [negative on impact]
Employment	**Large and stable:** 400 jobs [100% on impact]
GDP	**Large and stable:** €9.75 [48% on impact]
Impact on the Public Budget	**Positive**
Labor Productivity	**Small:** negative

Table 27 Infrastructure Investments: Scoreboard of Effects - Social Infrastructures

Health Facilities	
Private investment	**Large and decreasing:** €15.34 [31% on impact]
Employment	**Large and decreasing:** 306 jobs [23% on impact]
GDP	**Large and decreasing:** €16.54 [24% on impact]
Impact on the Public Budget	**Positive**
Labor Productivity	**Large:** 0.0579
Education Facilities	
Private investment	**Large and increasing:** €14.02 [68% on impact]
Employment	**Large and increasing:** 231 jobs [39% on impact]
GDP	**Large and increasing:** €10.04 [60% on impact]
Impact on the Public Budget	**Positive**
Labor Productivity	**Medium:** 0.0159

Table 28 Infrastructure Investments: Scoreboard of Effects - Public Utilities

Water and Wastewater Infrastructures	
Private investment	**Small and decreasing:** €4.47 [34% on impact]
Employment	**Medium and decreasing:** 108 [68% on impact]
GDP	**Small and decreasing:** €4.80 [44% on impact]
Impact on the Public Budget	**Neutral**
Labor Productivity	**Medium:** 0.0115
Electricity and Gas Infrastructures	
Private investment	**Small and decreasing:** €0.51 [78% on impact]
Employment	**Small and decreasing:** 9 jobs [100% on impact]
GDP	**Small and decreasing:** €0.40 [88% on impact]
Impact on the Public Budget	**Negative**
Labor Productivity	**Small:** 0.002
Petroleum Refining Infrastructures	
Private investment	**Small and stable:** €2.04 [2% on impact]
Employment	**Small and stable:** 54 jobs [12% on impact]
GDP	**Small and stable:** €3.05 [13% on impact]
Impact on the Public Budget	**Neutral**
Labor Productivity	**Small:** 0.0034
Telecommunications Infrastructures	
Private investment	**Medium and stable:** €8.60 [40% on impact]
Employment	**Medium and stable:** 164 jobs [12% on impact]
GDP	**Large and stable:** €10.70 [41% on impact]
Impact on the Public Budget	**Positive**
Labor Productivity	**Large:** 0.0412

