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## The effect of public investment in Europe: a model-based assessment

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# Abstract

We consider the effect of an increase in public investments on output in Europe against the background of a sharp drop of public investments in a number of EU countries during the crisis and subsequent policy discussions on the need to stimulate public investments. We start with a brief overview of recent developments in public investments, including some methodological issues, and provide a literature overview of the effect of public investments on growth. On the basis of updated estimates of the public capital stock, we estimate the output response to a public capital impulse, using VAR models. In addition, using a structural model, we investigate the sensitivity of the macroeconomic impact of an increase in public investments to alternative assumptions about economic structures and policy implementations.

**Keywords:** fiscal policy, public investment, euro area, general equilibrium modelling

**JEL codes:** E32, E62, C30

# Non-technical summary

Public investment in Europe has significantly declined since the crisis, although developments are heterogeneous across countries. This has led to calls for stimulating public investment in an environment of low borrowing costs for governments, weak economic growth and monetary policy at the lower bound. Against this background, this paper assesses the output effects of public capital and investments and discusses the importance of various economic mechanisms determining the transmission of public investment shocks.

The literature suggests that an increase in public investment has positive demand effects and can contribute to the economy's potential output by increasing the stock of public capital. While the empirical literature on the effect of public capital on output typically finds a positive effect, estimates vary considerably according to the time period, country, measure of capital and estimation method. Similarly, the productivity of public capital may vary over time and could decline. Any increase in public investment needs to be assessed in the light of its productivity, its financing and the relative costs and benefits of the financing options.

Using an updated data set of public capital stocks, we provide VAR-based estimates of the output effects of an increase in the public capital stock in twelve EU countries. In line with past studies, we find that public capital enhances productivity in most of the countries included in the sample as the long-run impact of a shock to public capital on GDP is estimated to be positive. However, even though public investment expenditures were cut strongly during the recent crisis in many countries with large consolidation needs, we find no conclusive evidence that the public capital effects on output are currently larger than before the crisis.

To gain further insights in the effects of public investments on output and public finances, we simulate a temporary but sustained increase in public investment in a large euro area economy using a structural model. The simulation results show the sensitivity of the implied output and budget responses to alternative policy implementation strategies. First, an increase in public investment will have the strongest short-term demand effects, including in terms of spillovers to other countries, with an anticipated accommodative monetary policy. This finding strengthens the case for increasing public investment in the current low-inflation environment. Second, a debt or revenue-financed increase in productive public investment implies significantly larger short-term output gains compared with an increase in investment financed by cutting other public expenditures. However, when distortionary taxes, e.g. labour income taxes, are used to finance public investment, the short-term output gains of additional public investment have to be traded off against the tax-induced output losses over the longer term, whereas any increase in public investment financed by higher public debt must be weighed up against possible fiscal sustainability concerns. Last, the longer-term positive effects on the economy's potential output and the impact on public finances crucially depend on the effectiveness of investment and the productivity of public capital. If these are low, an

increase in public investment is associated with a greater deterioration of the debt outlook and less persistent output gains.

In conclusion, to produce positive effects, any recommendation for a public investment push in the EU must go along with a rigorous selection of projects, to ensure that the investment is efficient and productive.

# 1 Introduction

Since the start of the global financial crisis, public investment has fallen in a number of countries, particularly those that experienced market pressure. Low levels of public investment, if maintained over a prolonged period, may lead to a deterioration of public capital and diminish longer-term output. The fall in public investment and the current low interest rate environment have prompted calls to stimulate public investment spending as a way to increase short-term demand and raise potential output (see e.g. IMF (2014)). In the European Union (EU), this has led to the adoption of the Investment Plan for Europe (2015), the so-called "Juncker plan". The latter aims to stimulate infrastructure and other public investments through combining first-risk guarantees for private sector participation, increasing information on viable projects, and improving the investment climate. The fiscal positions of many EU countries remain fragile, however, and the provisions of the Stability and Growth Pact call for further fiscal consolidation in many of them. In this regard, it seems to be prudent to take a closer look at the relationship between public investment and economic growth as well as budgetary implications of the proposed policy.

Against this background, this paper investigates economic effects of public capital and investment utilising both structural and non-structural model-based illustrative simulations. First, using the methodology proposed by Kamps (2006) for updating a dataset for twelve EU countries, the paper reports new VAR-based estimates of the output effects of an increase in public capital stock.[1] Similar to Kamps (2005), we find that, for most of the countries included in the sample, the long-run impact of a shock from public capital on GDP is estimated to be positive, i.e. public capital enhances the production capacity, but not necessarily differently than before the crisis.

Second, to gain further insights in the economic effects of an increase in public investment on output and public finances, the paper discusses simulations of a temporary but sustained increase in public investment, based on the EAGLE model – a multi-country dynamic general equilibrium model (Gomes et al., 2010). An increase in public investment is found to increase output both in the short term (demand effect) and long term (supply effect), with only a moderate increase in government debt or even a decrease if financed by revenue increases or other expenditure cuts. However, the debt increases considerably more in cases when the existing public capital stock is already high, the productivity of public capital is low or the efficiency of investment (e.g. through waste or corruption) is low. The effects are also sensitive to the monetary policy stance and cross-border spill-overs also matter.

Our model-based simulation results reveal that an increase in public investment will have the strongest short-term demand effects with a fully anticipated, non-

[1] Public investment data are subject to limitations in cross-country comparability, e.g. due to differences in sector delineation.

responsive monetary policy, which argues in favour of undertaking public investment at the current juncture. However, the longer-term positive effects on the economy's potential output and the impact on public finances crucially depend on the effectiveness of investment and its productive effect. If these are low, an increase in public investment is associated with a deterioration of the debt outlook. Accordingly, the recent evolution in public investment or public capital cannot by itself justify a "one-size fits all" recommendation for an investment push in the EU. Rather, the evidence presented here underlines the consideration that should be given to a rigorous selection of investment projects, which should be done on a case-by-case basis, to ensure that investment is efficient and productive.

The rest of the paper is structured as follows. Some stylized facts about recent developments in public investments and capital stocks are discussed in section 2. Section 3 provides a literature overview of the effect of public investment on growth. Our estimates of the effect of public capital on output are provided in section 4, while we present simulations of the impact of increasing investment under different conditions, based on a structural model, in section 5. Section 6 concludes.

# 2 Government investment and capital stocks: some stylized facts

In the empirical literature, a common approach to approximate public investment is to use statistical data on general government gross fixed capital formation. Public capital stock series are typically constructed as the sum of past investments, allowing for depreciation.[2] This approach is largely dictated by the required data availability. However, is not without caveats, which are mostly related to investment measurement issues.

A general issue with monetary measures of public investment is their ability to adequately describe 'true' public capital (investments). First of all, the distinction between public investment and other government expenditures is not always clear with respect to their effect on the productive capacity of the economy. One might expect public investments to be more supportive to growth compared to other government spending, by increasing the productive capacity of the economy. However, some current government expenditures, for example, education and health care expenditures, contribute to the building up of a (private) human capital stock, thus also enhancing the supply side of the economy and contributing to growth (e.g., Barro (2001) and Sala-I-Martin et al. (2004)).[3] A second issue is that the distinction between public and private investment is not always clear. For example, private parties often, through private-public partnerships (PPPs), participate in infrastructure projects – some of which are classified as public investments. Furthermore, privatisation and outsourcing have resulted in public investments being reclassified as private (with in some cases subsequent reversals). A third issue is inefficiency or corruption which can reduce the economic impact of public investments. This is a relevant consideration, since the quality of public governance and political checks and balances differs widely across countries (Keefer and Knack, 2007).[4] Using physical measures of investment or capital stocks[5] can circumvent only some of the monetary measurement issues since physical measures also face significant limitations (Hulten, 1996): quality measurement issues, comparability across countries, etc.

[2] While the terms general government gross fixed capital formation (GFCF) and public investment (as well as general government capital stock and public capital stock) are used throughout this chapter interchangeably, these are not the same concepts. As stated in ESA2010 20.303 public sector consists of general government and public corporations. Therefore, the general government GFCF potentially excludes large part of public sector investments.

[3] Also, at least part of regular maintenance expenditures will be classified as current expenditures, rather than investments.

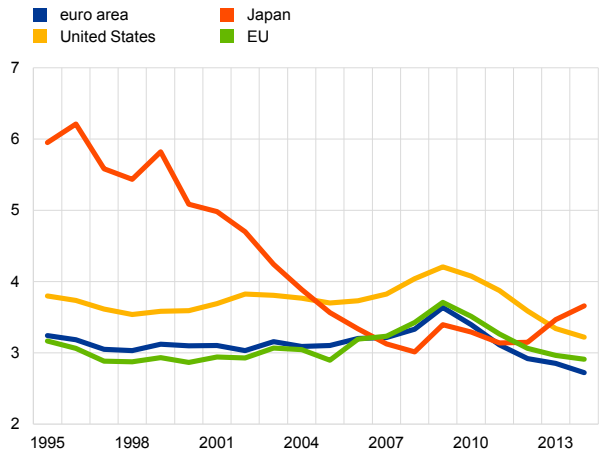
[4] Gupta et al. (2014) tackle this issue by constructing an efficiency-adjusted public capital stock, based on a public investment management index available for low- and middle income countries (see Dabla-Norris et al. (2011)). They find that ignoring public investment inefficiencies leads to an underestimation of marginal productivities of both private and public capital.

[5] A recent example is due to Calderón et al. (2014), who compose a synthetic measure of infrastructure comprising transport, power and telecommunications and estimate a production function. Positive contributions to economic growth are found in other studies using physical measures of public capital as well (e.g., broadband penetration (Czernich et al., 2011); length of roads and railways, number of fixed telephone lines and electricity generating capacity (Canning, 1999; Égert et al., 2009)).

With these caveats in mind, this paper, in line with the literature, uses the conventional measures of government investment as defined in national accounts. Charts 1 and 2 show dynamics of public and private investment over time and across countries whereas Chart 3 plots developments of the estimated capital stock series for EU countries.

**Chart 1**
Public investment

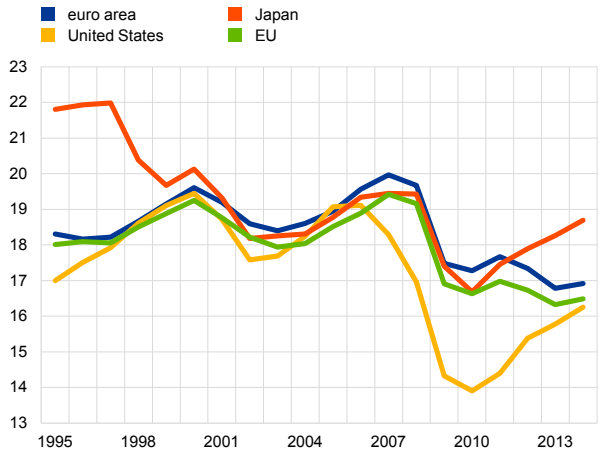
(as a percentage of GDP)




Source: European Commission.

**Chart 1b**
Private investment

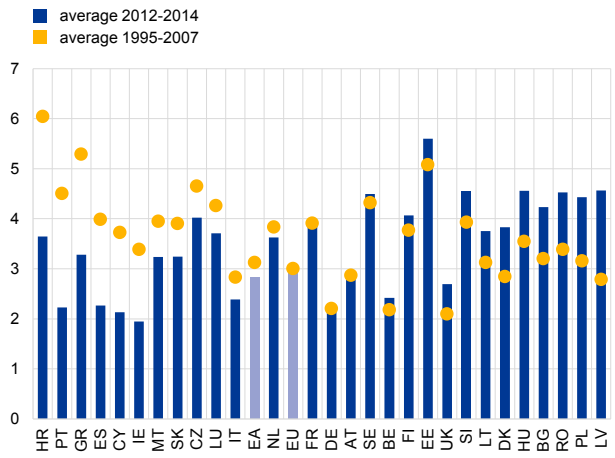
(as a percentage of GDP)




Source: European Commission.

**Chart 2a**
Public investment-to-GDP ratio

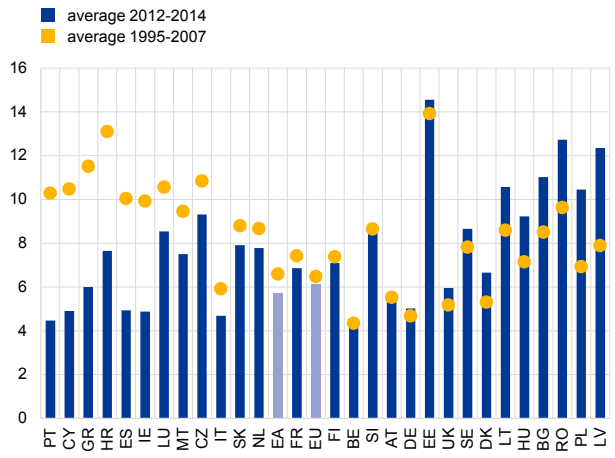
(as a percentage of GDP)




Source: European Commission.
Note: Countries ordered by change in average public investment 2012-14 versus 1995-2007.

**Chart 2b**
Public investment-to-government expenditure ratio

(as a percentage of government expenditure)




Source: European Commission.
Note: Countries ordered by change in average public investment 2012-14 versus 1995-2007.

In advanced economies, public investment has declined from around 4% of GDP in the 1980s to around 3% by the mid-1990s. This long-term downward trend could be attributed to a number of factors. First, this evolution could be related to economic

and demographic changes, such as a shift towards less capital intensive production and more services and the ageing of societies. Second, since public investment is considered to be among the easiest to cut during consolidation periods, the downward trend might have been driven by political considerations.

