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Why Virtuous Supply-Side Effects and Irrelevant Keynesian Effects are not Foregone Conclusions: What we Learn from an Industry-Level Analysis of Infrastructure Investments in Portugal [1]

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Abstract

We use the industry-specific effects of twelve different infrastructure investments in Portugal to inform about the mechanisms through which such investments affect economic activity. Our main findings are as follows. First, demand-side effects that are approximated by adding the short-term and long-term construction effects are very important. They are over 60% of total effects for airport investments, ports, refineries, and water, and over 45% for national roads, municipal roads, telecommunications, health and education. Second, site-location effects that are approximated by real-estate effects are also very significant, in particular for national roads, highways and railroads, with 30%, 35% and 64% of the total effects, respectively. They are negative for water and electricity, and zero for municipal roads, airports, and refineries, and negligible for ports, i.e., all these are cases in which we would expect adverse or small location effects. Third, the functional channel relating to internationally-traded goods, approximated by the effects on the primary sector, on manufacturing, and on transportation, is much less significant, although we estimate meaningful effects on heavy industry from investments in all types of road infrastructures, ports, health, and education, as well as on light industry from ports. Fourth, a functional effect affecting non-traded industries, mostly private and public services is much more relevant. It accounts for more than 30% of the effects in the cases of municipal roads, airports, and refineries, and in excess of 20% for highways, railroads, telecommunications, health and education. The fact that most functional effects accrue to non-traded industries is likely to affect international competitiveness adversely. Naturally, these results cannot be automatically generalized, as the nature of the effects of infrastructure investments crucially depends on the level of development of the country in question, on the maturity of its existent infrastructure systems, and on the rigor of all decisions pertaining to infrastructure investment. Nevertheless, they establish that, as infrastructure investments are concerned, the dominance of virtuous supply side effects is not a foregone conclusion and, conversely, the relevance of Keynesian effects cannot be dismissed.

JEL Classification: C32, E22, H54, L90, L98, O52.

Keywords: Infrastructure investment, Output, Industry-level, Supply-side effects; Demand-side effects, Vector-autoregressive, Portugal.

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1. Introduction

In a long bygone time, infrastructure investments were popular, mainly for their demand-side effects. For the old Keynesian view espousing a short-term demand-side paradigm, the point was to get people back to work and boost income. More recently, however, infrastructure investments gained attention mostly for their supply-side long-term credentials. In the aftermath of the seminal work of Aschauer (1989a, 1989b), public capital was brought to the limelight as a determining contribution to long-term economic performance. The body of empirical literature that followed is rather extensive [see, for example, Munnell (1992), Gramlich (1994), Kamps (2005), Romp and de Haan (2007), Pereira and Andraz (2013), and Bom and Ligthart (2014) for literature surveys]. This literature has invariably assumed that the estimated effects of infrastructure investments were to be understood as long-term supply-side effects.[3]

The view of the effects of infrastructure investments as important, primarily for their long-term supply-side effects has also been clearly present at the policy level. A prime example, directly pertinent to the Portuguese case, is the structural-policy programs of the European Union. Being aware of the glaring and persistent differences in standards of living among member-states, a comprehensive set of development programs was put in place. These programs were targeted at addressing the bottlenecks on the domestic fundamentals of long-term growth. A cornerstone of these programs was to provide, in the context of well-structured community frameworks, unilateral EU funds for infrastructure investments to cash-strapped economies such as Greece, Ireland, Portugal, and Spain. The ultimate objective was to promote the long-term international competitiveness and the long-term real convergence of these economies, i.e., to accelerate the process of converging to the average standards of living in the EU [see, for example, European Commission (1990)].

At this point, it is important to recognize that there is rather scant evidence on the actual relevance of the long-term demand-side effects, when compared to other potentially important channels through which infrastructure investments do affect economic performance. First, we would expect important demand-side short-term construction-related and construction-spillover effects. Second, we would expect maintenance and operation effects to be sizable too, also of a demand-side nature, but now appearing in the longer term. Third, we would naturally expect long-term supply-side effects. But these can come in different flavors, with rather different policy implications. Aside from effects on primary sector industries, on manufacturing, or on transportation, which are mostly traded goods, we have the possibility of great impact on services, as well as an impact through site-location mechanisms, which are unrelated to goods that are internationally traded. Overall, the existence of important demand-side effects opens the door to the consideration of the countercyclical potential of infrastructure investments. In turn, the existence of important supply-side effects is relevant for long-term growth. Which type of supply-side effects dominates has implications both for international competitiveness and for the development model that is adopted.

Considering these different channels is important to understand the industry-by-industry incidence of the effects of infrastructure investments. More importantly from our perspective, the type of industry-specific effects we observe, offers information as to the relative relevance of these different channels. Indeed, in this article, we provide empirical evidence on the effects of different types of infrastructure investments at the industry level in Portugal. We are interested in identifying how much of these effects is short term and how much is long term; how much is demand

[3] This view was greatly bolstered by the endogenous-growth literature that developed alongside. See, for example, Barro (1990), Futagami et al. (1993), Glomm and Ravikumar (1997), and Greiner and Hanush (1998).

side and how much is supply side; how much of the supply-side effects relates to internationally-traded goods, and how much is in goods that are not internationally traded; or how much is related to location effects.

Portugal engaged in a very significant infrastructure development effort over the last two decades of the twentieth century, as well as in the first ten years of the twenty-first. Over this time period, infrastructure investments averaged 4.2% of GDP. This effort was undertaken in direct connection with successive Community Support Frameworks for Portugal, the legal framework of the EU structural policies. These programs began in 1989 and continue until today, although with diminished significance after the late 2000s. The infrastructure-investment component of these programs averaged an annual 2.2% of GDP for the period 1989-2006, of which around 1.2% of GDP were EU unilateral structural transfers for infrastructure investments [see Pereira (2013)].

Although these facts make the Portuguese case an interesting case study, its actual empirical analysis is made possible by the recent publication of a rather comprehensive data set on infrastructure investments in Portugal for the period 1978-2011 [see Pereira and Pereira (2016)].[4] This data set includes information on twelve different types of infrastructure investments: national roads, municipal roads, highways, railroads, airports, ports, education, health, water and waste, electricity, refineries and telecommunications.

In this article, we use a multivariate dynamic time series approach, based on the use of industry-infrastructure specific vector-autoregressive (VAR) models including industry-specific output, employment, and private investment, in addition to each of the different types of infrastructure investments. We consider investments in twelve different infrastructure assets and in twenty-two industries that, together, span the whole spectrum of economic activity. This approach was developed in Pereira and Flores (1999) and Pereira (2000, 2001), and was subsequently applied to the US in Pereira and Andraz (2003, 2004), and to Portugal in Pereira and Andraz (2005, 2007, 2011). This econometric approach highlights the dynamic and simultaneous nature of the relationship between infrastructure investments and the rest of the economy. It accounts for such dynamic interactions in all relevant time frames: contemporaneously, over time, and in the long-term.[5]

To conclude, the relevance and timeliness of these issues should be highlighted. The quest for policies that promote long-term growth in a framework of fragile public budgets is widespread, and the role of infrastructure investments in this quest is becoming increasingly recognized. Among the international organizations there has been, in recent years, a remarkable renewal of interest in issues relating to public investment and, in particular, to infrastructure investments [see, for example, Council of Economic Advisers (2016), European Central Bank (2016), European Commission (2014a, 2014b, 2016), IMF (2014, 2015), and World Bank (2016, 2017)]. Naturally, a clear idea about the relevance of different mechanisms, short-term and long-term, demand-side or supply-side, functional channels that affect traded or non-traded industries, or the relevance of site location effects, is of the utmost important for the design and implementation of such future efforts.