Figure 1 Accumulated Impulse Response Functions – Road Transportation

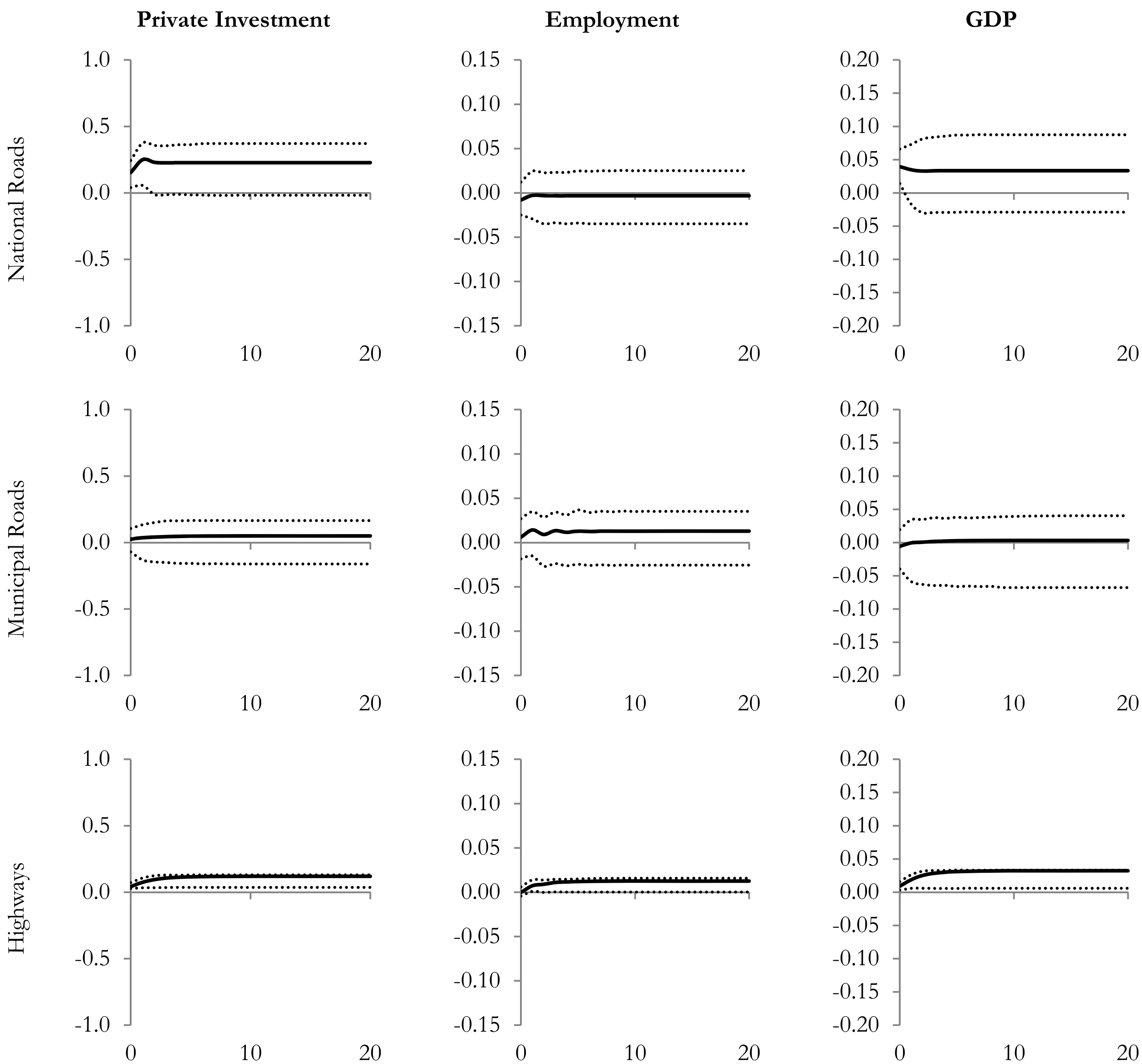

Figure 2 Accumulated Impulse Response Functions – Other Transportation

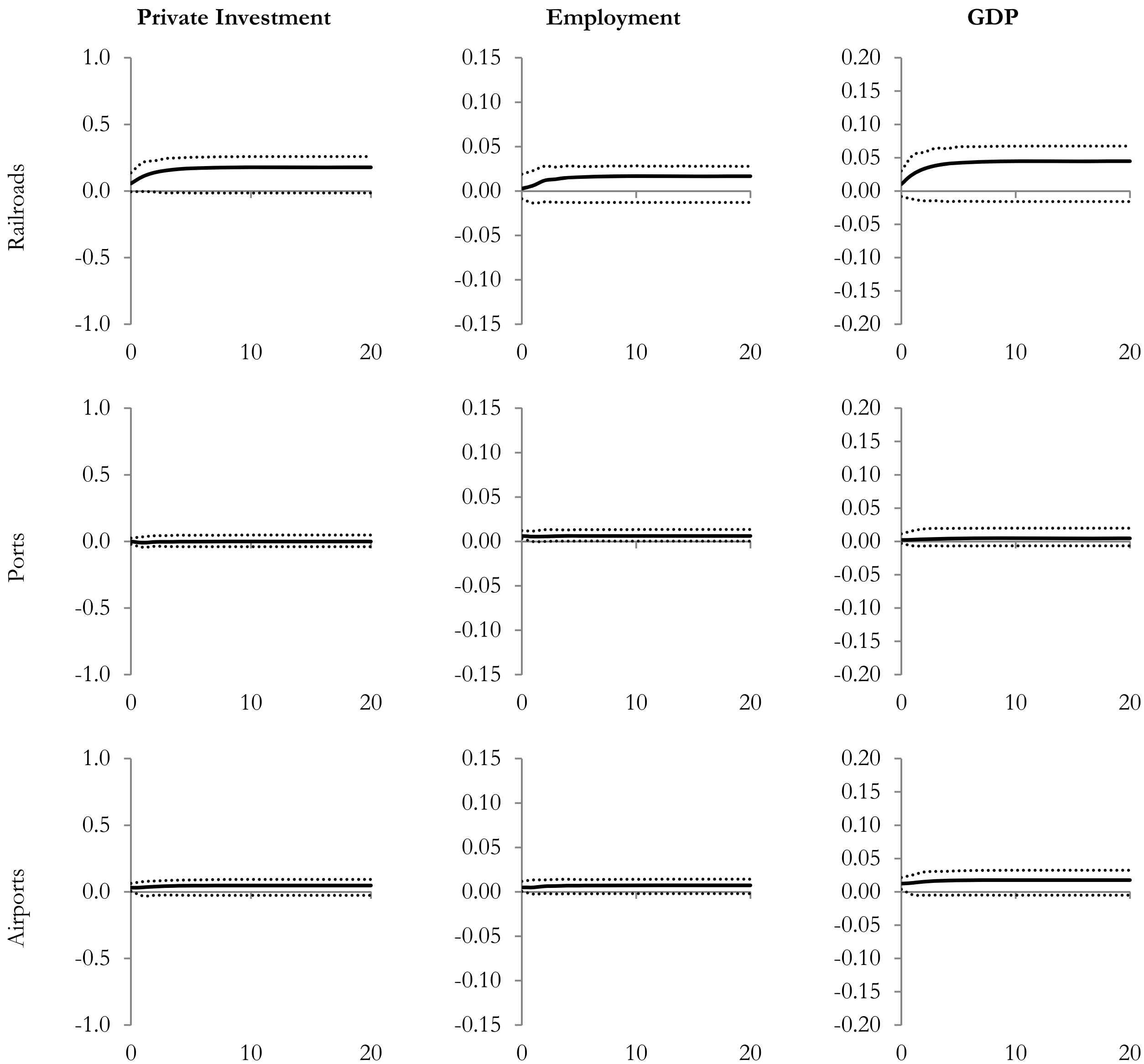