After being stable at the level of around 3% of GDP for more than a decade, general government investment in the EU increased significantly at the beginning of the crisis (see Chart 1). This reflected a strong fall in economic activity (denominator effect) as well as a response of the European governments to a call by the European Commission for a fiscal stimulus in 2009. However, with consolidation efforts accelerating from 2010 onwards, public investment expenditures declined rapidly and reverted to a ratio around the pre-crisis average of 3% of GDP. Private sector investment, on the contrary, declined primarily in the early years of the crisis but did not recover. Compared to the peak in 2007, the private investment-to-GDP ratio in 2010 was down by almost 3 pp, and remained more or less constant ever since at a below pre-crisis level. Developments for the euro area are more or less the same as for the EU, although public investments are currently somewhat below the pre-crisis ratio.

The EU average hides substantial differences between individual member states in terms of developments of public investment (Chart 2). In countries with relatively low levels of general government investment in the years before the crisis, public investment generally has not declined much or even increased (e.g., Germany, Austria, Belgium or Denmark). Public investment generally increased in countries that benefited from increasing support from EU funds during these years, e.g., Latvia, Lithuania, Bulgaria, Poland and Romania. The largest reductions in public investment ratios took place in countries with high pre-crisis public investment ratios and in countries with large consolidation needs. Most notably, public investments (as a percent of GDP) were reduced by more than a fifth in Portugal, Ireland, Spain, Croatia, Cyprus and Greece. Expressed in terms of government expenditures, the decline in these countries is even larger reflecting the fact that government investments were used more intensively than other expenditure items as a consolidation instrument.

The variation in public investment data thus suggests the existence of substantial differences in the capital stocks, although cross-country comparisons should be treated with caution on account of the data and measurement issues mentioned above. Eventually, it is the capital stock, or more specifically the flow of capital services it provides, that contributes to sustaining a certain level of potential output. Assuming decreasing marginal benefits of public capital, one would expect the highest levels of public investment to prevail in countries with a relatively small public capital stock. However, direct data on the size of the general government capital stock are generally not readily available.

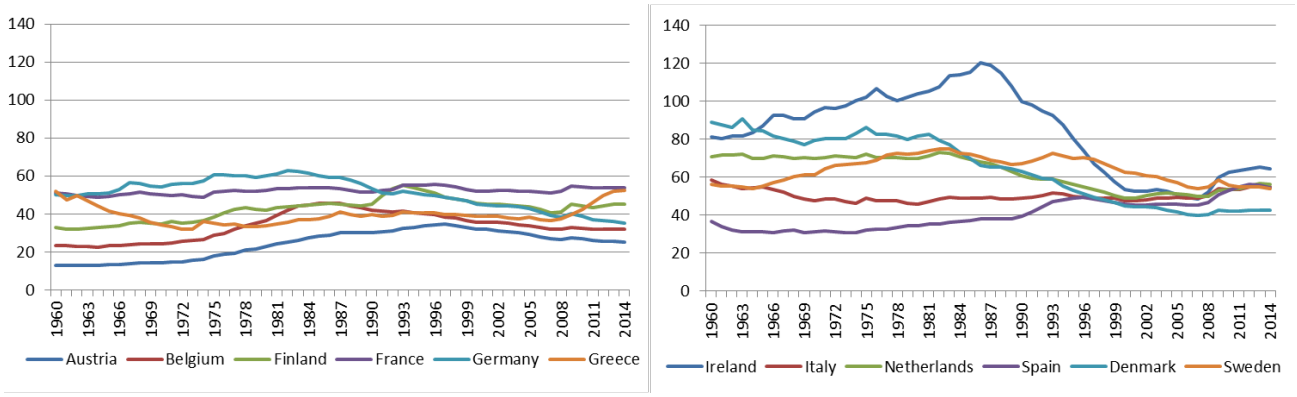
Chart 3 presents our estimates of public capital stocks for a selection of European countries, used later for the empirical analysis. These government capital stock data are constructed by applying a perpetual inventory method, updating earlier work of

Kamps (2006).[6] As the ESA2010 data on government investment are available only from 1995 or later, for this purpose ESA95 data with a reference year 2005 were used. While using ESA95 data also avoids including investment in military equipment, which are assumed not to be important for the production process, it omits spending on R&D that has been included in ESA2010.

**Chart 3**

Public capital stock, 1960-2014

(percent of GDP; volume)




Notes: authors' calculations.

Two observations stand out. First, despite still considerable cross-country differences, capital stocks seem to have been converging in size internationally. In 2014, most of the considered countries had public capital stocks between 25% and 60% of GDP. There is no apparent relation between the size of the public capital stock and GDP per capita. Secondly, in a number of countries, public capital stocks (as a ratio to GDP) have actually declined over the last two or three decades, reflecting a gradual decline in investment rates. To some extent, this may be the result of privatisations and outsourcing of public services which took place in the eighties and nineties. Another (statistical) reason could be that expenditures on regular maintenance are counted as current expenditures rather than investments. Even though, e.g., a road is maintained well, its statistical value would decline over time if the applied depreciation rate does not fully incorporate maintenance efforts. In any case, it should be clear that these public capital stock measures are necessarily only crude proxies for the true public capital stock. Furthermore, since capital is valued at production costs, these data do not give us any indication of the quality of the public capital stock.

Physical measures of countries' infrastructure point to substantial differences in levels of public capital (see Annex). The amount of motorways, railways and households with internet access vary considerably between countries. Measures of

[6] It is assumed that the depreciation rate for government capital increases from 2.5% in 1960 to 4.8% in 2014. The increasing depreciation rate may reflect an increasing weight of assets with relatively short asset lives or a shortening of asset lives, which are both characteristic of information and communication technology -related assets. Differences in the composition of the capital stock across countries are ignored due to lack of data. More details on the calculation of capital stocks, as well as the capital stock series themselves, are provided in De Jong et al. (2017) and references therein.

physical infrastructure are, not surprisingly, strongly related to country and population size. At a given population size, larger countries tend to have more kilometres of roads and railways; likewise, holding country size constant, countries with larger populations tend to have more kilometres of roads and railways. Of course, length of networks is only a rough measure of the economic relevance, as it is not a complete measure of network size (e.g., no distinction is made between a two-lane and a four-lane motorway), nor does it take the quality of the network into account. Concerning digital connectivity, income per capita appears to be an important driver of country differences.

According to survey data, the quality of infrastructure recently improved in most countries, although there are some exceptions. The World Economic Forum surveys business executives worldwide on a broad range of economic topics in the context of its Global Competitiveness Reports (World Economic Forum 2015 and earlier editions), among which the quality of infrastructure in their respective countries (see Annex). The World Bank asks international freight forwarders to rate the quality of trade and transport related infrastructure in countries their companies serve most, as part of its Logistics Performance Index (World Bank 2014 and earlier editions). Both surveys show that, overall, the perceived quality of infrastructure in Europe seems to have improved since 2006/2007. Notable exceptions are Germany, France and Denmark, where business executives have become less satisfied with infrastructure quality, albeit from a high level. Satisfaction with the quality of roads has suffered markedly in these three countries, but there has been a worsening of the perceived quality of other elements of infrastructure, such as railways, waterways or air transport infrastructure, as well. Freight forwarders were most critical of developments in Austria and Finland. Germany, France and Denmark actually performed similar or even slightly better in 2014 compared to 2007. The conflicting outcomes on both surveys underline that the survey results should be interpreted with great caution though.

# 3 Literature overview

There is a substantial, largely empirical, literature aiming to quantify the economic importance of public capital. One major branch focuses on partial effects of public capital, in particular on the contribution of public capital or investments to either output production or cost-reduction. The second major branch of the literature aims to provide a broader picture by taking into account feedback effects from higher public capital or investments on the rest of the economy. Two common methods for incorporating feedback effects are estimation of Vector Autoregressive models (VAR) and the use of structural macroeconomic models. This section gives a brief overview of some theoretical considerations, as well as of recent empirical research on the relationship between public investment or capital and output.

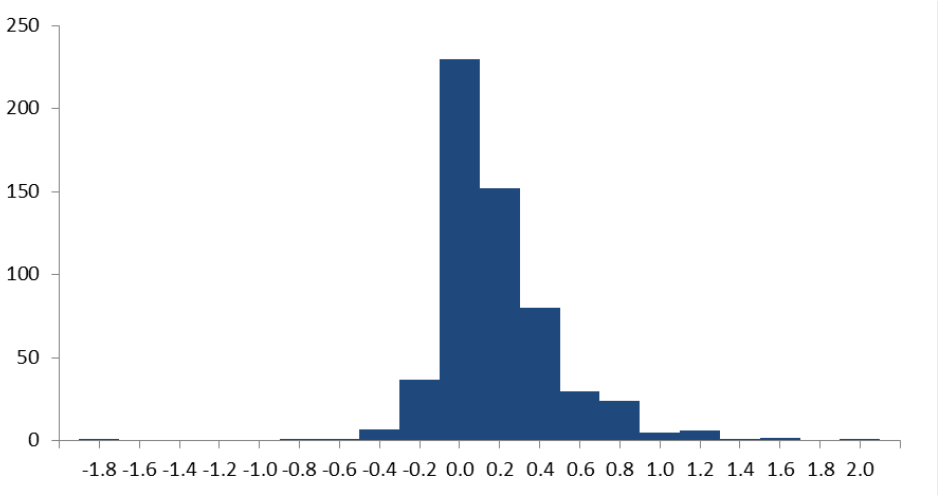
## 3.1 Partial equilibrium effects

In the so-called 'production function approach', a production function is estimated with public capital added as a separate production factor. Alternatively, the 'cost function approach' takes into account the role of factor prices as well, with public capital as a production factor that is available for free. The cost function approach offers some insight into firms' behaviour, whereas the production function merely focuses on the technical process of output production.

**Chart 4**

Production function estimates of the output elasticity of public capital

(frequency of estimates)




Source: based on data from Bom and Ligthart (2014b).

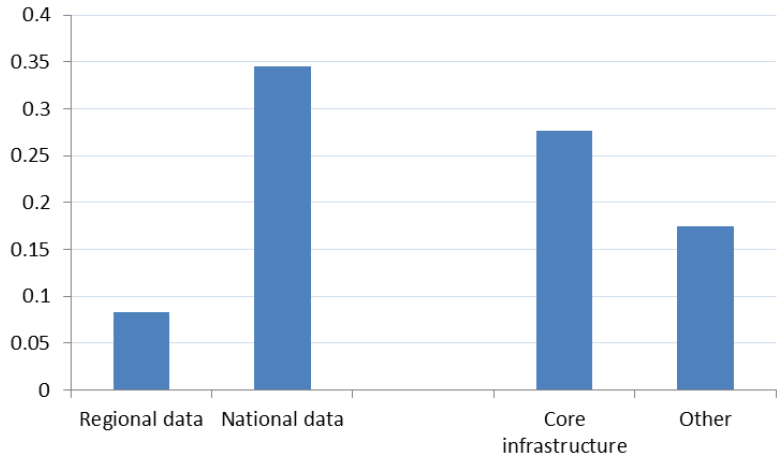
Pereira and Andraz (2013), European Commission (2014) and Romp and De Haan (2007) provide extensive reviews of the empirical literature on public capital and

growth. Overall, the literature provides mixed evidence on the economic importance of public capital. To illustrate the point, Chart 4 shows published estimates[7] of public capital output elasticities, taken from 68 papers published between 1983 and 2008 (data are from Bom and Ligthart, 2014b).[8] Values run from −1.7 to 2.04, with the average output elasticity of public capital after correcting for publication bias at 0.106.

**Chart 5**

Production function estimates of the output elasticity of public capital (subsamples)

(average estimated elasticity)




Source: based on data from Bom and Ligthart (2014b).

The estimates vary considerably over time, location, level of aggregation, measure of public capital or estimation method. Nevertheless, some important lessons can be learned from the past literature. First, public capital tends to contribute positively to output. In this regard, core infrastructure (roads, railways, telecommunications, etc.) is reported having a relatively stronger output impact as compared to other investments in physical capital (see Chart 5). Second, the effects of public capital are generally found to be lower for regions within countries than for countries as a whole, suggesting the presence of cross-border spill-overs[9] which could emerge given the network characteristics of, for example, road and telecommunications infrastructure (see Chart 5). Third, there is evidence showing that the contribution of public capital to growth has declined over time (see Chart 6). This finding could be attributed to

[7] We greatly thank Pedro Bom (University of Vienna) for sharing the data.

[8] Caution is warranted in interpreting the data in Charts 4-6, since data are not adjusted for publication bias.

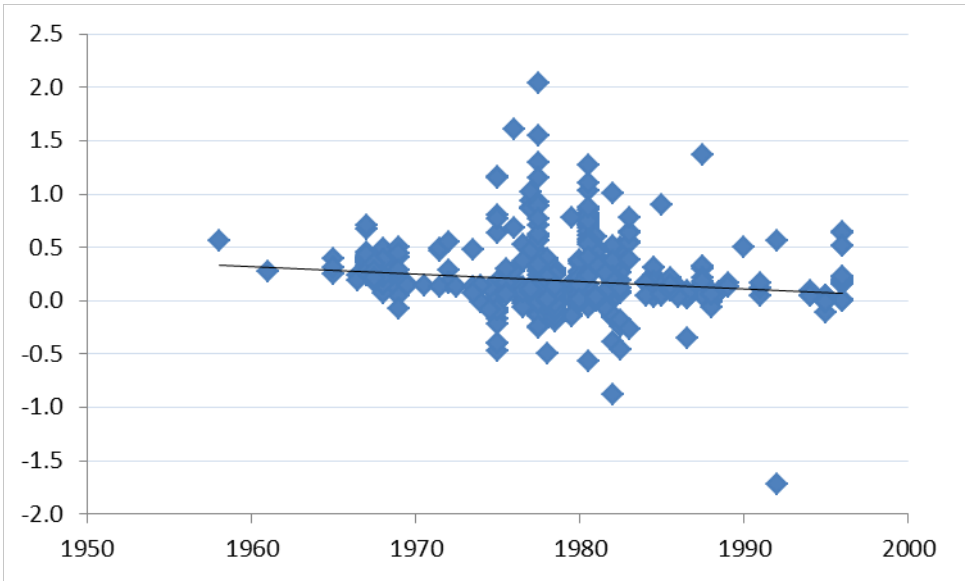
[9] A number of studies find evidence for spill-overs between U.S. states stemming from public investments in infrastructure (Andraz and Pereira, 2004; Cohen and Morrison Paul, 2004) or infrastructure maintenance spending (Kalyvitis and Vella; 2012). Pereira and Roca-Sagalés (2003) and Sagalés and Lorda (2006) report on spill-overs of public capital formation between Spanish regions. Di Giacinto et al. (2013) investigate spill-over effects of public transport infrastructure between Italian regions. The evidence from regional studies on the existence of spill-overs, however, is far from uniform and the available evidence should be interpreted with caution. Some authors have pointed to the possibility of aggregation bias or did not find evidence for spill-overs (see Creel and Poilon (2008) for an overview). De la Fuente (2010) in a survey finds that public capital variables are almost always significant in panel data specifications for the Spanish regions, and often insignificant in similar exercises conducted with US data, which could possibly be related to the difference in maturity of infrastructure networks in both countries.

maturing infrastructure networks in most developed countries, where gains from additional roads, railway connections or power lines which are built more recently are likely to be smaller than in the past.[10] Another potential, more technical explanation is that early empirical studies sometimes ignored endogeneity or non-stationarity of the data, biasing estimates upwards (Bom and Ligthart, 2014b).