The remainder of this article proceeds as follows. Section 2 presents the infrastructure investment and the industry-specific economic data. Section 3 exhibits preliminary econometric results. Section 4 presents in detail a

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

[5] This work is also related to the literature on fiscal multipliers, i.e., on the macroeconomic effects of taxes and government purchases [see, for example, Baunsgaard et al. (2014) and Ramey (2011), for recent surveys of this literature]. In fact, it is very much in the spirit of the approach pioneered by Blanchard and Perotti (2002), which is based on a VAR approach and uses the Choleski decomposition to identify government spending shocks. We focus, however, on a specific type of public spending – infrastructure investment – as opposed to aggregate spending, as is traditional in this literature. In this sense, our focus of this article is closer to Leduc and Wilson (2012).

discussion of the different mechanisms though which infrastructure investments affect economic performance, as well as the industry level results and their implications for this matter. Section 5 concludes with a summary and a few policy implications.

2. Data Sources and Description

2.1 The Infrastructure Investment Data Set

The data for infrastructure investment are from a new data set developed by Pereira and Pereira (2016), and covers the period between 1978 and 2011. Infrastructure investment is measured in millions of 2005 euros. We consider infrastructure investment in twelve individual types of infrastructures, which can be grouped in five main categories: road transportation infrastructure, other transportation infrastructure, social infrastructures, and utilities infrastructure. Table 1 presents some summary information for infrastructure investment effort, measured as a percent of GDP, as well as a percent of total infrastructure investment.

Road transportation infrastructures include national roads, municipal roads and highways, and account for 28.2% of total infrastructure investment over 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 significant increase in highway investments. In absolute terms, this corresponds to an increase from 0.75% of GDP in the 1980s to 1.56% in the last decade of the sample period.

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 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 investments.

Other transportation infrastructures include railroads, airports and ports, and account for 9% of total infrastructure investment. These investments reached their apex in the nineties with the modernization of the railroad network and port expansion projects, while the last ten years also saw substantial growth in investment in airports. In absolute terms, this reflects an increase from 0.22% of GDP in the 1980s to 0.48% in the last decade of the sample period.

Railroads represent the bulk, nearly 75%, of investment in other transportation infrastructures. Investment in railroad infrastructures amounted to 0.34% of GDP over the sample period, reaching 0.45% of GDP during the 1990s. Investment in ports and airports represented relatively smaller investment volumes due to the rather limited number of major airports and major ports in the country. Nonetheless, very substantial investments in the airports of Lisbon and Porto were undertaken in the last decade with investment volumes reaching 0.08% of GDP, nearly double that seen in the 1980s.

Public utilities include electricity and gas infrastructures, water supply and treatment facilities, and petroleum-refining plants, and account for 25.72% of total infrastructure investment in the sample period. Investment in public utilities reached a high level in the 1980s, driven by substantial investment in coal powered power plants and in refineries. More recently, investments in renewable energies and natural gas network have contributed to sustained growth in investment in utilities. In absolute terms, the importance of these investments increases from 0.94% of GDP in the eighties to 1.78% in the last decade.

Investment in electricity and gas infrastructures, the most important of the public utility assets in terms of the investment effort, averaged 0.73% of GDP or 14.34% of total infrastructure investment. In the 2000s, it reached 1.09% of GDP, and accounted for 17.53% of total infrastructure investment. In turn, water and waste-water investments averaged 0.37% of GDP or 6.80% of total investment for the period with a clear increasing trend while investments in refineries averaged 0.22% of GDP or 4.58% of total investment with a declining trend over the last two decades.

Finally, investments in **telecommunications** amounted to 0.67% of GDP, or 13.34% of total investment over the sample period. In the nineties, with the expansion of mobile communications networks, they reached their peak with 0.85% of GDP, accounting for 16.12% of total infrastructure investments.

Social infrastructures include health facilities and educational buildings, and account for 23.8% of infrastructure investment. These investments showed a slowly declining pattern over time in terms of their relative importance in total infrastructure investment. In absolute terms, however, they remained stable over the last two decades representing just over 1% of GDP.

Investment in health facilities amounted to 0.55% of GDP, or 10.7% of total investment, while investment in educational facilities amounted to 0.60% of GDP, or 13.1% of overall investment. While both are comparable in terms of their relative magnitude over the sample period, their evolution was markedly different. Investment in health facilities increased steadily, both as a percent of GDP and as a percent of total infrastructure investment, the opposite being the case in general terms for investment in educational buildings. Indeed, investment in educational facilities reached their highest level in the nineties with 0.73% of GDP, while investment in health facilities reached its greatest volumes in the last decade with 0.75% of GDP.

Overall, infrastructure investments grew substantially over the past thirty years, averaging 2.92% of 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 in the context of the EU Structural and Cohesion Funds, with the Community Support Framework I (1989-1993) and the Community Support Framework II (1994-1999). The infrastructure investment effort decelerated somewhat during the Community Support Framework III (2000-2006) and more significantly with the QREN (2007-2013). These landmark dates for joining the EU, as well as the start of the different community support frameworks, are all considered as potential candidates for structural breaks in every single step of the empirical analysis that follows.

2.2 The Industry Data Set

The data on industry-specific output, employment, and private investment are obtained from different annual issues of the National Accounts published by National Institute of Statistics and available on-line at http://www.ine.pt. Output and private investment are measured in millions of constant 2005 Euros, while employment is measured in thousands of employees.

We consider twenty-two industries divided in four main groups. The different industries are grouped into two primary industries (agriculture and mining), seven manufacturing (food, textiles, paper, chemical and pharmaceutical, non-metallic minerals, metallic, and machinery), ten private-services industries (electricity, water, construction, trade, transportation, hospitality, telecommunications, finance, real estate, and professional services) and three public-services industries (administration, health and education). In Table 2 we include details on the definition of the different sectors.

Summary statistics on the industry mix during the sample period are provided in Table 3. The output share of the primary and the manufacturing sectors declined sharply over the sample period. The primary sector was 14.1% of output in the 1980s, and declined to 3.4% in the last decade. The manufacturing sector, declined from 20.5% to 15.1%. The transportation industry declined in the 1990s, but has somewhat rebound over the last decade. Overall, the industries producing traded goods declined from 39.8% of output in the 1980s to 23.1% in the last decade, a decline that would be more pronounced, were it not for the small increase in the relative role of transportation and storage services over the last two decades. Private services, net of transportation, increased slightly from 47.5% of output in the 1980s to 55.7% in the last decade, led by a large increase in the role of professional services. The large increase over the sample period was in public services, which rose from 12.8% in the 1980s to 21.2% in the last decade, a change due to large increases in all of its components.

We use the share of exports in the sector output over the last decade to identify the sectors producing internationally-traded goods and those which do not. We define ten industries – the two primary industries, the seven manufacturing industries, and the transportation industry (S14) as comprising the traded-goods sectors. The remaining nine private service industries, as well as the three public service industries are defined as non-traded.

3. Preliminary Data Analysis [6]

3.1. Unit Roots, Cointegration, and VAR specification

We start with unit root and cointegration analyses. Having determined that stationarity seems to be a good approximation for all series, and in the absence of any evidence for cointegration, we 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 twenty-two industries, one for each of the different infrastructure types, for a total of two-hundred-and-sixty-four models. Each VAR model includes industry-specific output, employment, and private investment, as well as the relevant infrastructure-investment variable. We use the BIC to determine structural breaks and deterministic components to be included. Our test results suggest that a VAR specification of first order with a constant and a trend, as well as structural breaks in 1989, 1994, and 2000, the years of the inception of the first three community support frameworks, is the preferred choice in the overwhelming majority of the cases.

3.2. Identifying Exogenous Innovations in Infrastructure Investment

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

The identification of exogenous shocks to infrastructure investment would, in general, result from knowing what fraction of the government appropriations in each period is due to purely non-economic reasons. The econometric counterpart to this idea is to consider a policy function which relates the rate of growth of infrastructure investment to

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

the relevant information set. The residuals from these policy functions reflect the unexpected component of the evolution of infrastructure investment and are, by definition, uncorrelated with innovations in other variables.

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

We have two conceptual reasons for this assumption. First, it seems reasonable to assume that the economy reacts within a year to innovations in infrastructure investments. Second, it also seems reasonable to assume that the public sector is unable to adjust infrastructure investment decisions to innovations in the economic variables within the same year. This is due to the time lags involved in information gathering and public decision making.