Figure 3 Accumulated Impulse Response Functions – Social Infrastructures

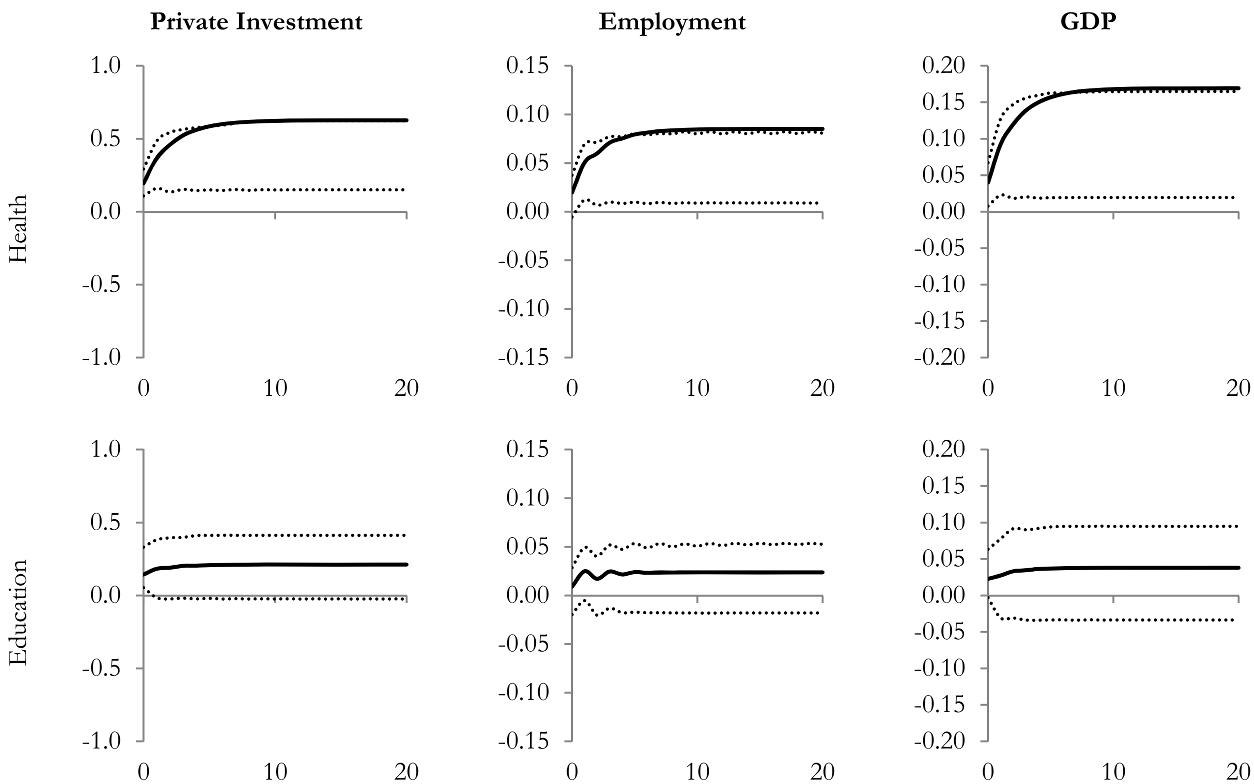

Figure 4 Accumulated Impulse Response Functions – Public Utilities

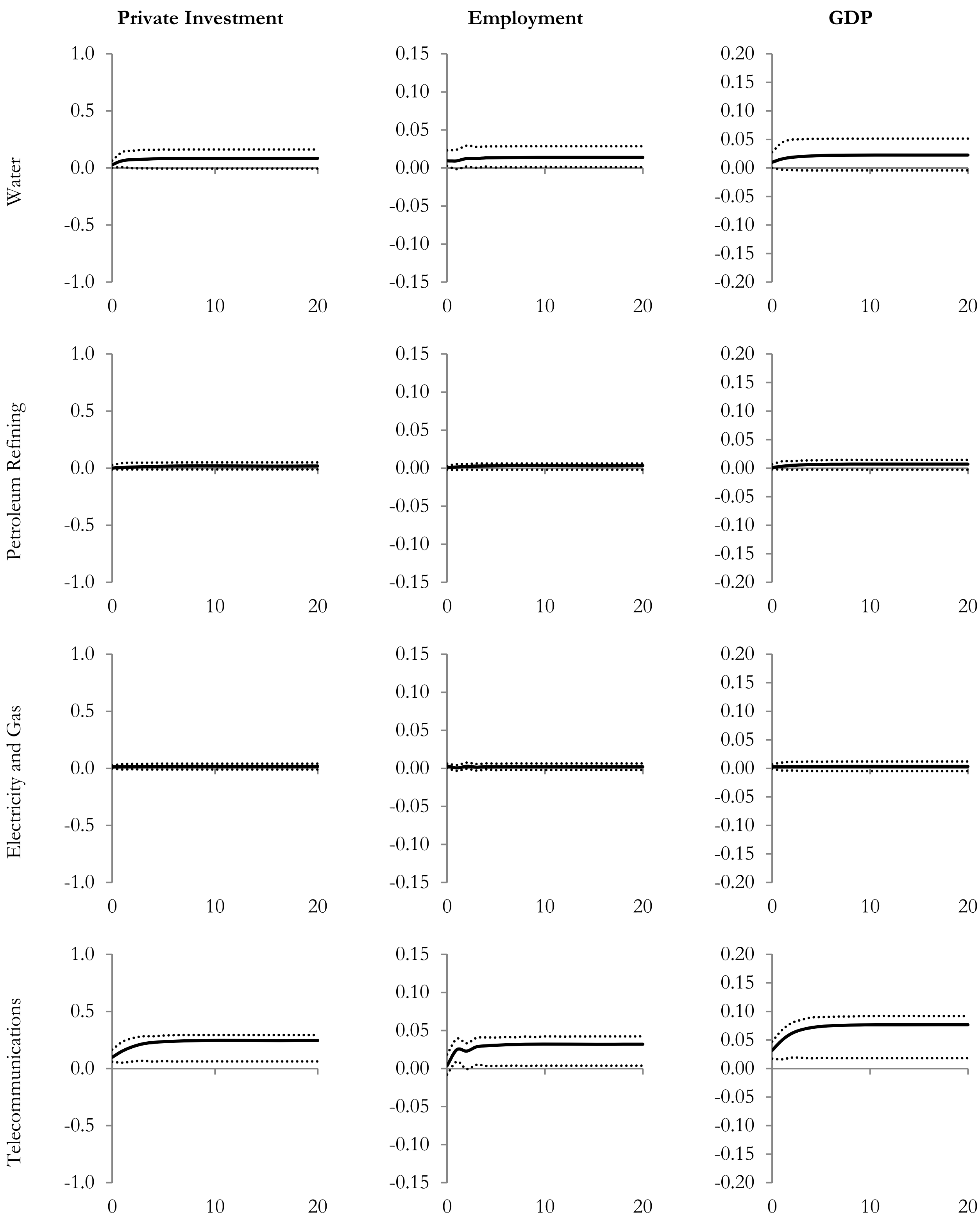