**Chart 6**

Production function estimates of the public capital elasticity of output by median year of sample

(estimated elasticity)




Source: based on data from Bom and Ligthart (2014b).

## 3.2 Studies estimating general equilibrium effects

The production and cost function approaches provide useful information on the macroeconomic production process and firm behaviour, but only highlight the benefits of public investment or public capital. More is always better, as more public capital will increase output and lower costs, ceteris paribus. However, a government facing the decision whether to invest more or not has to trade off these extra investments against lower consumption expenditures, higher taxes or an increase in the debt level. In order to shed light on this trade-off, we need insights on the dynamic relationship between public investments/capital and growth. In this regard, the analysis can benefit from application of VARs and structural macro models.

[10] On the other hand, one could argue that with more productive labour and new technological possibilities the economic value of some investments, e.g. in internet connections, could actually have increased.

### 3.2.1 VARs and other direct approaches

VAR-based analysis features a number of advantages. First, in contrast to the production function and cost function approaches, VAR models do not impose causal relationships between variables a priori; rather they allow for testing of the existence of causal relationships in either direction. For example, next to finding that infrastructure positively affects income growth, it could be envisaged that with income the demand for adequate infrastructure rises. Second, VAR models allow for indirect links between all the variables in the model, hence, the long-run output effect of a change in public capital results from the interaction of all the considered variables. Third, VARs do not a priori restrict the number of long-run relationships in the model, instead they can be consistently tested in the data (Kamps, 2005). On the downside, the VAR approach faces shock identification issues and often lacks a clear structural interpretation of the estimated relationships in the model. Furthermore, the so-called issue of 'curse of dimension' often limits the number of endogenous variables that can be included in the model.

One of the most cited papers in the literature employing the VAR approach is Kamps (2005). He estimates country-specific VAR models for 22 OECD countries using his constructed database on public capital stocks (see Kamps (2006) for details). In each country-specific VAR, next to the net public capital stock, Kamps (2005) includes the net private capital stock, the number of employed persons and real GDP. The VAR model-based simulations reveal that an increase in public capital seems to contribute to economic growth, but less so than often reported in studies utilizing the production-function approach. This finding points to the importance of feedback effects from output to public capital for which partial equilibrium analysis fail to account. Furthermore, public and private capital stocks are found to be long-run complements in the majority of countries.

Evidence on the output effects of public investments found in the empirical literature employing the VAR approach remains mixed though. Jong-A-Pin and De Haan (2008) extend the analysis by Kamps (2005), only partially confirming his findings. Using hours worked as a measure for labour input, they find a positive effect of public capital on output in some, but by no means all countries. In some cases the estimated effects are found to be negative. In addition, using a rolling-window panel VECM Jong-A-Pin and De Haan (2008) find that the long-run output impact of a shock to public capital did decline between 1960 and 2001. A more recent study, by Broyer and Gareis (2013), uses data for 1995–2011 and finds very strong positive effects for infrastructure expenditures in the four largest euro area countries.

Lastly, based on data for 17 advanced OECD economies over 1985–2013, IMF (2014) directly estimates the relationship between public investments and output growth in a panel setting and finds strong positive output effects of public investment. Interestingly, these effects appear to be particularly strong during periods of low growth and for debt-financed shocks, but are not significantly different from zero if carried out during periods of high growth or for budget-neutral investment shocks.

### 3.2.2 Macroeconomic structural models

In structural macroeconomic models, the public capital stock is typically incorporated as an additional production factor, next to the private capital stock and labour, by augmenting the production function (Leeper et al, 2010; Bom and Ligthart, 2014a; Baxter and King, 1993). In comparison to VAR models, structural models provide a richer and economically intuitive framework for analysing public investment effects, but often at the cost of imposing restrictions on the data. Clearly, the predictions of a particular model would largely depend on specific, often somewhat subjective, modelling choices. As a result, in structural model simulations, public investments indeed (by construction) often outperform government consumption in terms of positive output effects (e.g., Leeper et al. (2010) and Elekdag and Muir (2014)). There is, nevertheless, a growing literature attempting direct estimation of the relevant parameters. For example, in an extended version of the New Area-Wide Model, while still largely calibrating public capital to be productive, Coenen et al. (2013) estimate the elasticity of substitution between private and public capital. The estimation results point to a moderate complementarity between private and public capital stocks. Ercolani and Valle e Azevedo (2014) estimate a RBC model using US data and find that the preferred model specification is one where public investment is unproductive, i.e. the public capital stock does not have direct supply-side effects.

A general equilibrium modelling framework allows explicit analysis of the sensitivity of output effects of public investment to alternative policy simulation environments, such as the monetary policy stance or the way public investments are financed. For example, at the current juncture, many countries have limited, if any, fiscal room for manoeuvre, hence, they may only consider a budget-neutral expansion in public investment. In this regard, Warmedinger et al. (2015) report that in many structural models short-run public investment multipliers are typically larger than tax multipliers and conclude that the financing of additional investment with tax increases would contribute to higher output. On the other hand, Bom and Ligthart (2014a), using a dynamic general equilibrium model of a small open economy, show that in case additional public investment expenditures are financed by higher distortionary labour taxes output may decline in the short run, even when output does increase in the long run. In their model, the tax increase induces households to significantly reduce labour supply following the shock whereas the public capital stock increases and its beneficial supply-side impact materialises only slowly.

Another important consideration is that, in practice, it takes some time before investment plans are actually carried out. Leeper at al. (2010), in a closed-economy model, therefore allow for implementation delays in public investments. Implementation delays result in muted positive or potentially even negative responses in output and labour in the short run. Because it takes less time to build private capital, agents postpone investment until public capital significantly raises the productivity of private production inputs. Elekdag and Muir (2014) generalise the model of Leeper et al. (2010), employing a multi-region DSGE model and allowing for liquidity-constrained households and accommodative monetary policy. They confirm findings by Leeper et al. (2010) but show that accommodative monetary

policy can overturn the short-run contractionary effects from an increase in public investments.

# 4 VAR-based estimates of the effect of public capital on output

## 4.1 Model selection

To analyse dynamic effects of public capital on output we follow the approach used by Kamps (2005) and Jong-A-Pin and De Haan (2008). For each country included in the analysis[11] we specify a VAR model containing public (KGV) and private (KPV) capital, total hours worked (THW)[12] and real GDP as endogenous variables, and estimate this for the period 1960–2013.

A VAR model in its general form, ignoring deterministic elements, can be written as follows:

$$z_t = \mathrm{A}(L)z_t + \varepsilon_t,$$

where $z_t$ is a vector of endogenous variables and $\mathrm{A}(L)$ is a matrix of a polynomial order $\mathrm{p}$ (number of lags). $\varepsilon_t$ is a vector of reduced form i.i.d. residuals, with $\mathrm{E}(\varepsilon_t) = 0$, $\mathrm{E}(\varepsilon_t\varepsilon_t') = \Omega$ and $\mathrm{E}(\varepsilon_t\varepsilon_t') = 0$ for $\mathrm{s} \neq t$, with $\Omega$ a $(k \times k)$ symmetric positive definite matrix, k denoting the number of endogenous variables in vector $z_t$.

In order to gauge the long-run effects of public capital, it is sufficient to estimate an unrestricted VAR in levels. The OLS estimator for the autoregressive coefficients in such a model is consistent and asymptotically normally distributed, even in case where some variables are integrated or cointegrated. Therefore, a VAR in levels can be used to investigate the properties of the data and construct a valid empirical model. However, the consistency of estimates for the autoregressive coefficients does not carry over to the impulse response functions (IRFs) obtained from unrestricted VARs in levels. IRFs are inconsistent at long horizons if non-stationary variables are included (Phillips, 1998). To this end, a VAR model of order $\mathrm{p}$ can always be written in the form of a VECM:

$$\Delta z_t = \Gamma(L)\,\Delta\, z_t + \Pi z_{t-1} + \varepsilon_t,$$

where $\Gamma(L) \equiv \sum_{i=j+1}^{p} A_i$ (for $j = 1,2,\dots,p-1$) and $\Pi \equiv -\mathrm{I} + \sum_{i=1}^{p} A_i$ are matrices of coefficients. If matrix $\Pi$ has a rank of $0 < r < k$, $r$ linearly independent cointegrating vectors exist. In this case, a VECM is estimated. If the rank of $\Pi = 0$ , the non-stationary variables (in levels) are not cointegrated and a VAR in first differences is considered. If the rank of $\Pi = \mathrm{k}$ , all series are stationary in levels (i.e., $\mathrm{I}(0)$) and a VAR in levels is considered.

[11] Austria, Belgium, Denmark, Germany, Greece, Finland, France, Ireland, Italy, the Netherlands, Spain and Sweden.

[12] Kamps (2005) uses total employment as a measure of labour input.

**Table 1**

Summary statistics of the selected models

| Country | Sample period | Model type | # Lags | # Cointegr. Rel. | Johansen model type | Deterministic terms | Test-statistics | | Diagnostics | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Trace | Max. Eigenval | J-Bera | 1st order ac |
| AT | 1963-2013 | VECM | 2 | 2 | 4 | dummy 75-13, dummy 98-13 | 2 | 3 | 5.00 | 20.78 |
| BE | 1965-2013 | VECM | 1 | 1 | 4 | dummy 66, dummy 1972 | 1 | 1 | 10.24 | 12.33 |
| DK | 1966-2013 | VECM | 1 | 1 | 3 | dummy 90-93, dummy 2009-14 | 2 | 1 | 1.65 | 18.36 |
| FI | 1964-2013 | VECM | 3 | 1 | 3 | dummy 90-93, dummy 09, dummy 93-13 | 1 | 1 | 6.86 | 13.38 |
| FR | 1962-2013 | VECM | 1 | 2 | 4 | dummy 73, dummy 75, dummy 84-13 | 2 | 2 | 4.18 | 20.51 |
| DE | 1963-2013 | VECM | 2 | 2 | 4 | dummy 90-13, dummy 09-13 | 2 | 2 | 7.59 | 17.67 |
| EL | 1962-2013 | VECM | 1 | 2 | 4 | dummy 74-13, dummy 09-13 | 2 | 2 | 3.69 | 22.79 |
| IR | 1965-2013 | VECM | 1 | 1 | 4 | dummy 94-13, dummy 08-13 | 1 | 1 | 13.58* | 25.93* |
| IT | 1963-2013 | VECM | 2 | 1 | 5 | dummy 68, dummy 75, dummy 09 | 1 | 1 | 5.79 | 24.52* |
| NL | 1962-2013 | VECM | 1 | 1 | 4 | dummy 09 | 1 | 0 | 4.43 | 7.61 |
| ES | 1964-2013 | VECM | 3 | 2 | 3 | dummy 09 | 2 | 2 | 4.97 | 22.36 |
| SE | 1962-2013 | VECM | 1 | 2 | 4 | dummy 91-93, dummy 09 | 2 | 3 | 8.27 | 23.33 |

Source: authors' calculations.
Notes: Johansen model types refer to: 3 = model with intercept in cointegration relation and in VAR; 4 = intercept and trend in cointegration relation, intercept in VAR. Dummies with a single number are equal to 1 in the year mentioned, 0 otherwise. Dummies with two numbers added are 1 from the first year mentioned onwards, 0 before. Columns 'Trace' and 'Max. Eigenval.' show selected number of cointegration relations from Johansen cointegration tests, either according to the trace statistic or the maximum eigenvalue statistic. The Jarque-Bera statistic tests for normality of residuals, with as null hypothesis that residuals are multivariate normal, 8 degrees of freedom. The serial correlation LM statistic tests for first order autocorrelation, with a null of no autocorrelation. * Significant at 10%, ** significant at 5%, *** significant at 1%.

Table 1 provides an overview of the selected empirical models, as well as some diagnostic checks on these models. For all countries, the estimated impulse responses are non-explosive, nor oscillate too heavily to prevent results from being interpretable. We include a constant in both the cointegration relation and the VAR, and in a number of cases a trend in the cointegration relation. In most models, we also included some additional deterministic elements to allow for breaks in trends or to correct for observations in specific years to account for specific events. These specific events include, for example, privatisation in Austria from 1998 onwards, the reunification of Germany in 1990 and the global economic crisis from 2009 onwards. As regards the number of lags, to ensure a parsimonious use of degrees of freedom we choose the model specification with the lowest number of lags that is not suffering from too strong autocorrelation.