Furthermore, this assumption is reasonable also from a statistical perspective. Invariably, the policy functions point to the exogeneity of the innovations in infrastructure investment, i.e., the evolution of the different infrastructure investments does not seem to be affected by the lagged evolution of the remaining variables. This is to be expected because infrastructure investments were very much linked to EU support programs and therefore not responsive to the ongoing economic conditions. Moreover, we would not expect any single economic sector to have an impact on decision making for infrastructure investments at the national level.

3.3. Measuring the Effects of Innovations in Infrastructure Investment

To measure the effects of a one-percentage point, one-time shock in the rates of growth of the different types of infrastructure investment on output for the different industries, we estimate the accumulated impulse-response functions for each of the VAR models. The accumulated impulse response functions typically converge within a relatively short time period. The error bands surrounding the point estimates for the accumulated impulse responses are computed via bootstrapping methods. We consider 90% intervals, although bands that correspond to a 68% posterior probability are the standard in the literature [see Sims and Zha (1999)]. From a practical perspective, when the 90% error bands for the accumulated impulse response functions include zero we consider that the effects are not significantly different from zero.[7]

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

The total long-term accumulated elasticities are to be interpreted as the total accumulated percentage-point long-term change in output per one-percentage point accumulated long-term change in infrastructure investment. In turn, the total long-term accumulated marginal products measure the monetary change output for each additional euro of investment in infrastructures. The marginal products are obtained by multiplying the average output to infrastructure investment ratio by the corresponding elasticity. We use the average ratio over the last ten years of the sample. Using a recent time period allows the marginal products to reflect the relative scarcity of the different types of

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

infrastructures at the margin of the sample period, while the choice of ten years prevents these ratios from being overly affected by business cycle factors.

4. On the Effects of Infrastructure Investments

4.1 Preliminary Conceptual Remarks

To help frame the effects of infrastructure investments, it is useful to understand the different mechanisms through which these investments and the related assets affect economic performance. In general terms, infrastructures either fall in the public goods category or are considered production externalities – i.e., they provide services that, although being necessary for private sector activity, would not be available or would be in short supply if totally left to the initiative of the private sector. As such, their provision is either public or done through close public tutelage. For some assets, such as public utilities and telecommunications, technological advances and the evolution of the domestic and international markets has led to a fully private provision.

In this context, we can see infrastructure investments and the assets they generate affecting economic activity through different channels, each with a rather different impact on what one would expect in terms of the industry-specific incidence of the effects. First, there is what we could call a "**functional channel**". Infrastructures fulfill a role as production inputs, directly relevant for the activity in question. Transportation services for example, need a good road or other transportation network, while industries that are either more labor intensive or alternatively rely more on skilled labor, such as finance, telecommunications or professional services, will have their productivity affected directly by the network of social infrastructures. The effects of infrastructure investments are going to ultimately depend on the direct relevance of the infrastructure as an additional input to production as well as on the nature of the relationship between infrastructure and private inputs – labor and private capital. This is, therefore, essentially a supply-side channel. To make the discussion more meaningful, we will differentiate between a functional channel of effects on the primary sector, manufacturing and transportation, which are goods that are internationally traded and a functional channel relating to different types of private and public services, which are goods that are not traded internationally. While the functional channel is the most recognized – and, often, the only recognized channel – it is neither the only channel, nor necessarily the most important one.

A second channel is what we could call the "**construction channel**". These investment projects inevitably use vast pools of resources, engaging the rest of the economy in the process itself of constructing these assets. Making available a road, or a port, a hospital or a waste management facility, directly engages the construction industry and, through it, the rest of the economy, including different types of manufacturing, but also services such as finance and professional services. These are demand-side effects that, although reverberating throughout the economy, are expected to be short-lived.

A third channel through which infrastructures affect economic performance is the "**maintenance and operation channel**". Operating and maintaining existing infrastructures creates needs for use of resources – goods and services, as well as specialized labor. Although again to different extents, the need for maintenance applies to all types of infrastructures. It represents a more or less permanent need for the engagement of the construction and related industries. In turn, while the effects of the economic effort involved in operation a road infrastructures, for example, could easily be neglected, the same cannot be said about operating a port, an airport, a hospital or a school. This is also a demand-side effect but, unlike the previous one, it is more long lasting.

Finally, there is what we could call a "**location channel**". The existence of certain infrastructures, such as certain transportation infrastructures, schools, and hospitals, serve as an attractor for population and business. There could follow important effects, for example, for trade, hospitality and real estate. Naturally, the opposite is true for airports, waste and wastewater facilities or power plants and refineries which have a negative effect on the desirability of where they are located. This is also essentially a long-term supply-side channel, but different in nature from the functional channel. We consider this a separate channel as we are talking about an effect that is totally induced by the very presence of the infrastructure asset itself.

4.2 On the Total Long-term Effects of Infrastructure Investments

We start by considering the aggregate total long-term effects of the different types of infrastructure assets. These total aggregate effects are obtained as the sum of all statistically-significant sector-specific marginal products. See bottom row of Tables 4 to 7 for details. Broadly speaking we can divide the infrastructure assets in three groups in terms of the magnitude of their total long-term effects. First, we have a group of assets with high marginal products of around 20 euros. These are national roads, railroads, airports, ports, health and education. A second group has medium-size magnitude effects. These are municipal roads, highways, refineries, and telecommunication. Finally, we have water facilities and electricity and gas facilities, for which we estimate a negative marginal product. This reflects a great level of maturity of the water and electrical systems in the country already in the beginning of the sample period. Clearly, although there is a wide variety of results, the total long term effects of most of the infrastructure assets are sizable.

We now give a general overview of the industry-specific effects by type of infrastructure asset. Details are presented in Tables 4 to 7. In terms, of road infrastructure investments, we estimate the following effects. For investments in national roads, machinery and equipment (S9), construction (S12), real estate (S18), professional services (S19) and education (S21) are the economic sectors that benefit the most, and concentrate 82.2% of the total long-term effects of this investment. For municipal roads, the greatest beneficiaries are basic metals (S8), construction (S12), trade (S13), hospitality (S15), and public administration (S20), which combine 94.7% of the total long-term effects. For investment in highways, 79.8% of the benefits go to construction (S12), finance (S17), real estate (S18), public administration (S20) and education (S21).

In terms of investments in other transportation infrastructures, the effects are as follows. For railroad investments, most of the benefits go for electricity (S10), construction (S12), trade (S13), real estate (S18), and public administration (S20), which together account for 110.7% of the benefits.[8] For airport investments, the most important effects are on electricity (S10), trade (S13), transportation (S14), hospitality (S15), and education (S21), which jointly account for 91% of the total effects. Finally, for investments in ports, the industries that benefit the most are trade (S13), hospitality (S15), finance (S17), real estate (S18), and professional services (S19), with a combined share of 64.3% of the total effect.

As utilities are concerned, as we noted that for investments in water and in electricity, the estimated effects are negative. In both cases, a very large fraction of such negative effects, 88.2% and 78.3%, respectively, come from adverse effects on two industries, hospitality (S15) and real estate (S18). For investments in refineries, the effects occur in construction (S12), trade (S13), professional services (S19), public administration (S20), and education

[8] It is worth pointing out that, since there are industries with negative effects, the most important positive effects may turn out to be greater than the total effects.

(S21) with 102.7% of the net total effects. In terms of investments in telecommunications, most of the effects go to construction (S12), trade (S13), finance (S17), real estate (S18), and professional services (S19).

Finally, in terms of investments in social infrastructures, we observe that the most important effects of health infrastructure investments are on machinery and equipment (S9), construction (S12), transportation (S14), real estate (S18), and professional services (S19), with 96.7% of the total, while the most important effects of education infrastructure investments occur in construction (S12), finance (S17), real estate (S18), professional services (S19), and public administration (S20) with 80.1%.

From this first discussion of the industry-specific results, two important conclusions follow. First, the effects of the different types of infrastructure assets tend to be highly concentrated in a small number of industries. Second, there are some industries that appear again and again, and therefore seem to particularly benefit, overall. These are primarily construction (S12) and real estate (S18), but also trade (S13), hospitality (S15), and professional services (S20), and to a lesser extent finance (S17) and education (S21). These are just seven among twenty-two industries.

