Government Investment, Its Financing and the Public Capital Stock: A Business Cycle Perspective*

R. Hickey†
Central Bank of Ireland

M. Lozej‡
Central Bank of Ireland

D. Smyth§
Central Bank of Ireland

December 2018
PRELIMINARY.
PLEASE DO NOT CITE WITHOUT PERMISSION

Abstract

Expenditure reductions played a key role in many countries during the fiscal consolidation process over the period 2008 to 2013, with declines in public investment spending particularly notable. This had a marked impact on the public capital stock. Many governments consider increasing government investment to replenish the public capital stock. An important consideration is how this investment is financed. This paper shows that that adopting budget neutral investment spending can generate the long-term benefits of a higher public capital stock while at the same time limiting the risks of overheating dynamics and negative consequences for the public finances. The least harmful, in the sense of preserving both fiscal and external balances, way of financing government investment is by reducing other government spending. Financing government investment with debt worsens fiscal and external balances. Financing investment with labour taxes is harmful for external balance, while financing with VAT only reduces external balance in the very short run.

JEL classification: F16, F41, F42, F45, F47
Keywords: DSGE models, government investment, public finances, monetary union, open-economy macroeconomics.

*The opinions expressed are those of the authors and do not reflect views of the Central Bank of Ireland. We are grateful to Thomas Conefrey, John Flynn, Philip Lane, Reamonn Lydon, and Terry Quinn for comments on an earlier version of the paper. Any errors are the sole responsibility of the authors.

†Central Bank of Ireland, Irish Economic Analysis, New Wapping Street, North Wall Quay, Dublin 1, Ireland. Phone: +353 (0)1 224 6309. E-Mail: ronan.hickey@centralbank.ie.

‡Central Bank of Ireland, Irish Economic Analysis, Macro Modelling. New Wapping Street, North Wall Quay, Dublin 1, Ireland. Phone: +353 (0)1 224 6309. E-Mail: matija.lozej@centralbank.ie.

§Central Bank of Ireland, Irish Economic Analysis, New Wapping Street, North Wall Quay, Dublin 1, Ireland. Phone: +353 (0)1 224 6309. E-Mail: diarmaid.smyth@centralbank.ie.

1 Introduction

Following very strong growth prior to the financial crisis, the Irish economy has experienced a prolonged period of subdued government investment spending. This reflects the important role that expenditure reductions played in bringing the public finances back to sustainable levels and, within that, the large role that investment spending played. Two-thirds of the Governments consolidation measures were expenditure related, while public investment spending recorded a peak to trough decline of 65 per cent between 2008 and 2013. Plans are now in place to increase government investment in the coming years, with medium term spending of four per cent of GNI* targeted. Against this backdrop, we look at two aspects of higher investment spending: (i) the potential impact on the public capital stock; and (ii) the macroeconomic consequences of how investment is financed.

This paper first describes the developments in government investment spending in Ireland, putting recent developments in the context of what happened prior to, and during the, financial crisis, where adjustment in government investment expenditure played an important role in stabilisation of public finances. Importantly, the Irish example is not an isolated one, as reductions in investment expenditure were a key component of adjustment in economies receiving financial support, with the decline experienced in Ireland similar to that in Spain, Greece and Portugal. We also consider the impact that these long-lasting government investment spending reductions have had on the public capital stock. Economic literature typically finds a positive relationship between public capital and output, and, at a global level, low government investment has led to concerns about longer term potential growth rates.

The paper then takes a forward-looking approach. It first assesses the potential impact of the government investment projections in the 2018 Stability Programme Update on the public capital stock. While this requires assumptions on depreciation, it appears that the level of public capital will increase by a sizeable margin in the years ahead. We use the Global Dynamic General Equilibrium model of Ireland in a monetary union (Clancy et al., 2016) to assess how the build-up of public capital and different ways of financing of government investment affects key macroeconomic variables. In particular, we look at the difference between government investment that is fully debt financed relative to budget neutral financing. Budget-neutral financing can be

achieved in several ways, by redirecting government consumption, raising income taxes or by raising the VAT.

Our main findings are that no matter how government investment is financed, the build-up of productive public capital increases output in the medium and longer term. However, we find that the way public investment is financed has significant impact on the structure of output in the short and medium run. In particular, the case where the increase in government investment is financed by redirecting other government spending toward investment seems to be most beneficial in terms of achieving output growth, fiscal balance, and an improvement in the trade balance. Pure debt financing increases public debt, and financing with labour taxes increases marginal costs and reduces the external competitiveness of the economy, leading to a worsening of the trade balance. Financing of government investment with VAT depresses private consumption, but also quickly improves the trade balance. Importantly, in all cases, an increase in even moderately productive public capital has sufficiently strong effects on output that offsets the negative effects of higher taxes in the short run. If the productivity of public capital is higher, then beneficial output effects over the medium and longer term are even stronger.