The number of cointegration relations is a priori unknown; however, economic theory suggests constancy of the great ratios. Therefore, public capital to output and private capital to output could well form cointegrating relations. Furthermore, if technology behaves as a trend-stationary process, the macro-economic production function describes another cointegrating relation. With potentially up to three cointegrating relations, which is the maximum in our four-variable framework anyway, we need to resort to formal testing. Table 1 shows the test results of the Johansen's cointegration test. In about half of the cases, the trace and maximum eigenvalue statistics agree on the number of cointegration relations. For countries where both tests return different results, we generally follow the outcomes of the trace test as this test is more robust to non-normality (Cheung and Lai, 1993).

Lastly, analysis[13] of the residuals of the selected models suggests that the models are well specified. Normality of residuals cannot be rejected in nearly all cases, while there is no strong evidence for first order autocorrelation in the residuals of any model.

## 4.2 Simulation results

Chart 7 shows the GDP responses to a shock in the public capital stock based on the estimated country-specific VAR models. To orthogonalise shocks, a Cholesky decomposition of the residual covariance matrix is applied. The variables are ordered as follows: real public capital, real private capital, total hours worked and real GDP. This particular ordering assumes that public capital contemporaneously influences other variables, but is not contemporaneously influenced by the others. Government spending is largely considered to be unrelated to current period business cycle developments and there are considerable implementation time lags related to capital projects in the public sector. Similar considerations also hold for the private capital, except that it is contemporaneously affected by the public capital stock. While labour market developments are found to be highly pro-cyclical they tend to lag behind output developments. As the production function shows, three inputs have the contemporaneous effect on output, therefore, real GDP is ordered last in our specification.

Overall, similar to Kamps (2005), public capital seems to be productive for most of the countries included in the sample as evidenced by the positive long-run impact of a one standard deviation shock in public capital on GDP. As in the previous studies, these effects are not shown to be significant at 95% confidence interval over a longer horizon for many countries in the sample. Notable exceptions are Austria, Greece and Sweden.[14]

Regarding the response of other endogenous variables included in the analysis, private and public capital are found to be complements as evidenced by a positive response of private capital to a shock in public capital in several countries. The overall response of private capital to a shock in public capital is determined by the relative strength of two opposing factors (Baxter and King, 1993). First, there is a crowding out effect of additional public investment implied by a reduction in the resources available for financing private sector investment projects. Second, higher public capital boosts marginal productivity of private capital which stimulates demand for private investment. As regards the reaction of hours worked, our measure of labour input, in most cases we find responses that are negative or very close to zero, suggesting that additional public capital is not beneficial for employment. As Kamps

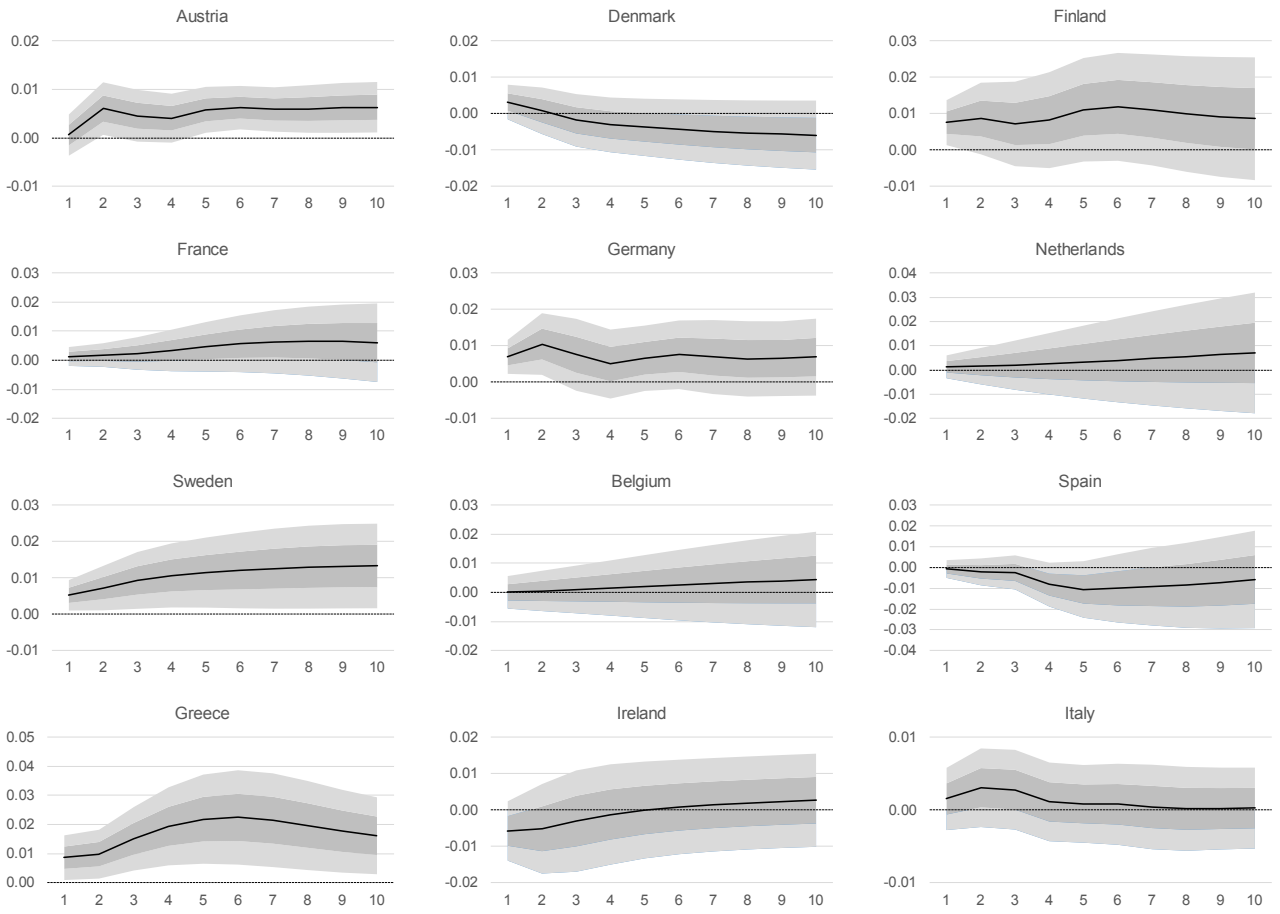
[13] Due to space limitations we do not report results of the model specification tests in the paper. They can be obtained from the authors upon request.

[14] Confidence intervals for impulse responses from VAR-models are notoriously wide (see e.g. Runkle, 1987), as the uncertainty on each model parameter translates into uncertainty around the impulse response. Therefore Kamps (2005), e.g., following up on Sims and Za (1999) presents 68%-confidence intervals. If we would apply this level of strictness, more results would be considered significant.

(2005) suggests, the reaction of labour might depend on the way the new public investments are financed (distortionary versus non-distortionary taxes).

**Chart 7**

Responses of GDP to a shock to public capital stock




Source: authors' calculations.
Note: Solid lines plot the impulse responses of GDP to a Cholesky one standard deviation public capital shock. Shaded areas mark a one standard deviation (dark grey) or two standard deviation (light grey) distance from the baseline impulse response. Standard deviations are obtained by bootstrapping the impulse response functions (1000 replications).

Chart 8 shows estimates of the general government capital multiplier[15] for the euro area and the weighted average of multipliers for individual countries for different years.[16] The higher multiplier for the euro area over the longer term could be interpreted as evidence of cross-country spill-overs of public investments, but as mentioned above this evidence should be interpreted with caution.

[15] Note that in contrast to Chart 7, the multiplier scales the GDP response to a public capital shock to the public capital shock itself. The interpretation of the bars in Chart 8 reads: if public capital stock increases by 1 euro, GDP increases by X euros.

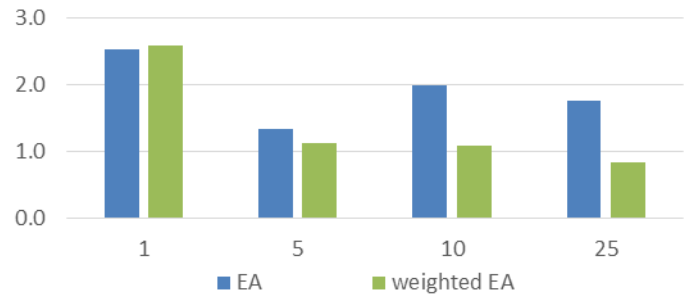
[16] The model for the euro area as a whole is a VECM, estimated over the period 1962–2013, with one lag and two cointegrating vectors. The cointegration relation contains an intercept and a trend, while the VAR has an intercept (Johansen model type 4). Dummies for 1973 and 1975 are included. Both the trace and the maximum eigenvalue statistic point in the direction of two cointegrating vectors. Normality and absence of first order autocorrelation of residuals cannot be rejected at the 10% significance level. The euro area comprises ten countries for which data are available: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands and Spain. In Chart 8, the GDP response is expressed relative to the public capital stock response and scaled by the capital-to-GDP ratio.

To see whether the impact of public capital has changed over time, especially during the recent crisis, we turn to recursive VAR estimates, following a similar approach as Jong-A-Pin and De Haan (2008). The optimised models based on the overall sample are also applied to a subsample 1960–2007, i.e. ending before the crisis. There is considerable heterogeneity across countries, and for some countries over time (see Chart 9). However, we find no systematic evidence that public capital has become more productive in recent years. Specifically, an increase in productivity of the public capital stock would be expected if public investment cuts following the crisis targeted less productive projects or if a significant investment gap emerged. Nevertheless, the difference in time periods considered is relatively limited and it is conceivable that the long run consequences have not fully materialized yet.

**Chart 8**

Implied multipliers in the euro area

(multiplier)

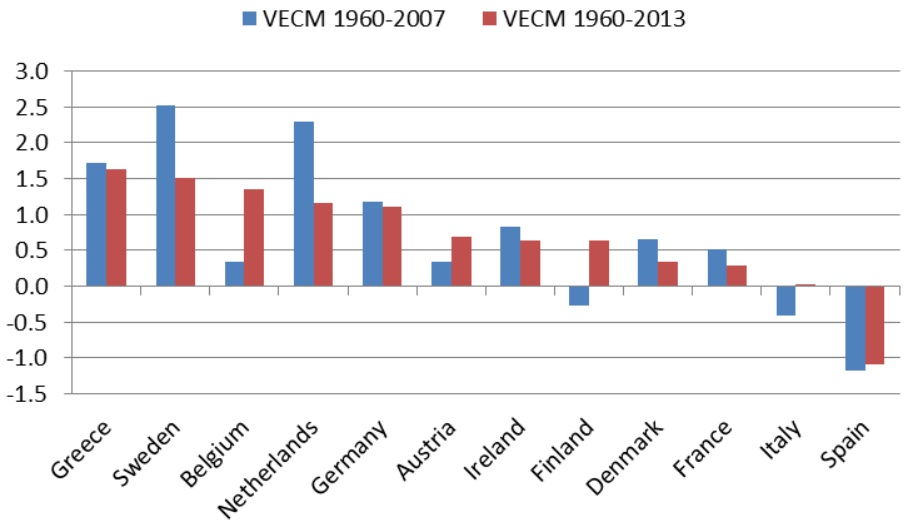



Source: authors' calculation

**Chart 9**

Recursive VAR estimates

(long-run response of GDP to change in public capital)




Source: authors' calculation.
Note: numbers denote long-run (100 year) responses of GDP to a Cholesky one standard deviation innovation in public capital.

# 5 Structural model-based simulations

This section discusses macroeconomic implications of a public investment shock in a general equilibrium micro-founded modelling framework. To this end, we apply the Euro Area and Global Economy (EAGLE) model (a basis version is due to Gomes at al. (2010)) calibrated for Germany, Rest of the Euro Area, the United States and Rest of the World. Thanks to its sound theoretical foundation, the model facilitates robust policy analysis under alternative scenarios and economic structures. Given its global dimension, the model is, in particular, suited to assess potential cross-border spillovers and gains from policy coordination.

The fiscal sector representation in the EAGLE model is standard in this class of macro models. The exception is due to recent enhancement of the fiscal bloc which allows for government consumption and investment to play a nontrivial role in affecting the optimal decision-making of the private sector. In this regard, we first provide a brief overview of the fiscal sector representation in the EAGLE model. Next, we describe model-based scenarios and discuss the implied simulation results.

## 5.1 Fiscal sector in EAGLE: an overview

Unlike modelling of private sector behaviour, fiscal policy in the EAGLE model is not based on any explicit optimal decisions. Fiscal authorities set government expenditures proportional to nominal output based on the relevant long-term GDP shares observed in the data. Similarly, on the revenue side, taxes are tied to the relevant tax bases via exogenous tax rates. The government may have a non-zero debt in equilibrium. Stability of the government debt is ensured by an endogenous response in one of the fiscal policy instruments to actual government debt deviations from its long-term value (the fiscal rule).