Figure 5 Effect of Infrastructure Investment on Labor Productivity

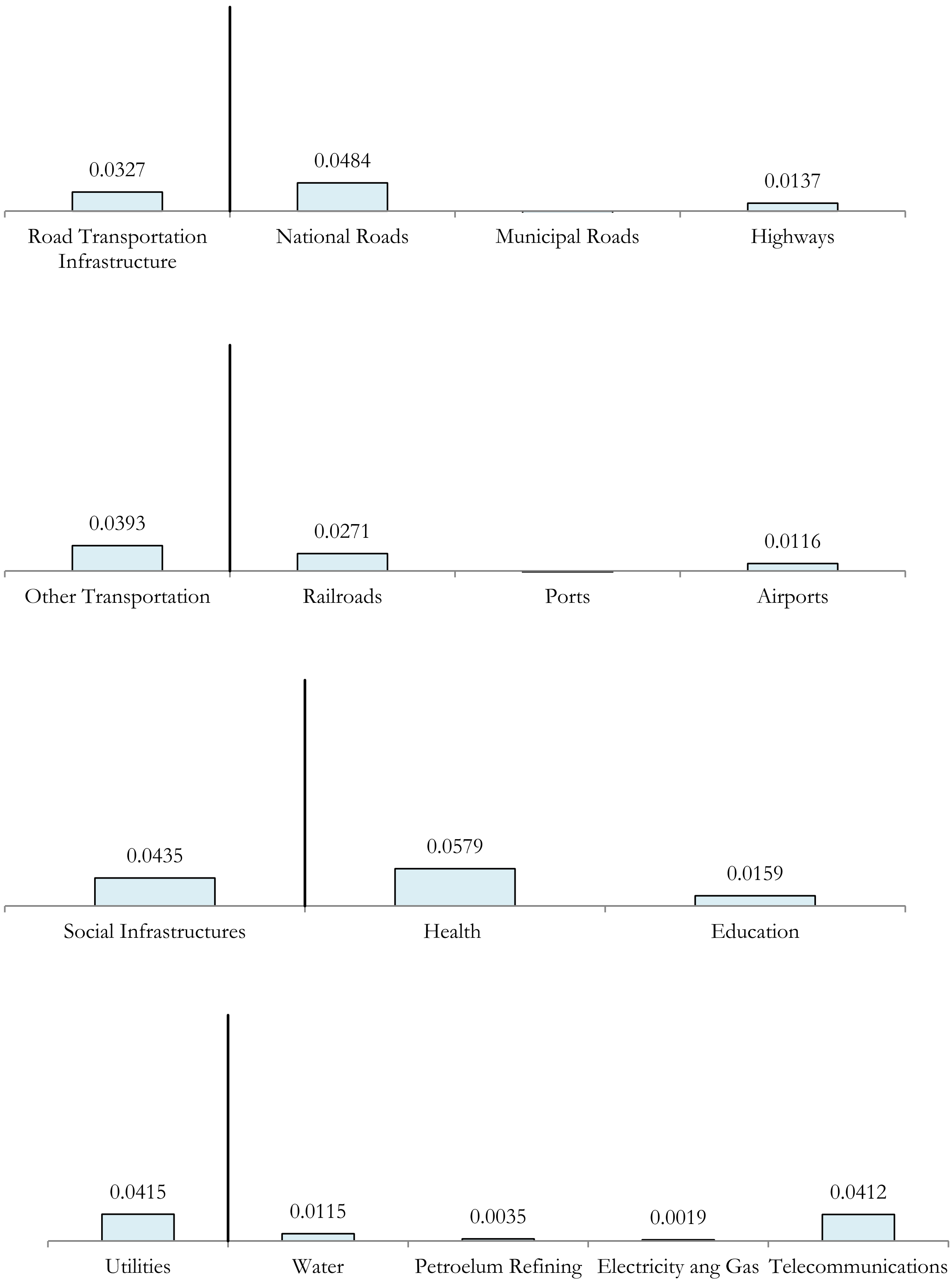

Figure 6 Long-Term Marginal Products of Infrastructure Investment – Road Transportation