4.3 On the Short-Term Effects of Infrastructure Investments

We start with an aggregate look at the decomposition of the short-term versus long-term effects by type of infrastructure asset. For each asset, the short-term effects are calculated as the sum across all industries of the statistically-significant marginal products on impact. See the bottom rows of Tables 8 and 9 for details. Among the six infrastructure assets with the highest marginal products, we see that for national roads, airports, ports, and education, the short-term effects are larger than 40% of the total long-term effects. For railroads and health, the short-term effects are just 15% and 28% of the total long-term effects. In turn, for the assets with middle-size effects, municipal roads, refineries, and telecommunications have short-term effects in excess of 40% and only highways have a short-term effect which is 29% of the total. Finally, for water and electricity, 59% and 31% of the negative effects occur in the short-term, respectively. Clearly, albeit to different degrees, the effects on impact are always sizable and cannot be ignored.

We now consider the issue from an industry-specific perspective, for each individual type of infrastructure investment. Details are presented in Tables 8 and 9. We start with road transportation infrastructures. For national roads, the industries more impacted in the short-term are machinery and equipment (S9), construction (S12), real estate (S18), professional services (S19), and education (S21). For municipal roads, only effects on trade (S13) and hospitality (S15) are important. It is worth highlighting, though, that there are relatively important short-term effects on light and heavy manufacturing, while the effects on the primary sector are negative, due to the fact that these roads are mostly rural. In turn, no short-term effect is of a meaningful magnitude for highway investments, the largest being construction (S12) and real estate (S18). Interesting as well for highways is the relative short-term importance of finance, directly related to the private financing of these investments.

As investments in other transportation infrastructure are concerned, for railroad infrastructures, construction (S12) and real estate (S18) are where the most important short-term effects appear, while, for investments in airports, the most important short-term effects are on electricity (S10), trade (S13), hospitality (S15), and finance (S17), and for investments in ports in construction (S12), trade (S13), hospitality (S15), finance (S17), and real estate (S18). To be noted, there is an interesting similarity between the short-term effects of airports and ports on trade, hospitality and finance, as well as with the fact that the effects of airports on real estate are not significant.

In terms of utilities, for investments in water and electricity infrastructures, the negative long- term effects are mirrored by negative short-term effects, although they tend to be dispersed, and are all of a small magnitude. For refineries, although the total long-term effects are positive, the short-term effects are also rather small and dominated by effects in construction (S12) and professional services (S19). For telecommunications, the most important short-term effects are in construction (S12) and real estate (S18) and to a lesser extent in trade (S13) and finance (S17).

Finally, for social infrastructures, the most important short-term effects for health investments accrue to construction (S12), transportation (S14), and real estate (S18), while for education they accrue to construction (S12), finance (S17) and professional services (S19).

The more disaggregated results paint a clear picture. Not only the short-term effects are important, but tend to be highly concentrated in construction (S12), as would be expected, as well as in real estate (S18), reflecting important immediate positive location externalities. This fits smoothly into the view that a good part of the effects of infrastructure investments are demand-induced and short-term in nature.

4.4 A Closer Look at the Longer-Term Effects of Infrastructure Investments

Having established the relevance of the short-term effects for each different type of infrastructure asset, we now focus on the longer-term effects at the industry-specific level. We define longer-term effects as the difference between the total long-term effects discussed in section 4.2, and the short-term effects discussed in section 4.3.

Detailed results are presented in Tables 10 and 11. In order to get more precise information in terms of the different channels behind the longer-term effects of infrastructure investments, we aggregate several industries to match as closely as possible the channels discussed in 4.1. The maintenance channel, a long-term but demand side channel, is approximated by considering construction (S12) separately. Then, we consider functional channels relating to internationally-traded goods, the primary sector and light manufacturing (S1 to S5), heavy manufacturing (S6 to S9), and transportation (S14). Then we consider several functional channels relating to goods that are not internationally traded: a cluster of trade (S13) and hospitality (S15), which relate to the issue of accessibility, a cluster of finance (S17) and professional services (S19), which relate to the issue of technical support, and other private services (S10, S11, S16), as well as public services (S20 to S22). Finally, we consider real estate (S18) which relates more directly to the location channel. All of these are long-term supply side channels.

We consider first road infrastructures. In the case of investments in national roads, to the 40% short-term demand-side effects accrue another 7% longer-term demand-side effects in construction (S12), for a total of 47% of demand-side effects. Of the remaining 53% long-term supply side effects, 30% reflect improvements in real estate (S18). In addition, there is a gain of 6% in heavy industries (S6-S9), and 11% in public services (S20 - S22). For investment in municipal roads, the longer term demand-side effects in the construction industry (S12) correspond to 12%, for a total of 53% demand-side effects. Of the remaining supply-side effects, 7% accrue to heavy industry (S6-S9), 28% to trade/hospitality (S13, S15), and 13% to public services (S20 - S22). Notably, long-term real-estate effects (S18) are null. For highways, the long-term construction effect (S12) corresponds to 6% of the effects. For the 65% supply-side effects, 35% come from real estate (S18), 12% from public services (S20 - S22) and the rest from the remaining channels, including 6% for heavy industry (S6-S9).

It is interesting to note a similarity between the long-terms effects of national roads and highways, as it is how these contrast with the effects of municipal roads. In fact, investments in municipal roads do not affect real estate (S18), and have a much larger effect on trade/hospitality (S13, S15). This reflects the different nature of municipal

roads being local rural accessibility roads. In addition, we note the effects of highway investments on finance (S17). This reflects the fact that this investment effort has been done in the last two decades through public-private partnerships, and therefore engaging directly the finance sector.

As to other transportation infrastructures, investments in railroads, the short-term demand effects account for just 15% of the total. To this, we add 5% for long-term maintenance (S12). Of the remaining 80% supply-side effects, a whole 64% refers to the impact on real estate (S18). For airport investments, the bulk is short-term demand side effects or 63%. The long-term construction channel (S12) and the locational effects as implied by the real estate effects (S18) are zero. The supply-side effects accrue mostly to public services (S20-S22), with 33%. Finally, for investments in ports, the 40% supply-side long-term effects are split between finance/professional services (S17, S19) and real estate (S18) with 13% and 15%, respectively.

Among investments in other transportation infrastructure, we see a sharp difference in the relevance of the real-estate effects (S18) between railroads, where such effects are overwhelming on one hand, and airports and ports, where such effects are either null or much smaller. In addition, airports, mostly used for passenger traffic, have a great effect on public services (S20-S22), while ports, used mostly for cargo, mostly impact finance/professional services (S17, S19). In fact, the effects on the functional channel for traded goods for investments in ports is the largest of all, certainly related with the ability to place exports of traded goods on international markets.

For public utilities, the cases of investments in water and electricity, show long-term negative effects which are dominated by adverse location effects, as reflected in the effects on the real-estate sector (S18). In the case of investments in water, we observe some positive effects on the primary sector and in light industry (S1-S5), trade/hospitality (S13, S15) and other private services. For refineries, the demand effects are very significant. Aside from the 44% short-term effects, we have 18% long-term effects on the construction sector (S18). The remaining 38% supply-side effects accrue to trade/hospitality (S13, S15) and to public services (S20 - S22). As for telecommunication investments, there is a 5% long-term effect on construction (S12). Of the remaining 55% supply-side effects, 14% go to finance/professional services (S17, S19), reflecting the fact that most of the industry is now privately-owned and requires highly-skilled labor, and 26% to real estate (S18).

To be noted, for water and electricity facilities, the effects on real estate (S18) are highly negative, reflecting a negative locational externality. For refineries, such effects are null, most likely due to the rather small size of the industry, located in just two specific areas of the country, although we could have expected negative effects as well. Overall, this pattern of results, together with the real-estate effects of the remaining infrastructure assets, highlights the accuracy of the real-estate effects as a measure of the location channel.