In terms of the overall government budget, the key expenditure items are government consumption and investment (respectively, $C_{G,t}$ and $I_{G,t}$), which are purchased at price $P_{G,t}$, and transfers to households ($TR_t$). Both consumption and investment public goods are composites of domestic nontradable intermediate goods only, i.e. have zero import content. The main revenue sources are due to taxation of private consumption, labour income, capital income and dividends applying the respective tax rates $\tau_{C,t}$, $\tau_{N,t}$, $\tau_{K,t}$, and $\tau_{D,t}$. Moreover, labour income is subject to a social contribution tax paid by households ($\tau_{Wh,t}$) and firms ($\tau_{Wf,t}$). Additional sources of fiscal revenues are due to seigniorage from a change in money holdings ($M_t - M_{t-1}$) and non-distortional taxes ($T_t$). Finally, each period the fiscal authorities issue new government bonds ($B_{t+1}$) at a riskless interest rate ($R_t$) in order to refinance its old debt ($B_t$) and to close the gap between expenditures and revenues:

$$P_{G,t}\left(C_{G,t} + I_{G,t}\right) + TR_t = \tau_{C,t}P_{C,t}C_t + \left(\tau_{N,t} + \tau_{Wh,t} + \tau_{Wf,t}\right)W_tN_t + \tau_{K,t}\left(R_{K,t}u_t - \left(\Gamma_{u,t} + \delta_P\right)P_{I,t}\right)K_t + \tau_{D,t}D_t + T_t + \left(B_{t+1}/(1+R_t) - B_t\right) + \left(M_t - M_{t-1}\right),$$

where $P_{C,t}$ and $P_{I,t}$ are the private consumption and investment deflators respectively, $C_t$ is the real private consumption, $W_t$ is the nominal wage rate, $N_t$ is the number of hours worked, $R_{K,t}$ is the nominal capital rental rate, $u_t$ is the capital utilisation rate, $\Gamma_{u,t}$ is the cost of varying the capital utilisation rate, $\delta_P$ is the private capital stock depreciation rate.

Government consumption and investment as well as transfers to households are specified as a fraction of the potential nominal GDP. The implied automatic stabilisers on the expenditure side, thus, support a counter-cyclical response of fiscal policy to shocks. In the reported model-based simulations the fiscal authorities set the expenditure rates and the distortionary tax rates exogenously. These expenditure/tax rates are assumed to follow an autoregressive process of order 1:

$$x_t = (1 - \rho_x)x + \rho_x x_{t-1} + \varepsilon_{x,t},$$

where $x_t$ is a fiscal expenditure/tax rate with its value in the steady-state denoted by $x$, $\rho_x$ is the persistency parameter, $\varepsilon_{x,t}$ is a shock term. Stability of the government debt is ensured via an endogenous reaction in the non-distortionary taxes to deviations of the government debt-to-GDP ratio from its targeted value.

The role of the government consumption and investment is enhanced in the model in line with Leeper et al. (2010). More specifically, it is assumed that government capital stock is an important factor of production. Consequently, variations in public investment have strong and persistent supply-side effects. More formally, the intermediate-good production technology is specified as follows:

$$Y_t = z_t(K_{P,t})^{\alpha}(K_{G,t})^{\beta}(N_t)^{(1-\alpha-\beta)},$$

where $Y_t$ is output, $z_t$ is total factor productivity, $K_{P,t}$ and $K_{G,t}$ are the private and government capital stock respectively, and $\alpha$ and $\beta$ are the output elasticity parameters of the private and government capital stock respectively.

The government capital evolves by accumulating government investments net of depreciation:

$$K_{G,t} = (1 - \delta_G)K_{G,t-1} + I_{G,t}\varepsilon_{I_G,t},$$

where $\delta_G$ is the government capital stock depreciation rate and $\varepsilon_{I_G,t}$ is the government investment efficiency shock.

The value of the output elasticity determines the productivity of public capital (when $\beta = 0$, government investment does not feature any direct supply-side effects as the entire government capital stock is not productive). Variation in the investment efficiency shock controls the extent to which new investment expenditures contribute to the productive public infrastructure. Furthermore, for a given government investment-to-GDP ratio, the government capital stock level relative to GDP can be inversely determined by varying the capital depreciation rate: a higher rate of depreciation implies a lower government capital stock-to-GDP ratio in equilibrium. The specific values of the parameters used in the baseline model simulations are similar to those used in Leeper et al. (2010): $\alpha = 0.3$, $\beta = 0.1$, $\delta_G = 0.025$.

Finally, households are assumed to derive utility from the consumption of a composite good consisting of private and public consumption goods. As a result of the assumed complementarity between private and public consumption goods, changes to public consumption have persistent effects on private consumption:

$$CC_t = \left( \nu^{\frac{1}{\mu}} C_{P,t}^{\frac{\mu-1}{\mu}} + (1-\nu)^{\frac{1}{\mu}} C_{G,t}^{\frac{\mu-1}{\mu}} \right)^{\frac{\mu}{\mu-1}},$$

where $CC_t$ is a composite consumption good, $C_{P,t}$ and $C_{G,t}$ are private and government consumption goods respectively, $\nu$ is the steady-state share of private goods in the consumption basket (when $\nu = 1$, government consumption yields no utility to households), $\mu$ is the elasticity of substitution between government and private consumption ($\mu \to 0$ implies that government and private goods are perfect complements; $\mu \to \infty$ implies that government and private goods are perfect substitutes). The specific values of the parameters used in the baseline model simulations are in line with the euro area estimates reports in Coenen et al. (2013): $\nu = 0.75$ and $\mu = 0.5$.

## 5.2 Model-based scenario analysis

All scenarios considered in this subsection feature a transitory, but persistent, ex-ante increase in government investment: government investment is increased by 1 percent of the initial GDP over 20 quarters; thereafter the government investment-to-GDP ratio returns to its baseline level gradually, assuming a decay factor of 0.9. The fiscal rule, based on the adjustment of non-distortionary taxes, remains inactive during the first 10 years of the simulation period.

In our benchmark scenario the increase in public investments is implemented only in the domestic economy (Germany[17]) and is not compensated by any equivalent discretionary reduction in other government expenditures or an increase in tax rates. Thus, the implied deterioration in the government budget is financed by raising government debt. Furthermore, in line with the current ECB's monetary policy stance of forward guidance and implementation of other non-standard monetary policy measures at the zero lower bound, the monetary policy is assumed to accommodate the expansionary fiscal shock in the short run (up to 8 quarters following the shock), i.e. the common interest rate does not increase in response to the implied changes in the euro area macroeconomic developments. Importantly, the accommodative stance of the monetary policy is fully anticipated by households and firms.

To assess the sensitivity of the simulation results with respect to the assumption about sources of financing of the government investment increase, we consider alternative scenarios where higher investment expenditures are compensated by an equivalent reduction in government consumption, or by an increase in the labour income tax or consumption tax. We investigate under what conditions and to what

[17] The simulations should be considered illustrative for the economic channels involved, rather than country specific.

extent an increase in government investment could be self-financing, i.e. would not result in an upward adjustment of the government debt level. Moreover, robustness of the estimates of the effects on GDP and the public debt level is evaluated by considering alternative assumptions about the sensitivity of output with respect to the government capital stock, the initial level of the government capital stock, the efficiency of government investment, the share of liquidity–constrained households in the economy, the role of monetary policy accommodation, and implications of cross-border policy coordination.

The simulation results of the alternative scenarios reveal that the positive shock to government investment features both demand-side and supply-side effects. In the short run, it boosts demand for final goods and exerts upward pressure on prices. The implied higher demand for factors of production (an increase in labour demand and capital utilisation) lifts labour income and returns on the private capital stock, which in turn stimulate an increase in domestic consumption and investment. The foreign trade balance deteriorates in the short run reflecting both the increase in the domestic absorption and price competitiveness losses. In order to absorb excess supply in the tradable sector, the nominal euro exchange rate depreciates on impact which has beneficial, albeit transitory, implications for the rest of the euro area economy. Over a longer-term horizon, the gradual build-up of the government capital stock expands the productivity frontier of the domestic economy. As a result, domestic output features a persistent increase. The inflation rate returns to the target level as, starting from the third year, the monetary policy stance turns more restrictive. In line with the implied productivity boost, the relative price of exports falls (terms-of-trade deteriorates), real exports gain strength and the trade balance improves in the medium run. Clearly, the strength and timing of the demand and supply-side effects of the government investment shock on the macroeconomic and fiscal developments depend on the specific assumptions underlying the policy scenario. In what follows, we discuss the importance of these assumptions for the simulation results in detail.

## 5.3 Alternative sources of financing

The macroeconomic impact of a positive government investment shock assuming alternative financing sources is displayed in Chart 10. In case of the debt-financed scenario (benchmark) the shock implies a large positive impact on domestic GDP already in the short run. Over the medium run, output expands further to almost 2 per cent above its baseline value. The inflationary pressure and expansion in domestic demand result in a cyclical increase in tax revenues and limit the deterioration of the government deficit implied by higher investment expenditures. The government debt-to-GDP ratio, due to a favourable denominator effect, falls in the short run and increases only moderately over the medium run.[18]

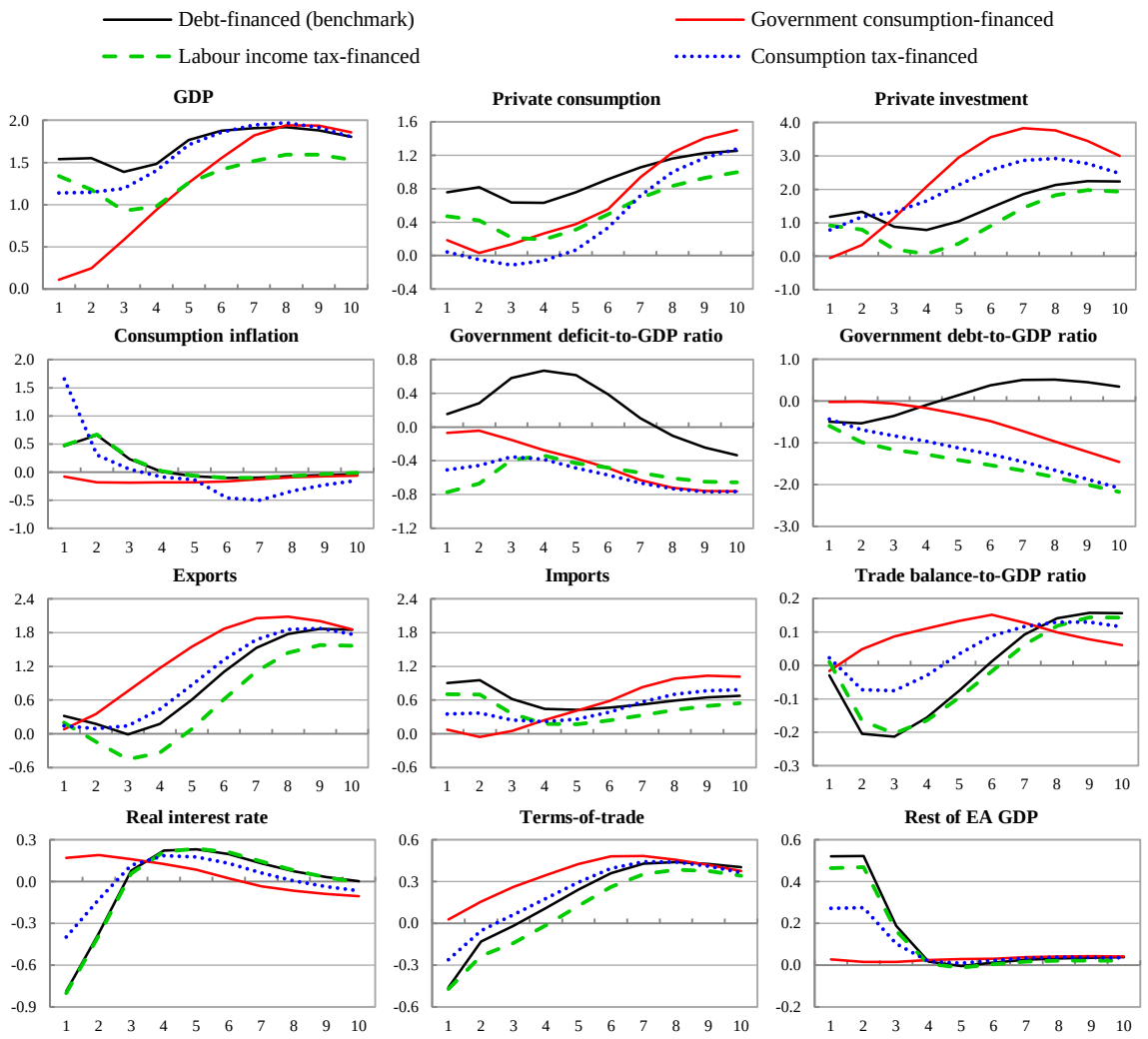
[18] Since the government by assumption finances its debt at a risk free rate, possible risk premium effects from a deteriorating debt outlook are ignored in these simulations.

## Chart 10

Macroeconomic impact of a government investment shock under alternative financing

**Over 10 years**

(percentage (points) deviations from the baseline)




Source: authors' calculations with EAGLE model.
Note: The chart shows the percentage (percentage-point, in case of inflation, interest rate and GDP ratios) deviations from the baseline of some selected macroeconomic variables over a period of 10 years.

If the increase in government investments is instead financed by an equivalent (ex ante) reduction in government consumption (1 per cent of GDP), the positive demand effects of the government investment shock would be essentially neutralised. Hence, under such a scenario, the output gains materialise more gradually and, in line with positive supply-side effects, the impact on inflation will be predominantly negative, albeit moderate. The implied real interest rate increases in the short run and has a negative impact on private consumption and investment. The weakness of private consumption can be also attributed to the assumed complementarity between private and government consumption. As a result, contrary

to the benchmark scenario, the trade balance will be in surplus both in the short and medium run.

When the increase in government investments is matched by an equivalent (ex ante) increase in labour income taxes or consumption taxes, positive demand effects of the government investment shock in the short run would be lower, in comparison to the benchmark results. In addition, the distortionary impact of the labour income tax increase on labour utilisation has negative output implications in the long run. On the external side, a higher labour income tax would also be harmful to the domestic exports for the entire simulation period. The consumption tax increase would primarily negatively affect private consumption via the reduced disposable real income channel. Overall, the use of tax instruments for financing higher government investment expenditure results in more favourable government deficit dynamics in the short run and implies a diminishing longer-term path of the government debt. This result depends on the assumption that the government keeps other expenditure than public investment in line with the initial baseline, whereas revenues increase with the additional GDP growth - in other words, the additional tax revenues associated with the increase in economic activity are not used for additional expenditures but for deficit reduction.