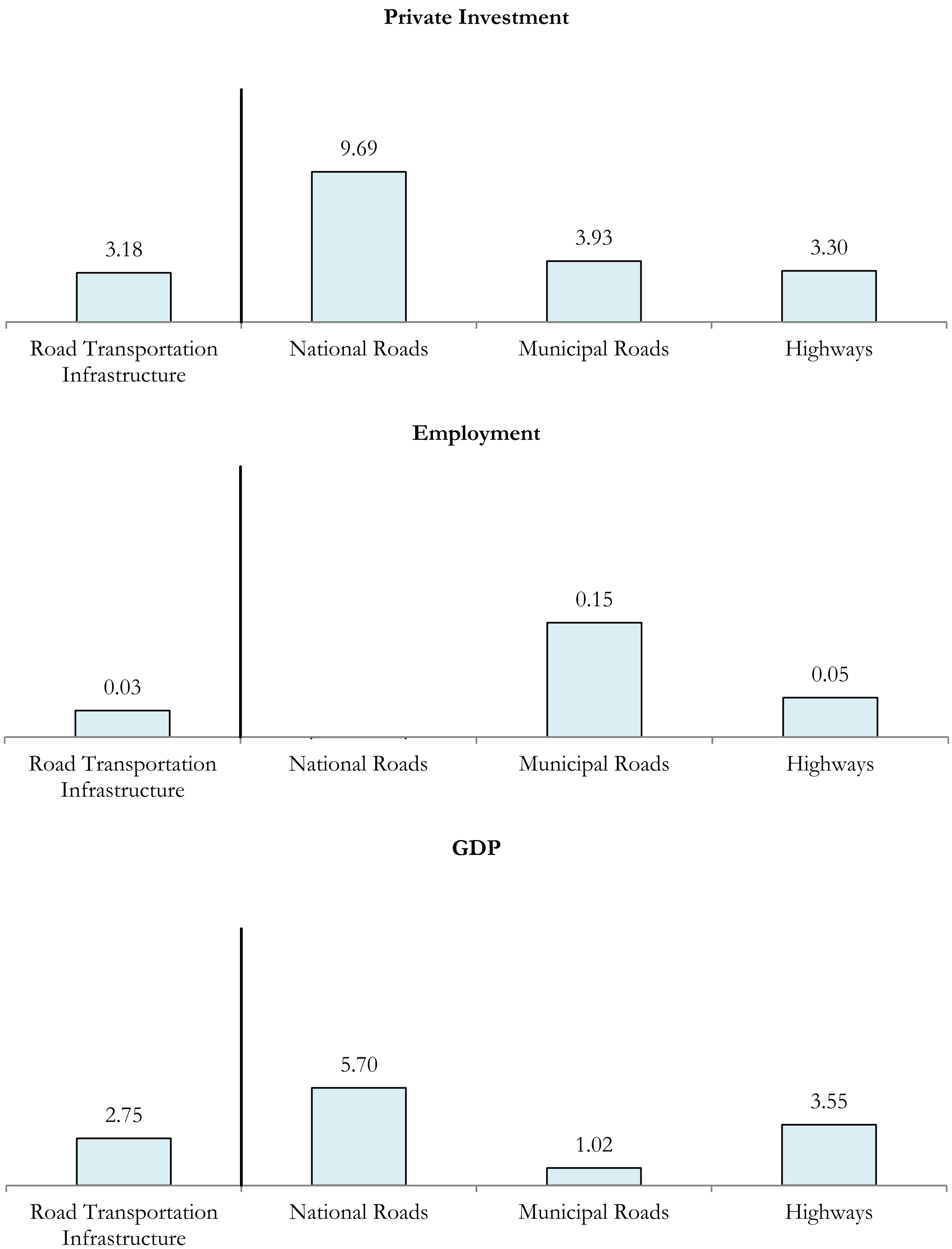

Figure 7 Long-Term Marginal Products of Infrastructure Investment – Other Transportation