Finally, for social infrastructures, investments in health facilities lead to a 19% long-term effect on construction (S12), for a total demand side effect of 47%. Of the supply-side, heavy industry (S6-S9) captures 9%, transportation (S14), 11%, finance/professional services (S17, S19), 8%, and real estate (S18), 24%. In turn, investments in educational facilities have a total demand-side effect of 48%, of which 7% are long-term construction effects (S12). The long-term effects accrue to heavy industry (S6-S9), 7%, trade/hospitality (S13, S15), 5%, public services (S20-S22), 12%, and real estate (S18), 23%.

Interestingly enough, the demand-side effects of both social infrastructures are comparable, as is the relevance of the functional effects on heavy industry (S6-S9) and of the locational effects (S18). In terms of the functional channel on non-traded goods, the most significant difference is that health has very large finance/professional services effects (S17, S19) and education, large public sector effects (S20 - S22). This reflects the reality of health having an

increasingly-large participation of the private sector through public-private partnerships, and that education is still overwhelmingly public.

5. Summary and Concluding Remarks

In this article, considering twenty-two industries that jointly covering the whole spectrum of economic activity in Portugal, we use the empirical evidence on the effects of twelve types of infrastructure investments at the industry level to inform the issue of how infrastructure investments affect economic activity. We are interested in identifying how much of these effects are short term in nature, and how much are long term, how much of these effects are demand side and how much supply side, how much of the supply side are traditional functional channels reflecting externalities to private production, and how much reflect other channels reflecting enhanced markets for services or location effects.

The main findings can be summarized as follows. First, demand-side effects that are approximated by adding the short-term effects and long-term construction effects are always very important. They are over 60% of total effects for airport investments, ports, refineries, and water, they are over 45% for national roads, municipal roads, telecommunications, health and education, and are the lowest for highways (35%), railroads (20%), and electricity (32%). Second, the location effects that are approximated by the real-estate effects are also very significant, in particular for railroads (64%). More importantly, they are negative for water and electricity (64% and 63% of the negative effects, respectively), and zero for municipal roads, airports, and refineries, and small for ports (15%), all cases in which we would expect adverse or small location effects. Third, the functional channel related to internationally-traded goods is approximated by the effects on the primary sector, as well as on the manufacturing and transportation industries. This is a channel with much less significance, although we see meaningful effects on heavy industry from investments in all types of road infrastructures, ports, health, and education, as well as on light industry from ports and transportation from health. Fourth and finally, the functional effect relating to goods that are not internationally traded is very important. It accounts for more than 30% of the effects in the cases of municipal roads, airports, and refineries, in excess of 20% for highways, railroads, telecommunications, and education, and above 15% for national roads and ports.

Now, it is important to acknowledge that the connection between the industry-specific effects and the channels considered is not perfect. Our long-term maintenance channel only considers construction effects and not all other indirect effects related to construction, as we do observe in the short term. In addition, we have not identified directly the long-term operation channel. Accordingly, our estimate of the demand-side effects of infrastructures understates the true value and the stated value, and is thus just a lower bound. Furthermore, our estimate of location effects is also likely to be understated, as some accessibility effects on trade, transportation and hospitality would likely be also related to location effects. In turn, our estimate of functional channels are upper bounds, as part is likely maintenance spillovers, as well as some operation and location effects. Nevertheless, all of these considerations only reinforce our point that demand-side effects are very important, and that among the long-term supply side effects, the functional channel related to traded goods is not that important, while the functional channel related to non-traded goods and location channels are very important.

There are important implications of these results. From a very narrow perspective, for the Portuguese case, the strategy of infrastructure development followed after the 1990s was predicated on the objective of improving long-term growth fundamentals. Indeed, starting in 1989, the successive Community Support Frameworks that crystalized

the European Union structural support policies had as explicit targets improving long-term international competitiveness and accelerating the Portuguese standards of living to those of the European Union. The evidence of the great relevance of demand-side effects and of long-term effects mostly on real estate and other services may help to explain why the actual success of Portugal converging to EU standards of living was rather stunted.[9]

From a more general perspective, our results show that it cannot be a foregone conclusion that the effects of infrastructure investments are mostly long-term supply-side effects helping the economy as positive externalities through conventional productivity channels. Short-term and other demand effects may turn out to be very important. While this questions the conventional wisdom that views an infrastructure investment as essentially a long-term tool to promote economic growth, it also opens the question of the possible role of these infrastructure investments as an effective countercyclical tool. Furthermore, the fact that even the favorable supply-side effects tend to be biased toward services suggests that infrastructure investments, when not accompanied by an appropriate industrial policy, may actually have a detrimental effect on international competitiveness, and ultimately real convergence itself, by favoring mostly non-traded sectors.

Naturally, the results in this paper cannot be automatically generalized to other cases or other historical circumstances. In fact, that may be exactly one of the most important implications of our results. The nature of the effects depends a lot on the level of development of the country, and on the maturity of its infrastructure systems. We would expect these types of results to be more common in developed economies with mature infrastructure systems. We would not expect the same type of results to apply to developing economies. Furthermore, the nature of the effects also depends greatly on the rigor of infrastructure investment decisions. Bad decisions are bound to have inadvertent effects. Nevertheless, our results establish very clearly that, as infrastructure investments are concerned, the dominance of virtuous supply-side effects cannot be assumed, and, conversely, the relevance of the Keynesian effects cannot be dismissed.

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[9] According to data from the European Commission (2017), in 1960, the standard of living in Portugal was 65.2% of the EU-15 average, measured in purchasing power parity. Convergence peaked at 74.6% in 2010. The figure projected for 2017 is just 71.6%.

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Table 1. Infrastructure Investment by Type of Asset

	1980-2011	1980-89	1990-99	2000-09
Percent of GDP				
Infrastructure Investment	**4.18**	**2.88**	**4.40**	**5.04**
Road Transportation	**1.19**	**0.74**	**1.32**	**1.52**
National Roads	0.52	0.33	0.61	0.57
Municipal Roads	0.36	0.34	0.41	0.36
Highways	0.32	0.07	0.30	0.59
Other Transportation	**0.38**	**0.22**	**0.47**	**0.46**
Railroads	0.29	0.15	0.37	0.35
Ports	0.05	0.03	0.06	0.06
Airports	0.04	0.03	0.03	0.06
Utilities	**1.65**	**1.11**	**1.53**	**2.04**
Water Infrastructures	0.31	0.14	0.27	0.42
Petroleum Refining	0.16	0.09	0.18	0.15
Electricity and Gas	0.61	0.46	0.38	0.87
Telecommunications	0.57	0.41	0.70	0.61
Social Infrastructures	**0.96**	**0.81**	**1.08**	**1.02**
Health Facilities	0.46	0.28	0.47	0.60
Educational Buildings	0.50	0.53	0.60	0.41
Percentage of Total Infrastructure Investment				
Infrastructure Investment	**100.00**	**100.00**	**100.00**	**100.00**
Road Transportation	**28.49**	**25.99**	**30.35**	**30.23**
National Roads	12.46	11.52	14.09	11.43
Municipal Roads	9.16	11.90	9.47	7.10
Highways	6.86	2.56	6.79	11.70
Other Transportation	**8.91**	**7.57**	**10.52**	**9.21**
Railroads	6.64	5.17	8.31	6.92
Ports	1.21	1.23	1.40	1.08
Airports	1.06	1.17	0.81	1.21
Utilities	**38.85**	**38.04**	**34.61**	**40.43**
Water Infrastructures	6.99	4.90	5.98	8.17
Petroleum Refining	3.64	3.22	4.06	2.83
Electricity and Gas	14.44	15.97	8.45	17.53
Telecommunications	13.77	13.94	16.12	11.89
Social Infrastructures	**23.76**	**28.41**	**24.52**	**20.13**
Health Facilities	10.82	9.89	10.73	11.97
Educational Buildings	12.94	18.52	13.79	8.16