## 5.4 Initial level of capital stock and investment efficiency

In the benchmark simulation, in line with the model calibration, the government capital stock ratio to (annual) GDP is 0.3. To assess the sensitivity of the investment shock impact to the initial level of the government stock, in what follows, we consider a baseline model parameterisation featuring a government capital stock-to-GDP ratio equal to 0.5.[19] In Chart 11 the corresponding alternative scenarios are referred to as low and high initial capital stock scenarios. In addition we report simulations featuring low efficiency of public investment. In the benchmark simulation, all new government investment is assumed to be added to the productive capital stock. Alternative scenarios of low investment efficiency envisage that only half of the new government investment contributes to the build-up of productive public infrastructure.

As expected, in case the domestic economy features a relatively high level of initial government capital, the government investment shock results in a considerably smaller macroeconomic impact mainly due to its limited supply-side contribution: the increase in the productive capital stock is only half of that achieved in the benchmark scenario. Consequently, the scope for self-financing of the government investment expenditures becomes more limited. Similar implications are obtained when the efficiency of new investment projects turns out to be low.

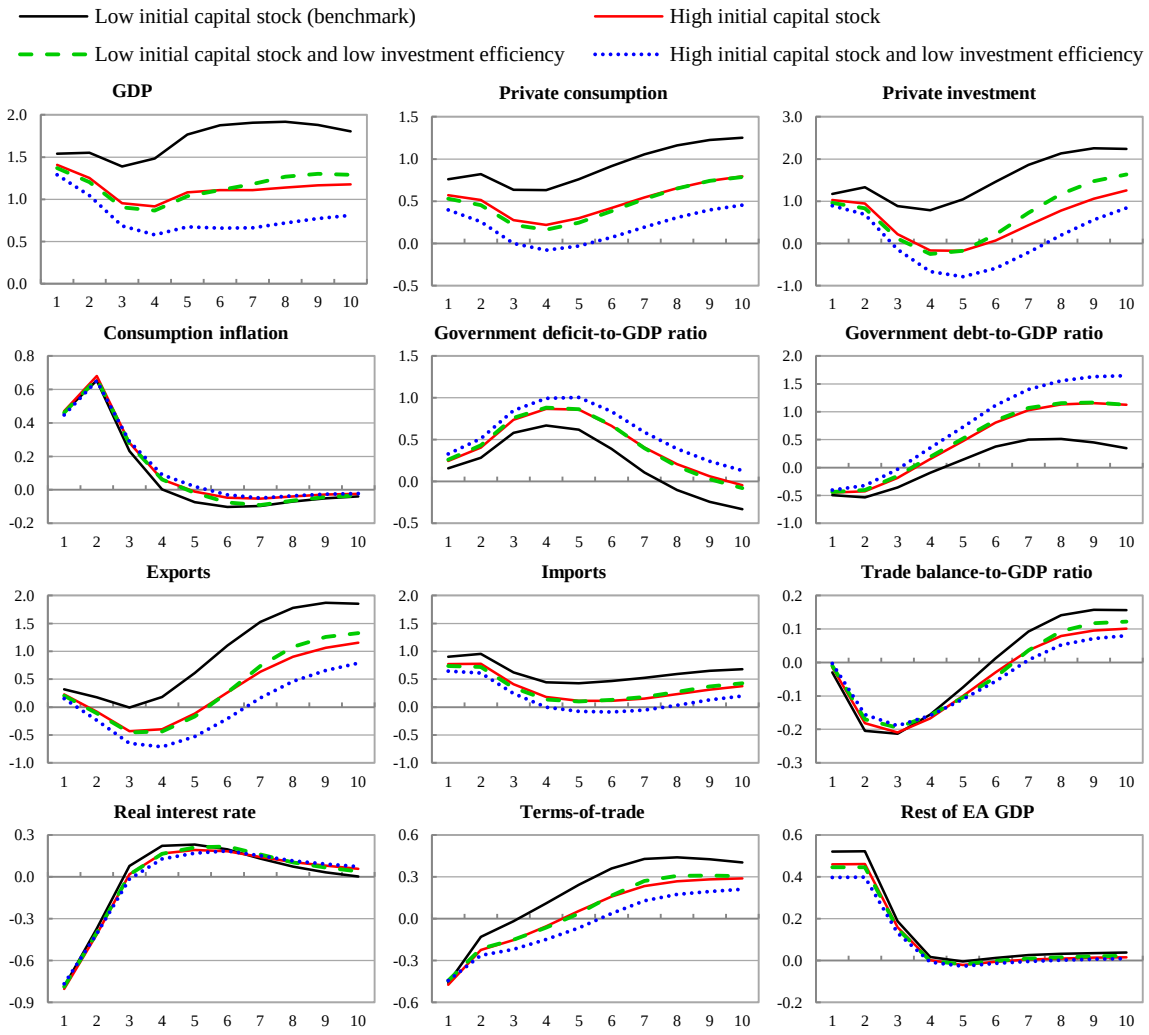
[19] This is achieved by considering a higher level of capital depreciation rate in equilibrium.

**Chart 11**

Macroeconomic impact of a government investment shock under alternative levels of initial capital stock and investment efficiency

**Over 10 years**

(percentage (points) deviations from the baseline)




Source: authors' calculations with EAGLE model.
Note: The chart shows the percentage (percentage-point, in case of inflation, interest rate and GDP ratios) deviations from the baseline of some selected macroeconomic variables over a period of 10 years.

## 5.5 Alternative output elasticity of public capital

In the benchmark simulation, the output elasticity of the government capital stock is calibrated to 0.1. In order to assess how a change in the output elasticity parameter affects model outcomes, in Chart 12 we present simulation results obtained assuming two alternative output elasticities of public capital: 0 and 0.2. The zero output elasticity essentially implies that public capital has no productive use. Hence, higher government investment would only have direct demand-side effects. In this case, the positive impact on output is still strong in the short run; however, it

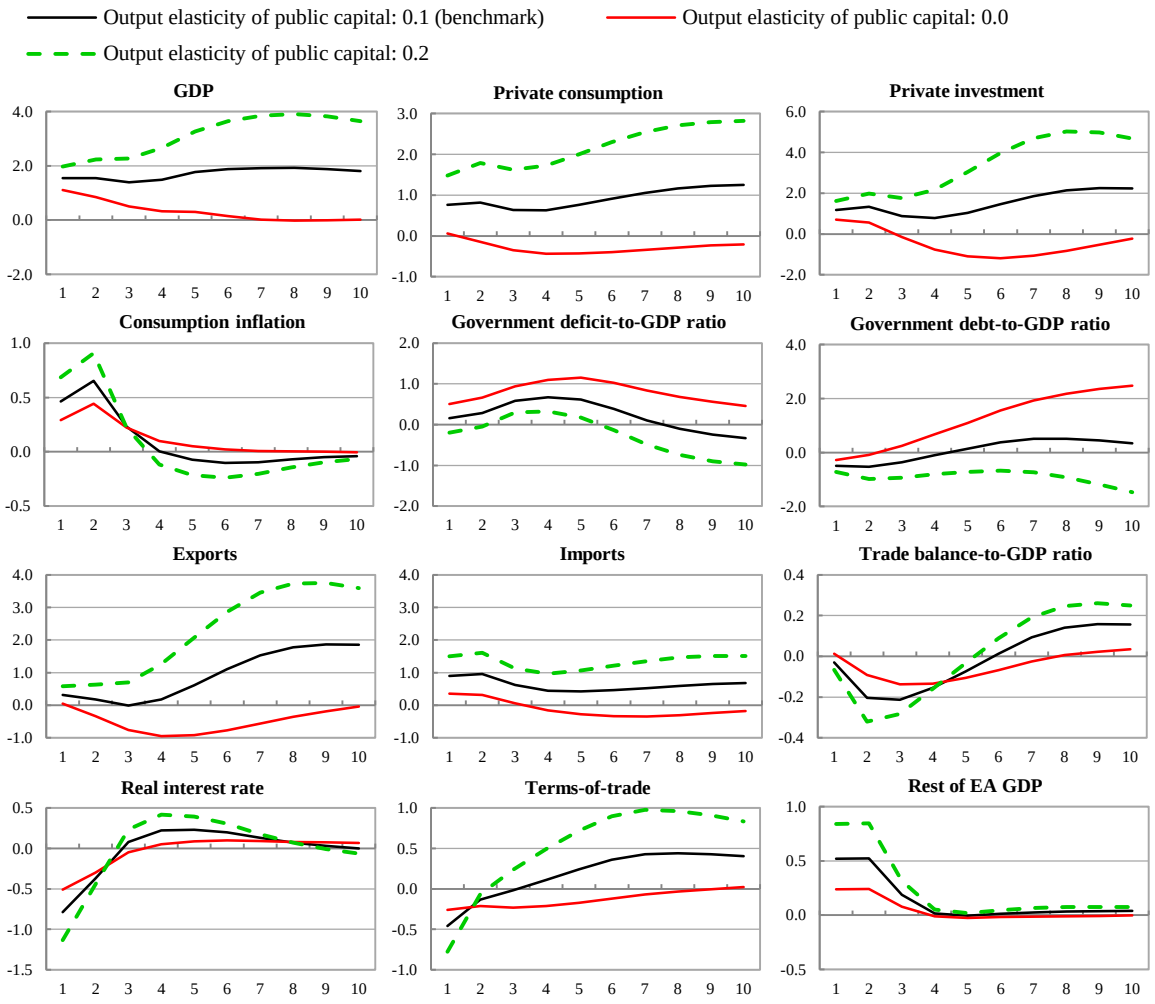
gradually diminishes over the medium run. Moreover, both private consumption and investment are no longer growth-supportive. Hence, the cyclical upswing in tax revenues is limited and the fiscal balance deteriorates significantly. By contrast, assuming a higher output elasticity parameter allows generating a stronger output increase, especially over the medium run, with significant positive implications for the dynamics of the government budget balance and debt path.

**Chart 12**

Macroeconomic impact of a government investment shock under alternative output elasticities of the government capital stock

**Over 10 years**

(percentage (points) deviations from the baseline)




Source: authors' calculations with EAGLE model.
Note: The chart shows the percentage (percentage-point, in case of inflation, interest rate and GDP ratios) deviations from the baseline of some selected macroeconomic variables over a period of 10 years.

## 5.6 Financing constraints in the private sector

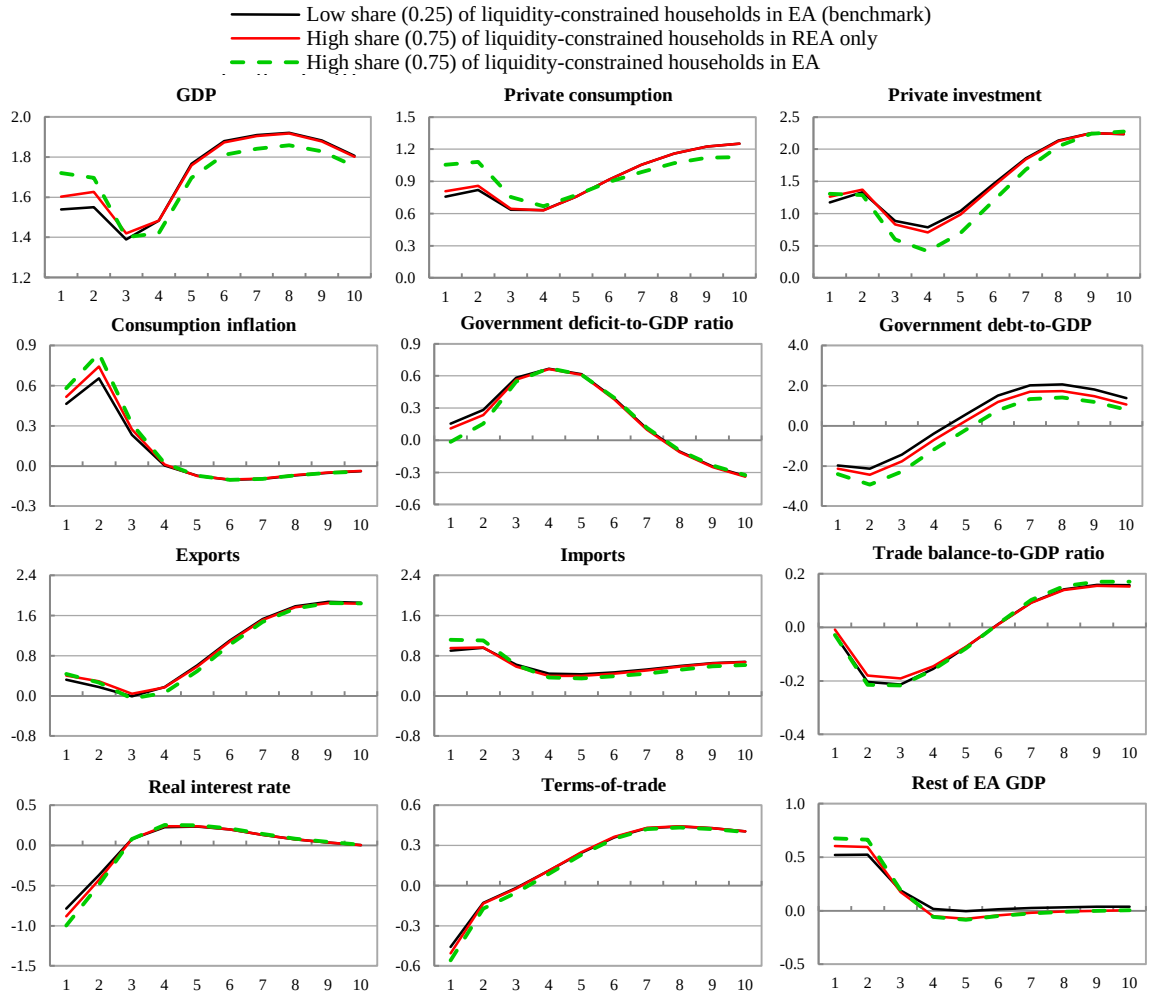
In the context of ongoing economic deleveraging, which is particularly pronounced in a number of euro area countries, the sensitivity of the macroeconomic response to a government spending shock is investigated next by assuming alternative shares of liquidity-constrained households. In the benchmark simulations, it is assumed that 25 per cent of households are not participating in the financial markets. An alternative parameterization features a considerably larger share of liquidity–constrained households (75 per cent) in the rest of the euro area or the euro area as a whole. The latter assumption implies a higher sensitivity of private consumption to contemporaneous income and strengthens Keynesian effects of fiscal policy.