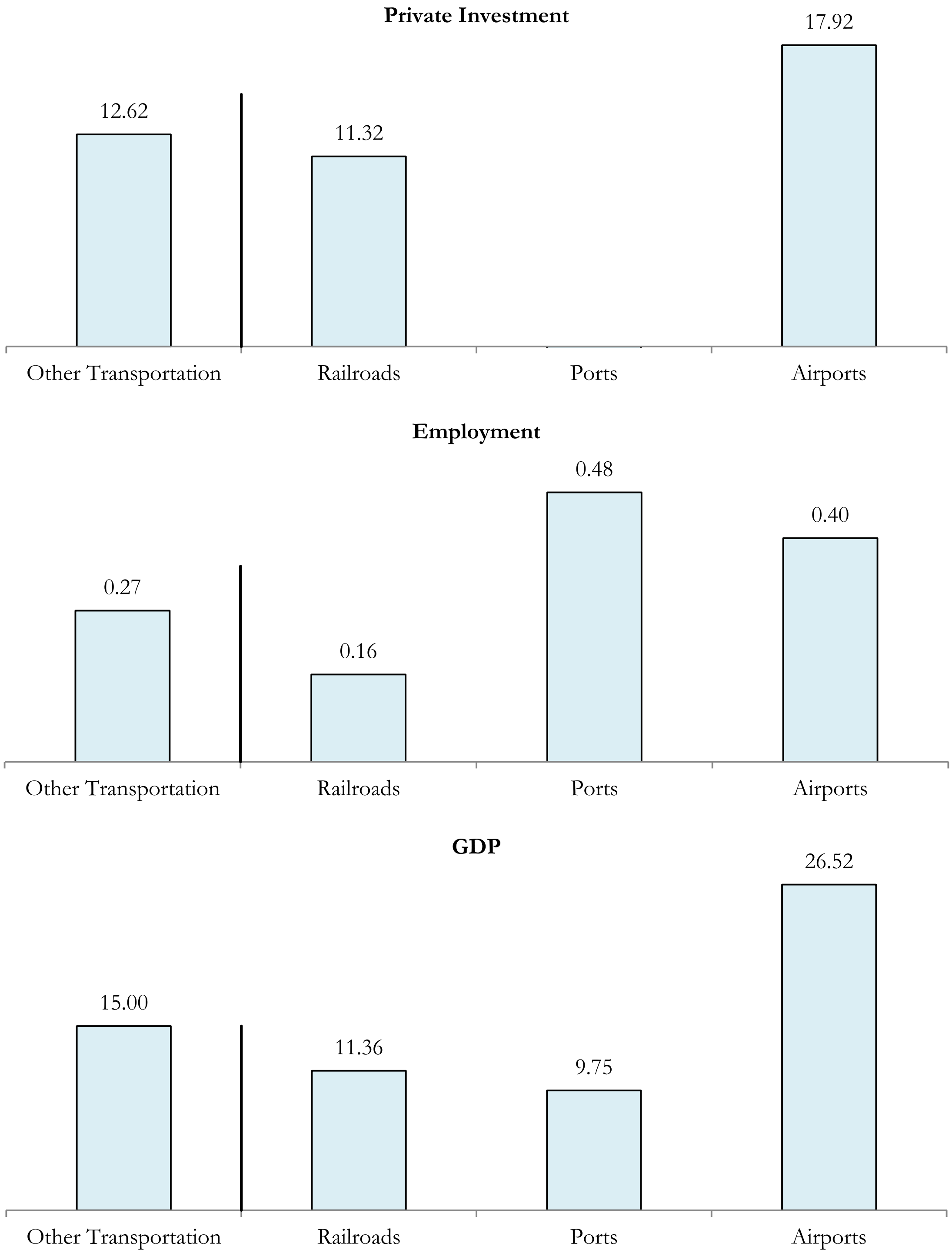

Figure 8 Long-Term Marginal Products of Infrastructure Investment – Social Infrastructure

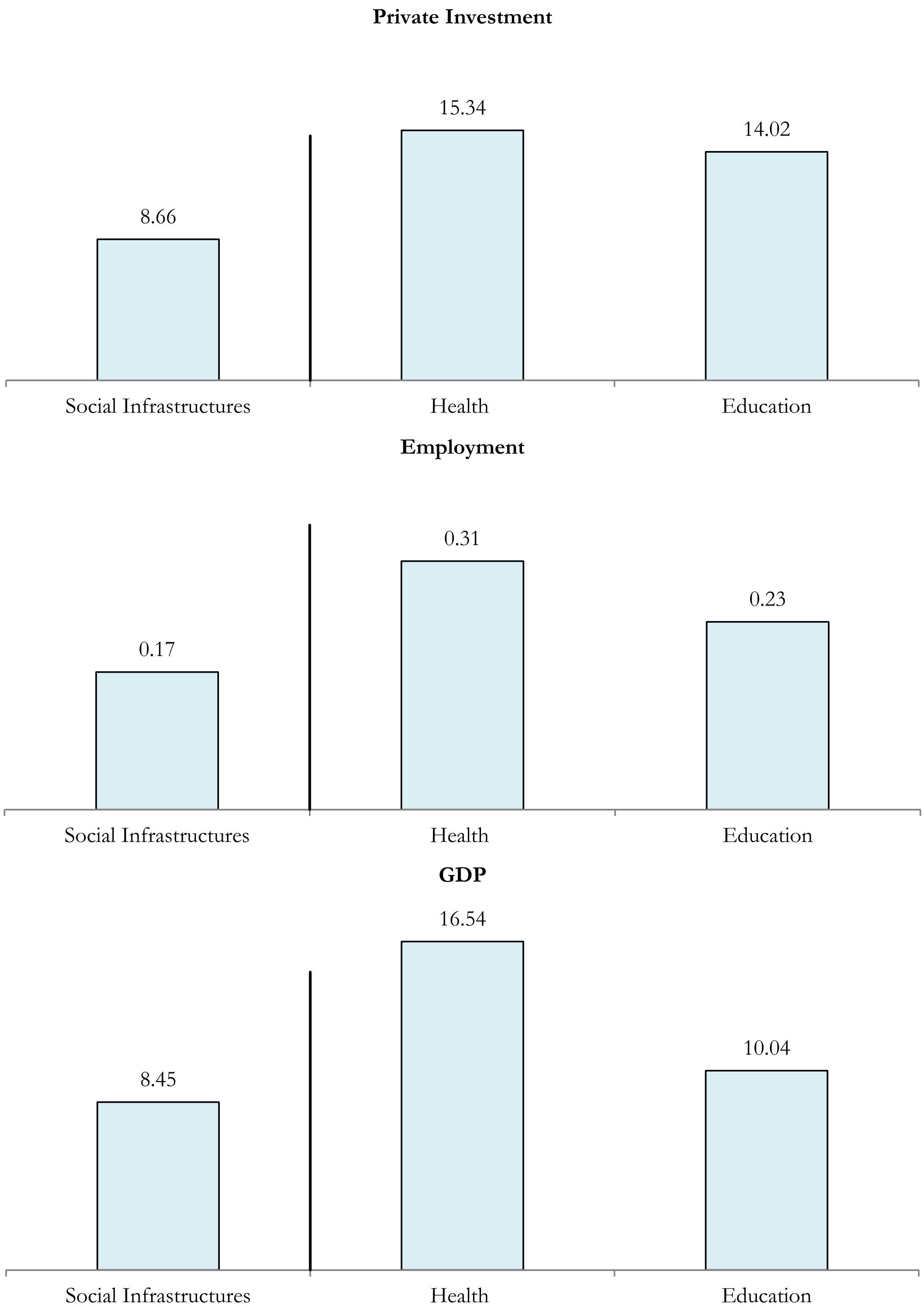

Figure 9 Long-Term Marginal Products of Infrastructure Investment – Public Utilities