Table 2. Industry Classification Grouped by Sector

Primary Sector – Agriculture	
Agriculture (S1)	Agriculture, forestry and fishing
Mining (S2)	Mining and quarrying
Secondary Sector - Manufacturing	
Food (S3)	Manufacture of food products, beverages and tobacco products
Textiles (S4)	Manufacture of textiles, wearing apparel and leather products
Paper (S5)	Manufacture of wood and paper products, and printing
Chemical and Pharmaceutical (S6)	Manufacture of chemicals and chemical products. Manufacturing of basic pharmaceutical products and pharmaceutical preparations.
Non-metallic minerals (S7)	Manufacture of rubber and plastics products, and other non-metallic mineral products
Basic metals (S8)	Manufacture of basic metals and fabricated metal products, except machinery and equipment
Machinery and equipment (S9)	Manufacture of computer, electronic and optical products; Manufacture of electrical equipment; Manufacture of machinery and equipment; Manufacture of transport equipment; Manufacture of furniture; other manufacturing; repair and installation of machinery and equipment
Tertiary Sector - Private Services	
Electricity and gas (S10)	Electricity, gas, steam and air-conditioning supply
Water (S11)	Water, sewerage, waste management and remediation activities
Construction (S12)	Construction
Wholesale and retail trade (S13)	Wholesale and retail trade, repair of motor vehicles and motorcycles
Transportation and storage (S14)	Transportation and storage
Hospitality (S15)	Accommodation and food service activities
Telecommunications (S17)	Telecommunications
Finance (S17)	Financial and insurance activities
Real estate (S18)	Real estate activities
Professional services (S19)	Publishing, audiovisual and broadcasting activities; Computer programming, consultancy and related activities; information service activities; Legal and accounting activities; activities of head offices; management consultancy activities; architecture and engineering activities; technical testing and analysis; Scientific research and development; Advertising and market research; other professional, scientific and technical activities; veterinary activities; Administrative and support service activities; Arts, entertainment and recreation; Other services activities
Tertiary Sector - Public Services	
Public administration (S20)	Public administration and defense; compulsory social security
Education (S21)	Education
Health (S22)	Human health services; Social work activities

Table 3. Share of GDP by Industry

	1978-2009	1980-89	1990-99	2000-09
Agriculture	**8.6**	**14.1**	**6.6**	**3.4**
Agriculture (S1)	6.7	10.2	5.6	2.9
Mining (S2)	1.9	3.9	1.0	0.5
Manufacturing	**18.1**	**20.5**	**18.5**	**15.1**
Food (S3)	2.1	2.0	2.2	2.1
Textiles (S4)	3.7	4.2	4.2	2.7
Paper (S5)	2.2	2.4	2.2	1.8
Chemical and pharmaceutical (S6)	1.7	2.3	1.5	1.2
Non-metallic minerals (S7)	2.7	3.4	2.6	2.0
Basic metals (S8)	2.5	3.5	2.1	1.8
Machinery and equipment (S9)	3.3	2.7	3.7	3.7
Private Services	**56.3**	**52.7**	**56.7**	**60.3**
Electricity and gas (S10)	2.1	1.8	2.4	2.2
Water (S11)	0.6	0.5	0.6	0.9
Construction (S12)	7.1	6.8	7.0	7.7
Wholesale and retail trade (S13)	15.4	16.8	15.1	14.1
Transportation and storage (S14)	4.6	5.2	4.3	4.6
Hospitality (S15)	3.7	2.7	3.9	4.7
Telecommunications (S16)	1.9	1.4	2.0	2.3
Finance (S17)	6.3	6.3	6.1	6.6
Real estate (S18)	7.5	6.0	7.4	8.0
Professional services (S19)	7.2	5.2	7.8	9.1
Public Services	**17.0**	**12.8**	**18.2**	**21.2**
Public administration (S20)	8.5	7.2	8.9	9.9
Education (S21)	5.3	3.6	6.0	6.8
Health (S22)	3.2	2.0	3.3	4.5
Total	**100.0**	**100.0**	**100.0**	**100.0**

Table 4. Industry-Specific Effects of Investments in Road Transportation Infrastructure

	National Roads		Municipal Roads		Highways	
	Elasticity	**Marginal Product**	**Elasticity**	**Marginal Product**	**Elasticity**	**Marginal Product**
Agriculture and Mining						
Agriculture (S1)	0.1147	0.47	-0.1381	-0.90	-0.0028*	*
Mining (S2)	-0.5102	-0.35	0.2890	0.32	-0.0833	-0.06
Manufacturing						
Food (S3)	0.0510	0.15	0.1115	0.53	0.0057*	*
Textiles (S4)	0.1321	0.49	0.0870	0.52	-0.0044*	*
Paper (S5)	0.1046	0.26	-0.1499	-0.59	0.0470	0.11
Pharmaceuticals (S6)	-0.0294*	*	-0.1280	-0.25	-0.0092*	*
Non-metallic minerals (S7)	0.3105	0.85	0.0764	0.34	0.0351	0.09
Basic metals (S8)	-0.0295*	*	0.1865	0.74	0.0013*	*
Machinery and equipment (S9)	0.3756	1.93	-0.0897*	*	0.0423	0.21
Private Services						
Electricity and gas (S10)	-0.4776	-1.49	0.0174*	*	-0.0213*	*
Water (S11)	-0.5831	-0.71	0.0152*	*	-0.0196*	*
Construction (S12)	0.2841	3.06	0.0670	1.16	0.0526	0.56
Wholesale and retail trade (S13)	0.0759	1.51	0.0934	2.97	0.0123	0.24
Transportation and storage (S14)	0.0605	0.39	0.0439	0.45	-0.0020*	*
Hospitality (S15)	0.0837	0.56	0.1643	1.75	0.0180	0.12
Telecommunications (S16)	-0.0295*	*	-0.0274*	*	-0.0027*	*
Finance (S17)	-0.0672*	*	0.0386*	*	0.0489	0.45
Real estate (S18)	0.6682	7.48	-0.1126*	*	0.1918	2.12
Professional services (S19)	0.1472	1.89	0.0134*	*	0.0135	0.17
Public Services						
Public administration (S20)	0.1002	1.23	0.0505	0.99	0.0289	0.35
Education (S21)	0.3291	3.16	-0.0173*	*	0.0438	0.41
Health (S22)	0.0644	0.41	0.0309*	*	0.0194	0.12
TOTAL		**21.29**		**8.03**		**4.89**

Note – values marked with * are not statistically significant as implied by the standard deviation bands around the impulse response functions.

Table 5. Industry-Specific Effects of Investments in Other Transportation Infrastructure

	Railroads		Airports		Ports	
	Elasticity	**Marginal Product**	**Elasticity**	**Marginal Product**	**Elasticity**	**Marginal Product**
Agriculture and Mining						
Agriculture (S1)	-0.0428*	*	0.0085*	*	0.0046	0.20
Mining (S2)	0.0148*	*	-0.0914	-0.59	0.0242	0.18
Manufacturing						
Food (S3)	0.0083*	*	0.0304	0.85	0.0258	0.82
Textiles (S4)	-0.0394*	*	0.0067*	*	0.0258	1.03
Paper (S5)	-0.0962	-0.39	-0.0287	-0.67	0.0208	0.55
Pharmaceuticals (S6)	-0.0681	-0.14	-0.0017*	*	-0.0275	-0.35
Non-metallic minerals (S7)	-0.0598	-0.27	0.0115*	*	0.0216	0.63
Basic metals (S8)	-0.0582	-0.24	-0.0212*	*	0.0368	0.96
Machinery and equipment (S9)	-0.1894	-1.62	0.0141	0.68	-0.0029*	*
Private Services						
Electricity and gas (S10)	0.1829	0.95	0.1008	2.97	-0.0242*	*
Water (S11)	0.2035	0.41	0.0917	1.06	-0.0382	-0.50
Construction (S12)	0.1518	2.72	-0.0074*	*	0.0124	1.43
Wholesale and retail trade (S13)	0.0517	1.70	0.0253	4.74	0.0122	2.58
Transportation & storage (S14)	-0.0532	-0.57	-0.0474	-2.87	0.0226	1.54
Hospitality (S15)	0.0399	0.44	0.0502	3.16	0.0289	2.05
Telecommunications (S16)	-0.0078*	*	0.0035*	*	-0.0097	-0.34
Finance (S17)	-0.0283*	*	0.0254	2.24	0.0228	2.28
Real estate (S18)	0.8968	16.69	-0.0576*	*	0.0419	5.00
Professional services (S19)	-0.0367	-0.78	-0.0158*	*	0.0293	4.01
Public Services						
Public administration (S20)	0.0482	0.98	0.0234	2.70	0.0143	1.86
Education (S21)	0.0500	0.80	0.0432	3.92	0.0085*	*
Health (S22)	0.0149	0.16	0.0200	1.19	0.0130	0.87
TOTAL		**20.84**		**19.38**		**24.80**

Note – values marked with * are not statistically significant as implied by the standard deviation bands around the impulse response functions.