**Chart 13**

Implications of private sector's financing constraints

**Over 10 years**

(percentage (points) deviations from the baseline)




Source: authors' calculations with EAGLE model.
Note: The chart shows the percentage (percentage-point, in case of inflation, interest rate and GDP ratios) deviations from the baseline of some selected macroeconomic variables over a period of 10 years.

Indeed, as shown in Chart 13, in the presence of severe financing constraints for the private sector, the increase in private consumption is stronger in the short run. As a result, domestic inflation is higher and so is the degree of self-financing of the government budgets. Over a more medium-term horizon, however, stronger financing constraints in the home economy imply weaker private investment dynamics which leads to a somewhat lower, in comparison to the benchmark case, path of output and private consumption. In line with the effects on the domestic economy, the alternative scenario implies somewhat stronger transitory positive spill-over effects on the rest of the euro area.

## 5.7 Monetary policy accommodation

The monetary policy stance plays a crucial role in shaping the overall macroeconomic response to the government investment increase. In the baseline simulations, the interest rate is held unchanged 8 quarters following the shock; moreover, the accommodative stance of monetary policy is fully anticipated by the private sector (ex-ante policy). If, however, the euro area monetary authorities do not accommodate the shock but, instead, raise the interest rate in response to higher inflation, the pick-up in both private consumption and investment turns to be more gradual (see Chart 14). Under such a scenario, the self-financing of the government investment increase will be limited, implying a less favourable public debt development over the entire simulation horizon. Moreover, accommodative monetary policy could essentially shutdown the positive spill-over effects of the shock on the rest of the euro area where positive foreign trade effects are compensated by negative real interest effects. Similarly, in case the constant interest rate policy is not communicated to the private sector or the latter does not believe the policy (ex post policy), a more gradual, as compared to the benchmark scenario, macroeconomic response is likely to follow.

Lastly, the short-term impact on the domestic economy and the implied spillovers on the rest of the euro area depend crucially on the central bank's strategy of exiting the constant interest rate policy. The benchmark model simulations are based on a monetary policy rule which describes the interest rate reaction to its lagged values as well as to deviations of the inflation rate and output growth rate from the respective targeted values. The policy rule coefficients are similar to those used in the estimated New Area-Wide Model (see Christofell et al. (2008)): the coefficient on the lagged interest rate is set to 0.87 whereas coefficients on inflation and output growth are 1.7 and 0.1 respectively. If one assumes instead a more aggressive policy rule[20] with less persistence in the interest rate setting and greater weights put on stabilisation of inflation and output growth, then the short-term macroeconomic impact of the shock is estimated to be considerably smaller (see "aggressive normalisation" scenario results in Chart 14). In fact, the implied spillover effects

[20] For a more aggressive rule, similar to Blanchard et al. (2015), we set the coefficient on inflation to 2.5 while the coefficient on output is fixed to 0.5. At the same time, the lagged interest rate coefficient is set to 0.7.

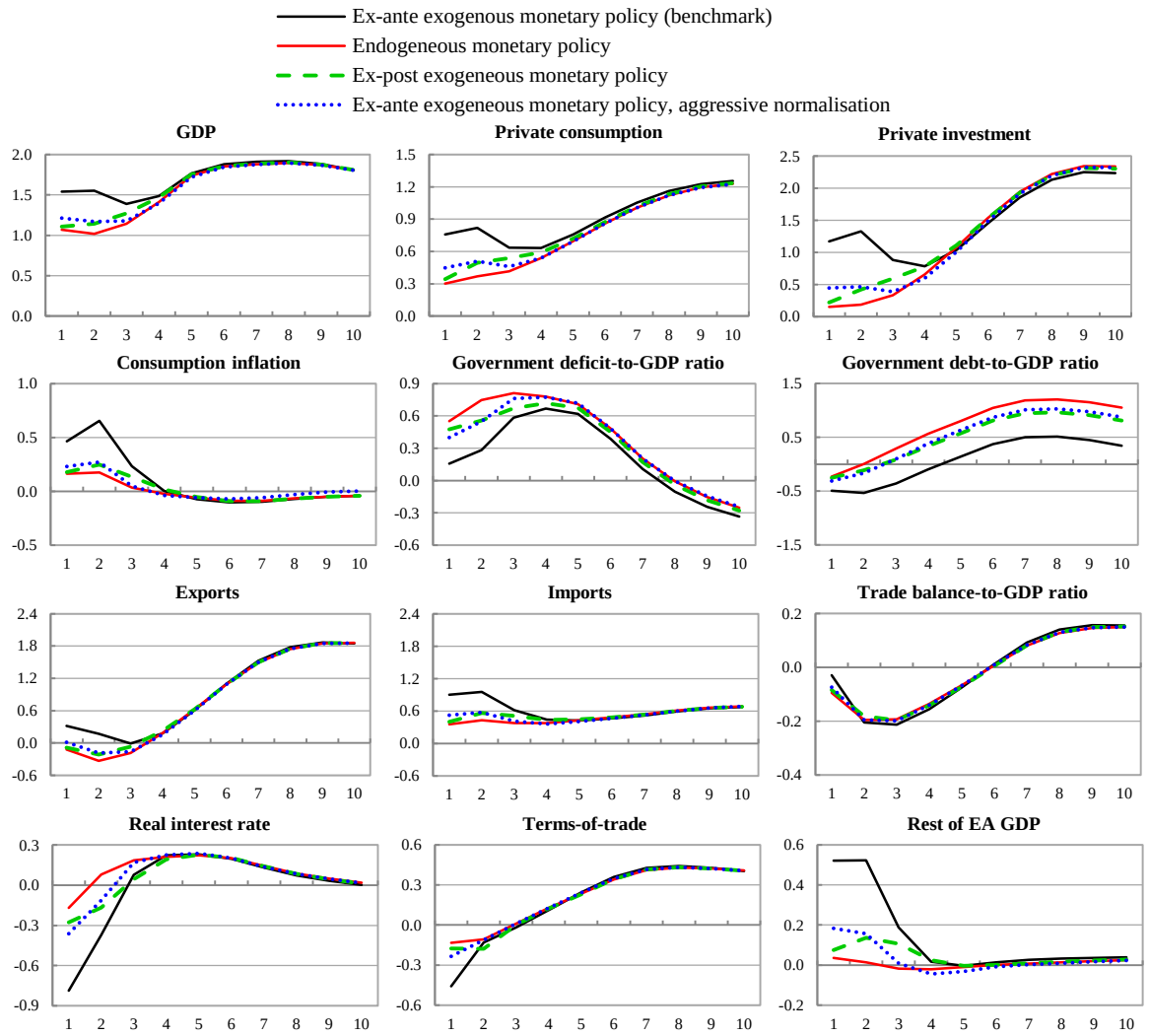
would be close to the estimated impact of a German public investment shock found by Blanchard et al. (2015).

**Chart 14**

Implications of differences in the monetary policy stance

**Over 10 years**

(percentage (points) deviations from the baseline)




Source: authors' calculations with EAGLE model.
Note: The chart shows the percentage (percentage-point, in case of inflation, interest rate and GDP ratios) deviations from the baseline of some selected macroeconomic variables over a period of 10 years.

These findings seem to support the view that, in comparison to 'normal times', in a liquidity trap environment fiscal expenditure multipliers may increase significantly (see, for example, Eggertson (2011) and Woodford (2011)). In case of public investment though, the amplification of the multiplier may be limited because, besides immediate positive effects on aggregate demand, expansion in public infrastructure also raises productivity and, therefore, exerts downward pressure on

inflation. In the short run, the latter, if it dominates over demand-side effects on inflation, may lead to a higher real interest rate and lower private sector demand, thus limiting output effects of public investments. Bouakez et al. (2014) show that the undesirable negative effects on inflation at the zero lower bound can be reduced provided there are sufficiently long time-to-build delays in the public capital accumulation process. In our analysis, the strength of the output response in the benchmark simulations is, in particular, supported by the persistence of anticipated public investment plans which go beyond the period over which the monetary policy is assumed to be inactive.

## 5.8 Cross-border spill-overs and policy coordination

The benchmark simulation results reveal that the government investment shock in the domestic economy has also positive spill-over effects on the rest of the euro area economy. An important channel of transmission in this regard is due to trade linkages. Higher import demand by the private sector and an increase in the relative price of the domestic goods contribute to stronger exports in the rest of the euro area. In addition, both euro area regions benefit from the depreciation of the euro in the short run. In case both euro area regions boost government investment, the positive cross-border spill-over effect on the domestic output is sizable, albeit, only transitory (see Chart 15). Nevertheless, a simultaneous public investment expansion across euro area countries implies significant benefits in terms of a more favourable path for the fiscal budget and debt, as compared to the unilateral policy in the benchmark scenario.

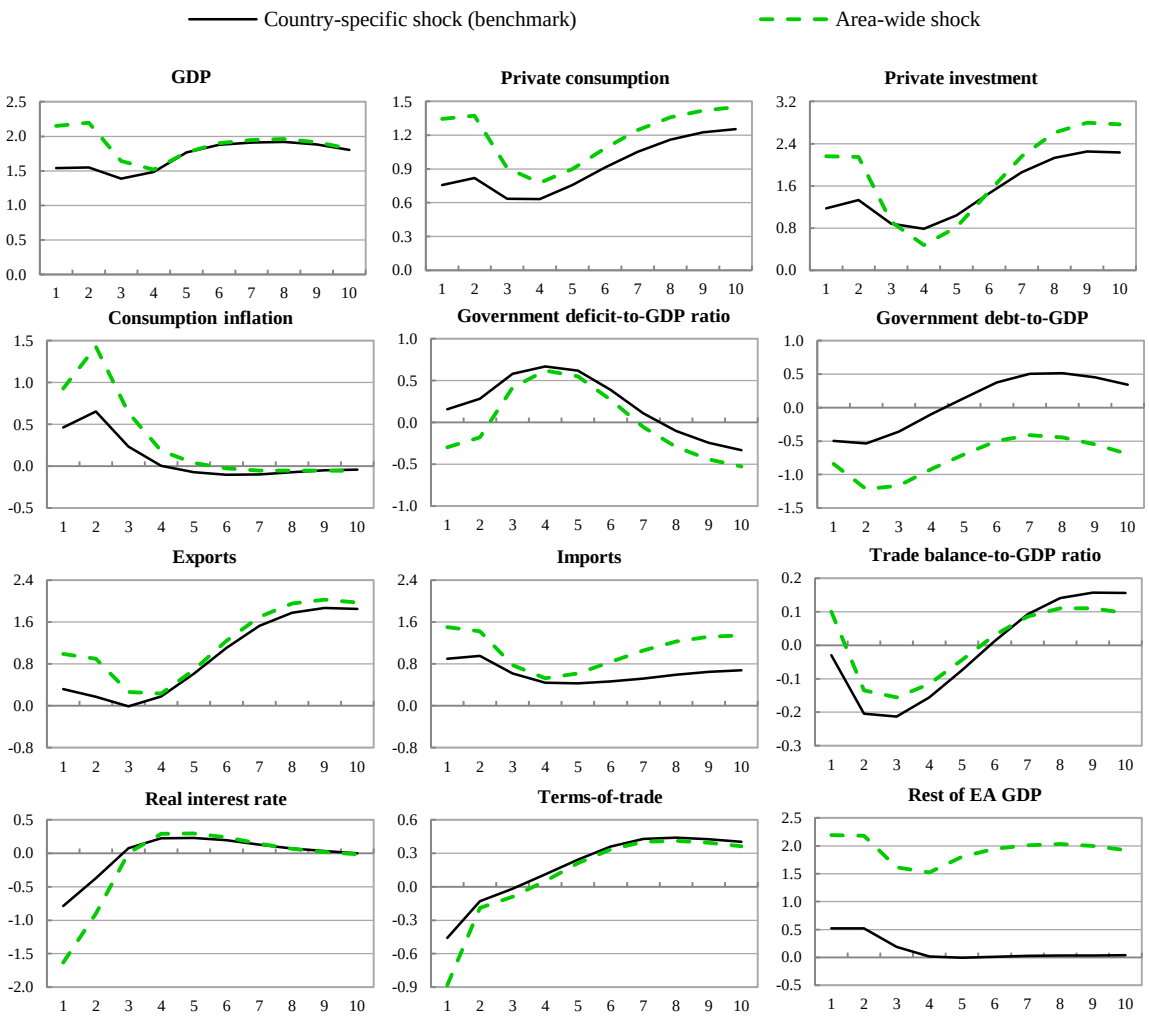
In conclusion, the model-based simulation results reveal that even a transitory, but persistent, increase in government investment could lead to a substantial and long-lasting positive domestic macroeconomic impact as well as produce sizable cross-border spillover effects. Moreover, relatively high output multipliers of government investment mitigate, to a significant extent, the negative implications of the fiscal expansion on the government budget and the debt path. As regards the reaction of private investment, this tends to respond positively to the shock both in the short and long run. A number of factors, however, may induce considerable crowding out effects of the public spending shock, e.g. inefficiencies in public investment, unaccommodative monetary policy and strong financing constraints faced by the private sector. The estimated positive cross-border spill-over effects are predominantly of a demand-side nature reflecting the foreign trade linkages. They may also benefit from an accommodative monetary policy stance and favourable common exchange rate movements. Admittedly, the applied model does not account for possible supply-side cross-border linkages; hence, the reported results of a simultaneous increase in government investment across the euro area may underestimate the long-term gains from policy coordination.