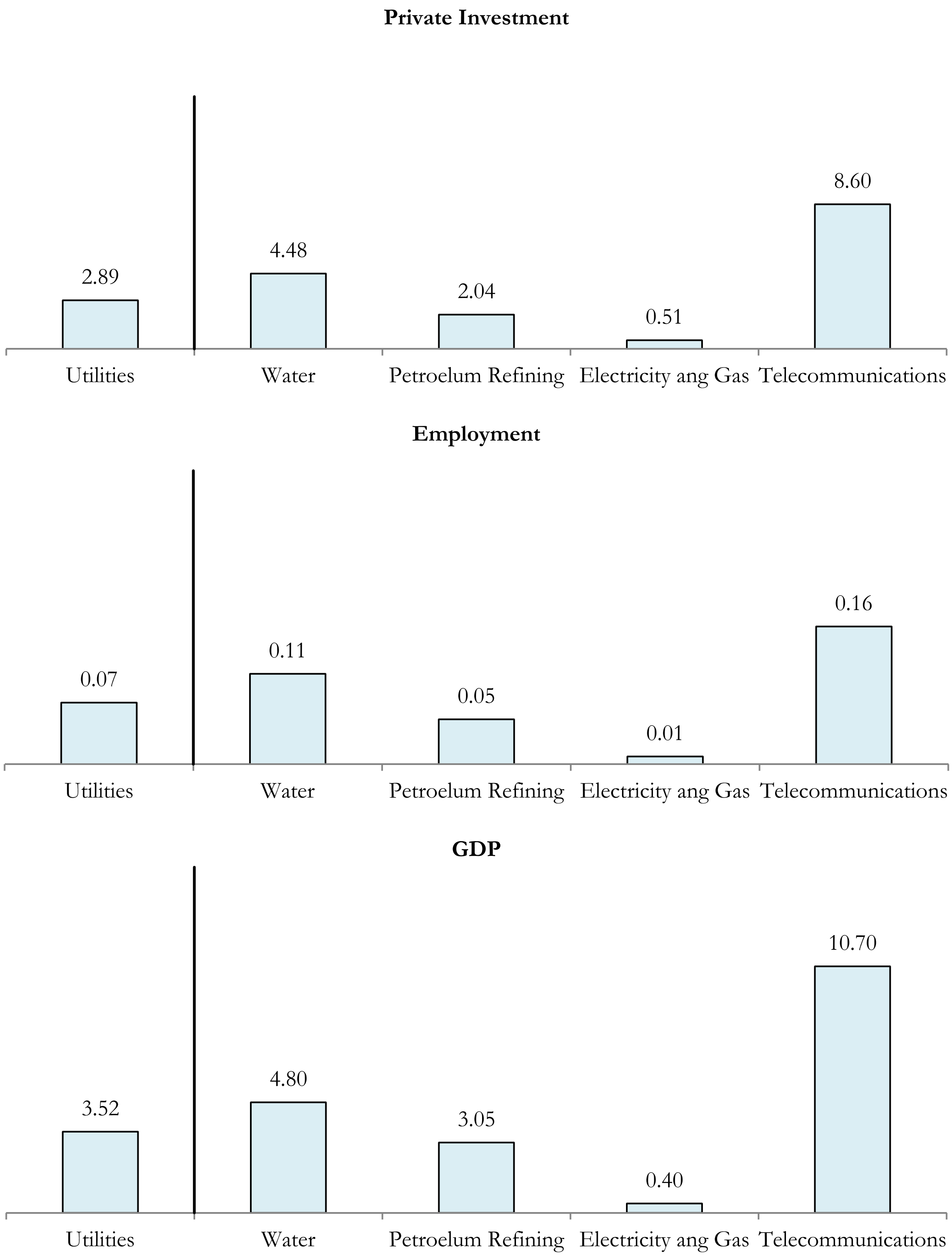

Figure 10 Evolution of the Marginal Products – Road Transportation

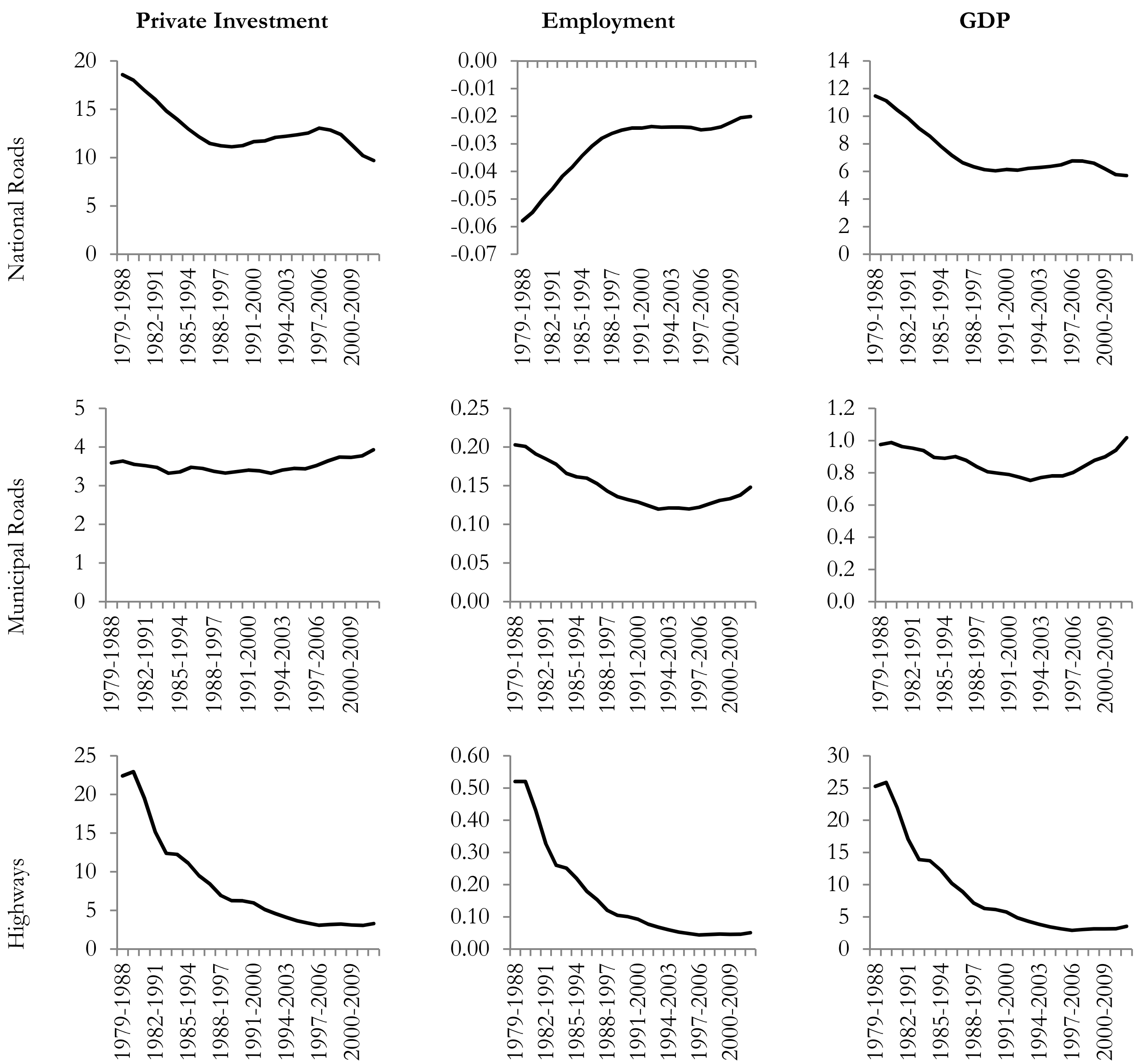

Figure 11 Evolution of the Marginal Products – Other Transportation