Table 6. Industry-Specific Effects of Investments in Public Utilities

	Water		Electricity		Refineries	
	Elasticity	**Marginal Product**	**Elasticity**	**Marginal Product**	**Elasticity**	**Marginal Product**
Agriculture and Mining						
Agriculture (S1)	-0.0537	-0.33	-0.0311	-0.08	-0.0033*	*
Mining (S2)	0.1996	0.20	-0.0345*	*	0.0080*	*
Manufacturing						
Food (S3)	0.0155	0.07	-0.0110*	*	0.0027*	*
Textiles (S4)	0.0218	0.12	-0.0036*	*	0.0001*	*
Paper (S5)	-0.0548	-0.20	0.0152	0.02	0.0080*	*
Pharmaceuticals (S6)	-0.0325	-0.06	-0.0224	-0.02	-0.0160*	*
Non-metallic minerals (S7)	0.0102*	*	-0.0071*	*	0.0001*	*
Basic metals (S8)	0.0345*	*	0.0318	0.05	0.0069*	*
Machinery and equipment (S9)	-0.1811	-1.39	0.0045*	*	-0.0042*	*
Private Services						
Electricity and gas (S10)	-0.0482*	*	-0.0288	-0.06	-0.0347	-0.43
Water (S11)	-0.0436*	*	-0.0192*	*	-0.0160*	*
Construction (S12)	-0.0006	-0.01	0.0010*	*	0.0258	1.10
Wholesale and retail trade (S13)	0.0201	0.60	-0.0007*	*	0.0057	0.44
Transportation and storage (S14)	0.0217	0.21	-0.0150	-0.06	0.0019*	*
Hospitality (S15)	0.0702	0.70	-0.0208	-0.09	-0.0024*	*
Telecommunications (S16)	-0.0043*	*	0.0019*	*	-0.0009*	*
Finance (S17)	0.0074*	*	-0.0406	-0.25	0.0065*	*
Real estate (S18)	-0.1687	-2.82	-0.1324	-0.96	0.0252*	*
Professional services (S19)	-0.0012*	*	0.0016*	*	0.0186	0.94
Public Services						
Public administration (S20)	-0.0196	-0.36	0.0143	0.11	0.0154	0.74
Education (S21)	-0.0225	-0.32	-0.0088*	*	0.0161	0.61
Health (S22)	-0.0190	-0.18	0.0022*	*	0.0133	0.33
TOTAL		**-3.99**		**-1.34**		**3.73**

Note – values marked with * are not statistically significant as implied by the standard deviation bands around the impulse response functions.

Table 7. Industry-Specific Effects of Investments in Telecommunications and Social Infrastructure

	Telecom		Health		Education	
	Elasticity	**Marginal Product**	**Elasticity**	**Marginal Product**	**Elasticity**	**Marginal Product**
Agriculture and Mining						
Agriculture (S1)	0.0126*	*	-0.0648*	*	-0.3254	-1.85
Mining (S2)	0.0706*	*	0.1137*	*	-0.3136	-0.30
Manufacturing						
Food (S3)	0.0194*	*	-0.0507*	*	0.0718	0.30
Textiles (S4)	-0.0146*	*	-0.0338*	*	-0.1441	-0.75
Paper (S5)	0.0955	0.20	0.0728	0.41	0.0938	0.32
Pharmaceuticals (S6)	-0.0117*	*	-0.0655*	*	-0.1597	-0.27
Non-metallic minerals (S7)	0.0746	0.17	0.1517	0.94	0.1644	0.63
Basic metals (S8)	0.1609	0.33	0.0944*	*	-0.0430	-0.15
Machinery and equipment (S9)	0.0276*	*	0.1650	1.93	0.1969	1.41
Private Services						
Electricity and gas (S10)	0.0283*	*	-0.1839*	*	-0.2802	-1.22
Water (S11)	0.0294*	*	-0.2439	-0.68	-0.1959	-0.33
Construction (S12)	0.1994	1.79	0.2421	5.93	0.2896	4.35
Wholesale and retail trade (S13)	0.0701	1.16	0.0155*	*	0.0628	1.74
Transportation & storage (S14)	0.0327*	*	0.2272	3.31	0.1365	1.22
Hospitality (S15)	0.0946	0.52	-0.0042*	*	-0.0430*	*
Telecommunications (S16)	-0.0397*	*	-0.0270*	*	-0.0100*	*
Finance (S17)	0.2044	1.59	0.0848*	*	0.2075	2.71
Real estate (S18)	0.4784	4.46	0.2611	6.64	0.3925	6.13
Professional services (S19)	0.1112	1.19	0.0674	1.97	0.1599	2.86
Public Services						
Public administration (S20)	0.1024	1.04	-0.0275*	*	0.1486	2.53
Education (S21)	0.0671	0.54	-0.0015*	*	0.2057	2.75
Health (S22)	0.0185*	*	-0.0295*	*	0.1349	1.18
TOTAL		**12.99**		**20.45**		**23.26**

Note – values marked with * are not statistically significant as implied by the standard deviation bands around the impulse response functions.

Table 8. Short-Term versus Total Effects of Road and Other Transportation Infrastructures

		National Roads	Municipal Roads	Highways	Railroads	Airports	Ports
Agriculture (S1)	Total	0.47	-0.90	*	*	*	0.20
	Short Term	0.52	-0.82	*	*	*	-0.14
Mining (S2)	Total	-0.35	0.32	-0.06	*	*	0.18
	Short Term	-0.16	0.24	-0.01	*	-0.37	-0.03
Food (S3)	Total	0.15	0.53	*	*	0.85	0.82
	Short Term	0.09	0.42	*	*	0.08	0.43
Textiles (S4)	Total	0.49	0.52	*	*	*	1.03
	Short Term	0.40	0.36	*	*	*	0.40
Paper (S5)	Total	0.26	-0.59	0.11	-0.39	-0.67	0.55
	Short Term	0.14	-0.38	0.07	-0.49	-0.75	0.59
Pharmaceuticals (S6)	Total	*	-0.25	*	-0.14	*	-0.35
	Short Term	*	-0.13	*	-0.20	*	-0.44
Non-metallic minerals (S7)	Total	0.85	0.34	0.09	-0.27	*	0.63
	Short Term	0.49	0.34	0.03	-0.11	*	0.36
Basic metals (S8)	Total	*	0.74	*	-0.24	*	0.96
	Short Term	*	0.17	*	0.00	*	0.28
Machinery and equipment (S9)	Total	1.93	*	0.21	-1.62	0.68	*
	Short Term	1.03	*	-0.01	-0.61	0.52	*
Electricity and gas (S10)	Total	-1.49	*	*	0.95	2.97	*
	Short Term	-1.07	*	*	-0.21	2.15	*
Water (S11)	Total	-0.71	*	*	0.41	1.06	-0.50
	Short Term	-0.56	*	*	-0.07	0.71	-0.15
Construction (S12)	Total	3.06	1.16	0.56	2.72	*	1.43
	Short Term	1.59	0.21	0.25	1.60	*	1.04
Wholesale and retail trade (S13)	Total	1.51	2.97	0.24	1.70	4.74	2.58
	Short Term	1.4	1.24	0.07	0.56	4.31	2.71
Transportation & storage (S14)	Total	0.39	0.45	*	-0.57	-2.87	1.54
	Short Term	0.07	0.44	*	-0.19	-1.33	0.60
Hospitality (S15)	Total	0.56	1.75	0.12	0.44	3.16	2.05
	Short Term	-0.10	1.29	-0.04	0.04	2.02	1.95
Telecommunications (S16)	Total	*	*	*	*	*	-0.34
	Short Term	*	*	*	*	*	-0.41
Finance (S17)	Total	*	*	0.45	*	2.24	2.28
	Short Term	*	*	0.31	*	3.46	2.15
Real estate (S18)	Total	7.48	*	2.12	16.69	*	5.00
	Short Term	1.09	*	0.42	3.4	*	1.28
Professional services (S19)	Total	1.89	*	0.17	-0.78	*	4.01
	Short Term	1.28	*	0.03	-0.95	*	0.98
Public administration (S20)	Total	1.23	0.99	0.35	0.98	2.70	1.86
	Short Term	0.55	-0.03	0.09	-0.09	0.16	1.67
Education (S21)	Total	3.16	*	0.41	0.80	3.92	*
	Short Term	1.31	*	0.16	0.15	0.87	*
Health (S22)	Total	0.41	*	0.12	0.16	1.19	0.87
	Short Term	0.53	*	0.03	0.20	0.42	1.10
TOTAL	**Total**	**21.29**	**8.03**	**4.89**	**20.84**	**19.38**	**24.80**
	Short Term	**8.60**	**3.35**	**1.40**	**3.03**	**12.25**	**14.37**