## Chart 15

Implications of cross-border linkages and policy coordination

**Over 10 years**

(percentage (points) deviations from the baseline)




Source: authors' calculations with EAGLE model.
Note: The chart shows the percentage (percentage-point, in case of inflation, interest rate and GDP ratios) deviations from the baseline of some selected macroeconomic variables over a period of 10 years.

# 6 Conclusions

Public investments in Europe have significantly declined since the crisis, although developments are heterogeneous across countries. This has led to calls for stimulating public investment in an environment of low borrowing costs for governments, weak economic growth and monetary policy at the lower bound.

Economic theory suggests that an increase in public investment has positive demand effects and can contribute to the economy's potential output by increasing the stock of public capital. While the empirical literature on the effect of public capital on output typically finds a positive effect, estimates vary considerably according to the time period, country, measure of capital and estimation method. Similarly, the productivity of public capital may vary over time and could decline. Any increase in public investment needs to be assessed in the light of its productivity, its financing and the relative costs and benefits of the financing options.

The empirical analysis carried out in the paper, estimating country-specific VAR models for twelve EU economies over the years 1960–2013, provides evidence of a generally positive output impact of an increase in the public capital stock. Recursive estimations do not suggest that the productivity of public capital has increased substantially following the crisis, which could have been expected if investment cuts under financial pressure would have been aimed at the least productive projects. The simulation results also suggest presence of positive spill-overs at a longer horizon. Lastly, no strong evidence of crowding out effects of public investment on private investment is found. On the contrary, the analysis points to complementarity between public and private capital.

Structural model-based simulations of an increase in public investment in a large euro area economy illustrate the sensitivity of the implied output and budget effects to alternative policy implementation strategies. First, an increase in public investment will have the strongest short-term demand effects, including in terms of spillovers to other countries, with an anticipated accommodative monetary policy. This finding strengthens the case for increasing public investment in the current low-inflation environment. Second, a debt or revenue-financed increase in productive public investment implies significantly larger short-term output gains compared with an increase in investment financed by cutting other public expenditures. However, when distortionary taxes, e.g. labour income taxes, are used to finance public investment, the short-term output gains of additional public investment have to be traded off against tax-induced output losses over the longer term, whereas any increase in public investment financed by higher public debt must be weighed against possible fiscal sustainability concerns. Last, the longer-term positive effects on the economy's potential output and the impact on public finances crucially depend on the effectiveness of investment and the productivity of public capital. If these are low, an increase in public investment is associated with a greater deterioration of the debt outlook and less persistent output gains. These findings underline the fact that

economic considerations are important for ensuring a rigorous selection of productive investment projects.

In conclusion, any recommendation for a public investment push in the EU must go along with a case-by-case rigorous selection of projects, to ensure that the investment is efficient and productive.

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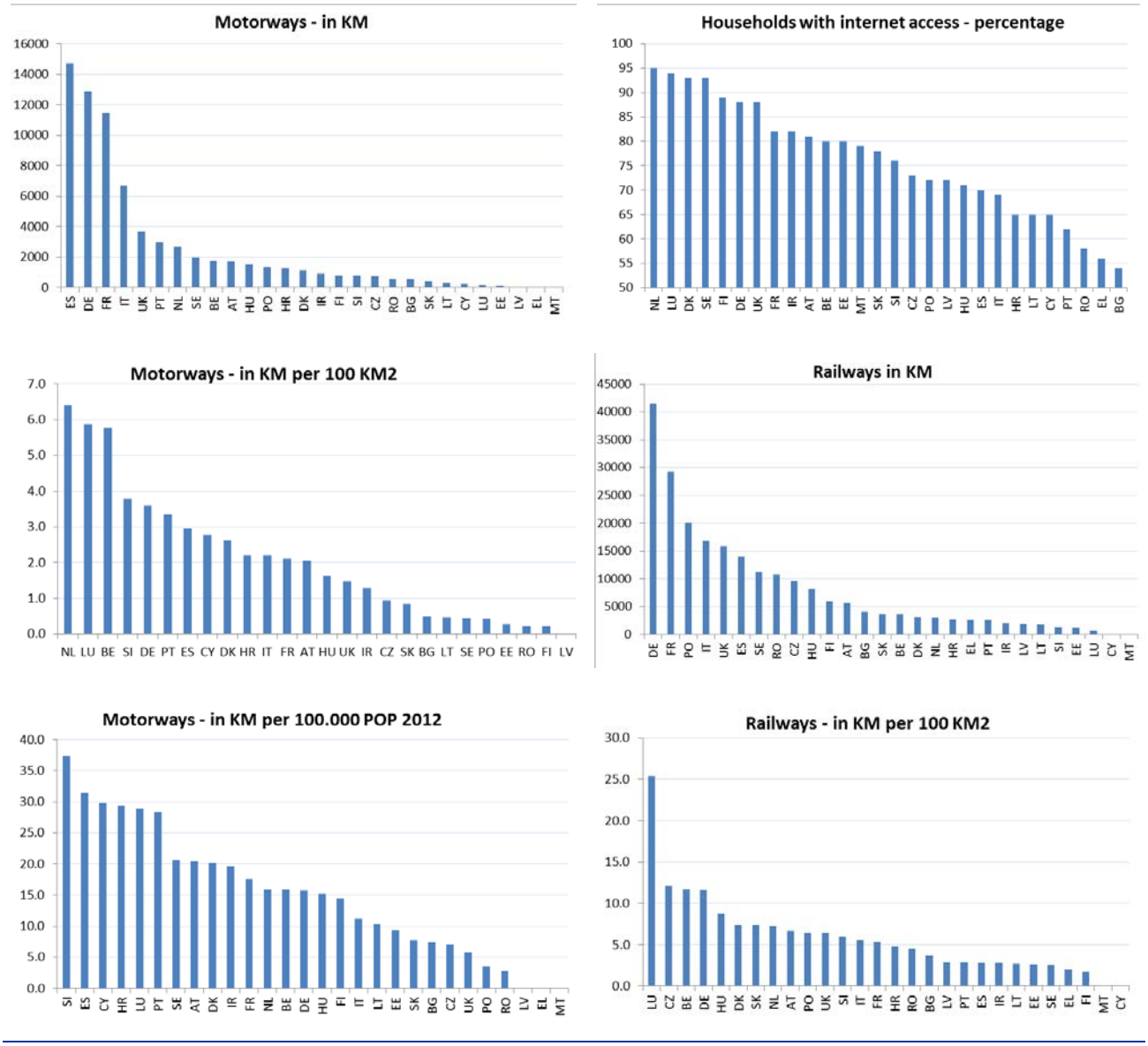
# 8 Annex

**Chart A1**

Physical measures of infrastructure

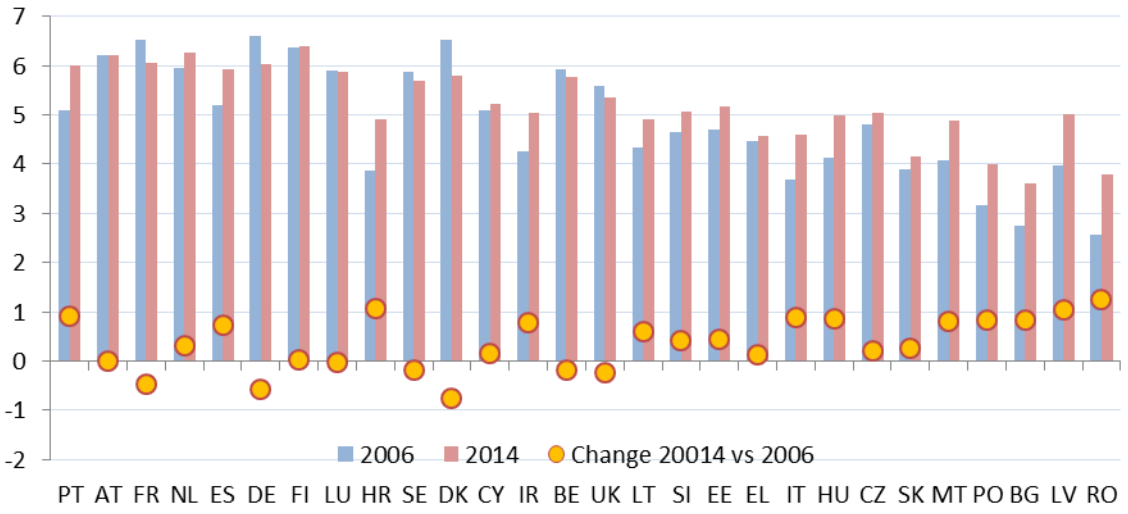



Source: Eurostat.
Note: data motorways: DK from 2008; IT, LT and UK from 2011; no data for EL and MT. Data Railways: DK and EL from 2008; LU from 2009; FR and UK from 2010; LT, NL and SE from 2011. Data percentage households with internet access: 2012. Data railways: 2012.

**Chart A2**

Quality of overall infrastructure

(scale 1 to 7 (best))

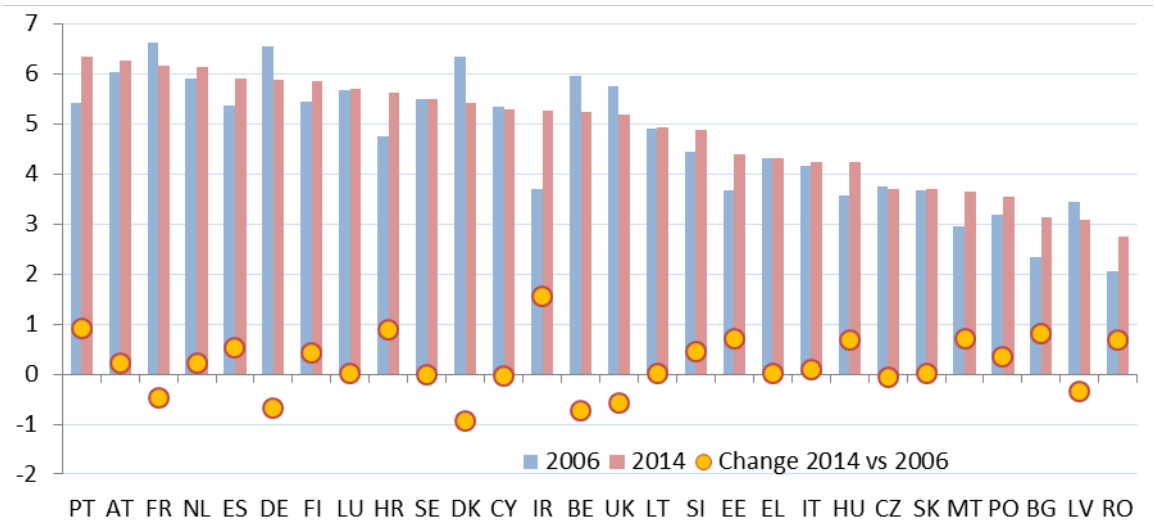



Notes: World Economic Forum. Countries ordered by 2014 score.

**Chart A3**

Quality of roads

(scale 1 to 7 (best))

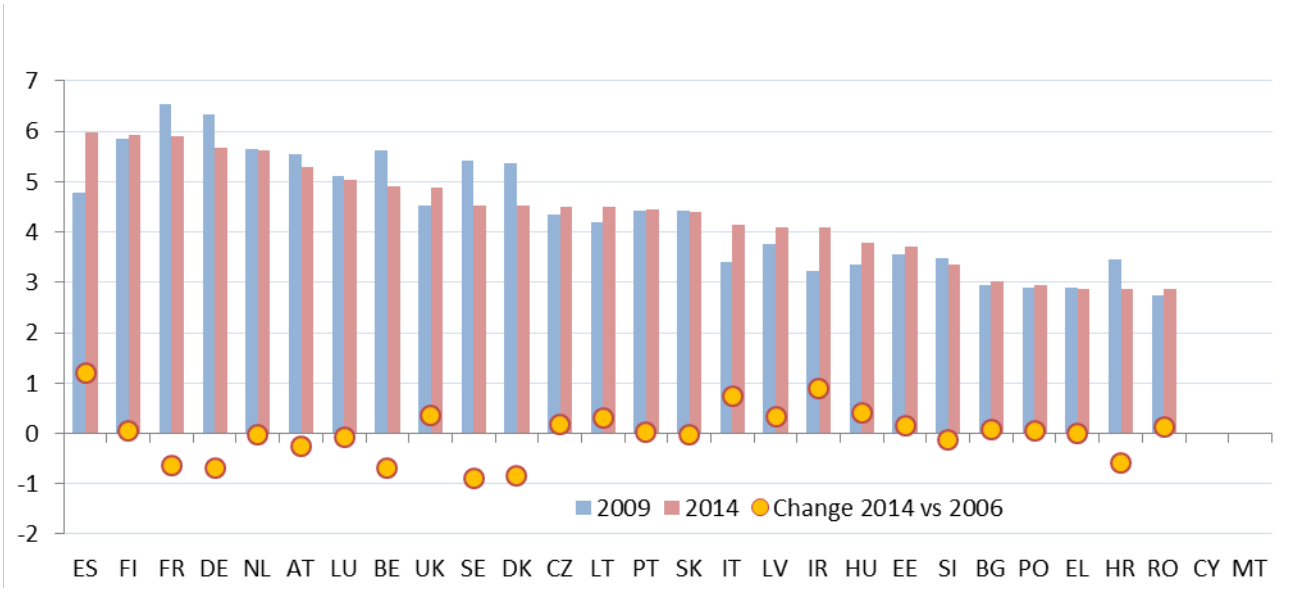



Notes: World Economic Forum. Countries ordered by 2014 score.

**Chart A4**

Quality of railroads

(scale 1 to 7 (best))




Notes: World Economic Forum. Countries ordered by 2014 score.

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