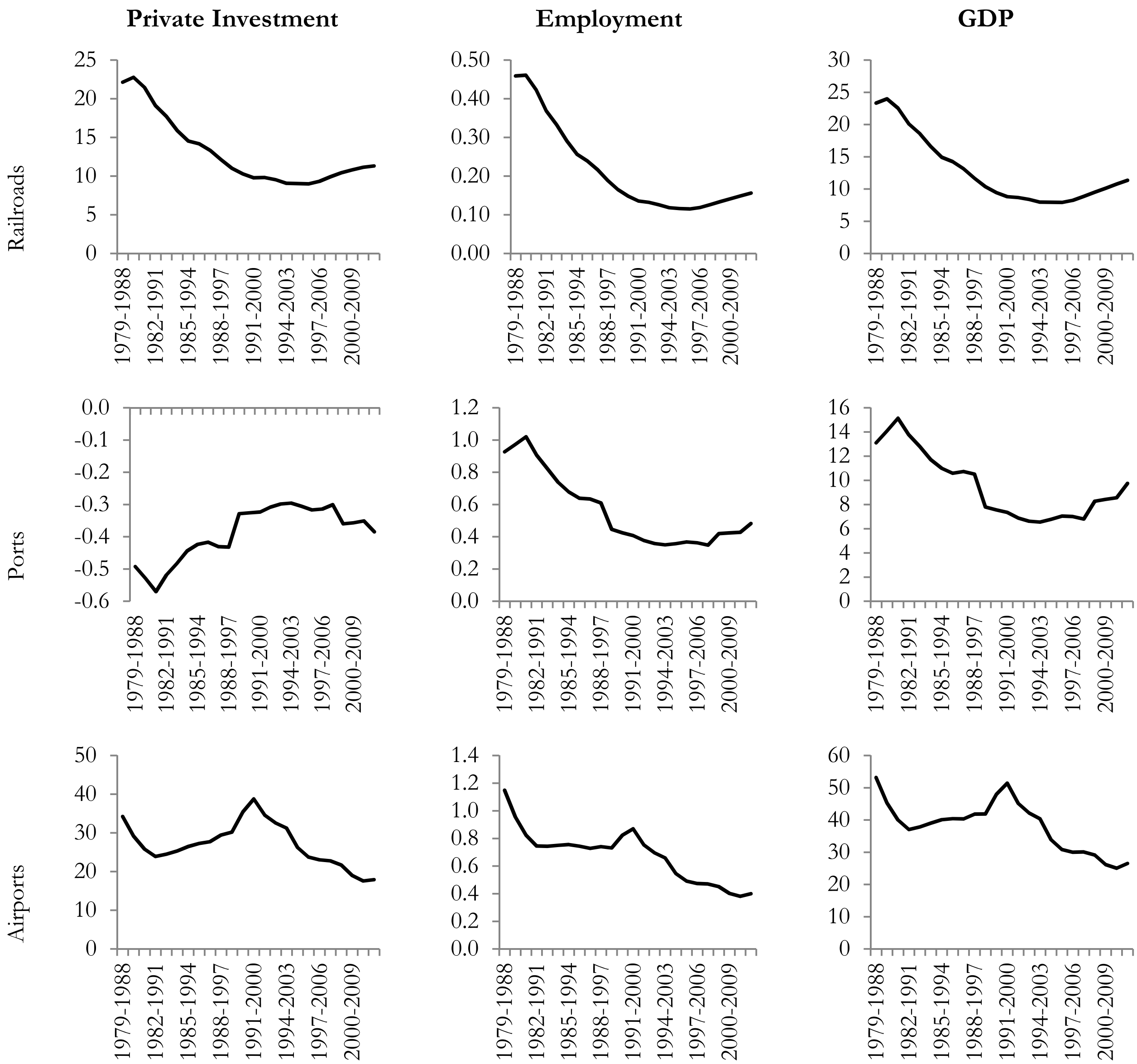

Figure 12 Evolution of the Marginal Products – Social Infrastructures

Figure 13 Evolution of the Marginal Products – Public Utilities