Note – values marked with * are not statistically significant as implied by the standard deviation bands around the impulse response functions.

Table 9. Short-Term versus Total Effects of Utilities and Social Infrastructures

		Water	Electricity	Refineries	Telecom	Health	Education
Agriculture (S1)	Total	-0.33	-0.08	*	*	*	-1.85
	Short Term	-0.44	-0.07	*	*	*	-1.52
Mining (S2)	Total	0.20	*	*	*	*	-0.3
	Short Term	0.13	*	*	*	*	-0.25
Food (S3)	Total	0.07	*	*	*	*	0.3
	Short Term	-0.02	*	*	*	*	-0.03
Textiles (S4)	Total	0.12	*	*	*	*	-0.75
	Short Term	-0.12	*	*	*	*	-0.49
Paper (S5)	Total	-0.2	0.02	*	0.20	0.41	0.32
	Short Term	-0.19	0.04	*	0.10	0.49	0.12
Pharmaceuticals (S6)	Total	-0.06	-0.02	*			-0.27
	Short Term	-0.02	-0.01	*	*		-0.12
Non-metallic minerals (S7)	Total	*	*	*	0.17	0.94	0.63
	Short Term	*	*	*	0.09	0.49	0.32
Basic metals (S8)	Total	*	0.05	*	0.33	*	-0.15
	Short Term	*	0.04	*	0.13	*	-0.45
Machinery and equipment (S9)	Total	-1.39	*	*	*	1.93	1.41
	Short Term	-0.86	*	*	*	0.63	0.46
Electricity and gas (S10)	Total	-0.23	-0.06	-0.43	*	*	-1.22
	Short Term	-0.61	-0.05	-0.33	*	*	-1.21
Water (S11)	Total	*	*	*	*	-0.68	-0.33
	Short Term	*	*	*	*	-0.86	-0.34
Construction (S12)	Total	*	*	1.1	1.79	5.93	4.35
	Short Term	*	*	0.44	1.13	1.99	3.07
Wholesale and retail trade (S13)	Total	0.60	*	0.44	1.16	*	1.74
	Short Term	0.22	*	0.12	0.83	*	0.6
Transportation & storage (S14)	Total	0.21	-0.06	*	*	3.31	1.22
	Short Term	0.12	0.00	*	*	1.15	0.4
Hospitality (S15)	Total	0.70	-0.09	*	0.52	*	*
	Short Term	0.27	-0.03	*	0.26	*	*
Telecommunications (S16)	Total	*	*	*	*	*	*
	Short Term	*	*	*	*	*	*
Finance (S17)	Total	*	-0.25	*	1.59	*	2.71
	Short Term	*	-0.29	*	0.85	*	2.46
Real estate (S18)	Total	-2.82	-0.96	*	4.46	6.64	6.13
	Short Term	-0.26	-0.12	*	1.14	1.63	0.87
Professional services (S19)	Total	*	*	0.94	1.19	1.97	2.86
	Short Term	*	*	0.68	0.18	0.25	2.47
Public administration (S20)	Total	-0.36	0.11	0.74	1.04	*	2.53
	Short Term	-0.42	0.07	0.23	0.5	*	1.04
Education (S21)	Total	-0.32	*	0.61	0.54	*	2.75
	Short Term	-0.16	*	0.21	0.1	*	2.09
Health (S22)	Total	-0.18	*	0.33	*	*	1.18
	Short Term	-0.01	*	0.29	*	*	0.48
TOTAL	Total	**-3.99**	**-1.34**	**3.73**	**12.99**	**20.45**	**23.26**
	Short Term	**-2.37**	**-0.42**	**1.64**	**5.31**	**5.77**	**9.97**

Note – values marked with * are not statistically significant as implied by the standard deviation bands around the impulse response functions.

Table 10. Decomposition of Channels of Effects of Investments In Road Transportation Infrastructure and Other Transportation Infrastructure

	National Roads	Municipal Roads	Highways	Railroads	Airports	Port
SHORT-TERM EFFECTS	**40%**	**41%**	**29%**	**15%**	**63%**	**58%**
LONG-TERM EFFECTS	**60%**	**59%**	**71%**	**85%**	**37%**	**42%**
Maintenance Channel [S12]	**7%**	**12%**	**6%**	**5%**	**0%**	**2%**
Functional Channel – Tradable Goods	**8%**	**6%**	**6%**	**-8%**	**-4%**	**14%**
Primary Sector and Light Industry [S1-S5]	0%	-1%	0%	1%	3%	6%
Heavy Industry [S6-S8]	6%	7%	6%	-7%	1%	4%
Transportation [S14]	2%	0%	0%	-2%	-8%	4%
Functional Channel – Non Tradable Goods	**15%**	**41%**	**24%**	**24%**	**41%**	**11%**
Trade, Hospitality [S13, S15]	4%	28%	6%	7%	8%	-1%
Finance, Professional Services [S17, S19]	3%	0%	6%	1%	-6%	13%
Other Private Services [S10, S11, S16]	-3%	0%	0%	8%	6%	-1%
Public Services [S20, S21, S22]	11%	13%	12%	8%	33%	0%
Location Channel - Real Estate [S18]	**30%**	**0%**	**35%**	**64%**	**0%**	**15%**

Table 11. Decomposition of Channels of Effects of Investments in Public Utilities and Social Infrastructures

	Water(*)	Electricity(*)	Refineries	Telecom	Health	Education
SHORT-TERM EFFECTS	**61%**	**32%**	**44%**	**40%**	**28%**	**41%**
LONG-TERM EFFECTS	**39%**	**68%**	**56%**	**60%**	**72%**	**59%**
Maintenance Channel [S12]	**0%**	**0%**	**18%**	**5%**	**19%**	**6%**
Functional Channel – Tradable Goods	**-1%**	**6%**	**0%**	**3%**	**20%**	**11%**
Primary Sector and Light Industry [S1-S5]	-12%	3%	0%	1%	0%	-1%
Heavy Industry [S6-S8]	13%	-1%	0%	2%	9%	7%
Transportation [S14]	-2%	4%	0%	0%	11%	4%
Functional Channel – Non Tradable Goods	**-24%**	**-1%**	**38%**	**27%**	**9%**	**20%**
Trade, Hospitality [S13, S15]	-21%	4%	9%	5%	0%	5%
Finance, Professional Services [S17, S19]	0%	-3%	7%	14%	8%	3%
Other Private Services [S10, S11, S16]	-10%	1%	-3%	0%	1%	0%
Public Services [S20, S21, S22]	7%	-3%	25%	8%	0%	12%
Location Channel - Real Estate [S18]	**64%**	**63%**	**0%**	**26%**	**24%**	**23%**

(*) As the total long-term effects in these two industries are negative, the positive numbers in this table are shares of the negative effect in the industry in the total effect while negative numbers reflect positive effects.