2 Government investment and the public capital stock in Ireland

Expenditure reductions played a key role in the recent Irish fiscal consolidation process. Reflecting the Department of Finances (2011) view that spending led adjustments would be more successful in reducing deficits and stabilising debt ratios, approximately two-thirds of the Governments adjustment measures came via reductions in government expenditure. This followed rapid growth in the years prior to the crisis; in nominal terms spending increased by 57 per cent in the five years to 2007, compared to an increase of 20 per cent for the Euro area as a whole. Abstracting from the spike in government spending in 2010 related to banking related measures, there was a peak to trough decline of 8 per cent in spending between 2008 and 2013, before spending gradually picked up. Changes in total expenditure is not an ideal measure of spending adjustments, however, due to the impact of capital transfers to the financial sector and higher

interest costs. What we call core government spending excluding these two components - provides a more accurate picture of the measures taken by successive governments in order to bring the public finances back to more sustainable levels. Relative to 2008, core government spending reached a peak decline of 15 per cent in 2013 and the gradual nature of its subsequent recovery meant it was still 6 per cent below its pre-crisis peak in 2017, four years after the conclusion of the Economic Adjustment Programme.

Chart 1 looks at components of core spending. It illustrates the increase in social payments that occurred over the period as unemployment increased sharply in the wake of the crisis. These were 12 per cent higher in 2012 as the unemployment rate averaged 15.5 per cent that year. Despite this, the drop in other areas of current spending was broadly the same as for core spending (Chart 1). This highlights the significant role that government investment spending played in reducing total expenditure with the former declining by two-thirds between 2008 and 2013. As a result, and despite its small relative weight in total expenditure (capital spending represented 12 per cent of core spending in 2008), it accounted for just over half of the nominal core spending reduction that took place between 2008 and 2013 (6.2 billion out of a total reduction of 11.1 billion). Furthermore it was still just over half of its pre-crisis peak in 2017.

Chart 2 shows government investment spending as a percentage of GNI* over a longer time frame.[1] In common with broader government expenditure, this highlights the very strong increases recorded in investment spending prior to the crisis (reaching a peak of 6.1 per cent of GNI* in 2008). Spending growth was particularly marked in the period 2006 to 2008, increasing by 40 per cent in those two years alone. This spending was primarily driven by increases in the broad areas of transport and housing related investments.

Government investment may have been expected to fall back once key capital projects had been delivered, and reflecting the phase of the cycle. The close relationship between public investment spending and economic activity is well established. Looking at the cyclical behaviour of fiscal policy in OECD countries, Lane (2003) finds that investment is the most pro-cyclical component of public spending, with a particularly strong pro-cyclical relationship identified in Ireland. The subsequent decline was very large; in 2013 investment spending had declined to

[1] GNI* is a measure of the Irish GDP that excludes most of the activities that have little or nothing to do with the domestic Irish economic developments. These are mainly the activities pertaining to foreign multinational firms, mostly related to intellectual property rights.

levels not seen since the mid 1990s (2.5 per cent of GNI*) and the improvement since has been gradual. The Chart also outlines depreciation in the government sector. This allows us to highlight the sharp fall in net investment (investment less depreciation) that also occurred, both in an absolute sense and relative to pre-crisis levels. Annual net investment spending averaged just 0.5 per cent of GNI* in the 5-year period to 2017, compared to an average rate of over 3 per cent in the years immediately prior to the crisis. Furthermore, the announced capital expenditure adjustments between 2008 and 2013 could also have understated the actual level of adjustment borne by capital in the event that certain projects were delayed or postponed.

Reductions in investment spending were an important part of fiscal consolidation in each of the euro area countries that accessed financial assistance programmes following the financial crisis. Peak to trough declines in investment spending ranged from 37 per cent to 71 per cent in these six economies, but when Latvia which was in a balance of payments programme is excluded, that range narrows from 55 per cent (Cyprus) to 71 per cent (Portugal). As mentioned above the Irish peak to trough decline in investment spending was close to two-thirds, very similar to that in Greece and Spain. Most of these countries saw growth boosted by unsustainable macroeconomic imbalances prior to the financial crisis. Ireland, Greece, Spain and Portugal were, according to the European Commissions Macro Imbalance Procedure (MIP) scoreboard, the only euro area members that had at least five indicators breaching MIP thresholds in 2007, with these breaches broad based across internal and external indicators. This supported sharp increases in total expenditure and the investment component in particular. Investment spending was well above the Euro area average in these four economies, but experienced a sharp decline around the end of the decade. The fact that government investment was commonly used in consolidation programmes could partly reflect the strength of spending in preceding years. However, Bedogni and Scott (2017) have noted that a possible anti-investment bias may exist when reducing expenditure. Given the lack of an intertemporal dimension in metrics of fiscal performance, they point to a greater incentive to maintain current expenditure, reductions of which can be more politically sensitive.

Government investment differs from government consumption spending because it contributes to the stock of public capital, which can have a longer lasting impact on the economy. While estimates of the effect of public capital on growth vary - and depend on factors such as the

composition and efficiency of spending - the literature typically finds a positive relationship between the two (de Jong et al. (2017)). The effects of public investment spending tend to be stronger when the spending is more effective and productive. This highlights the need for rigorous assessment and appraisal of planned investment projects. The literature on the impact of public capital on output is mixed, with a range of estimates on output elasticities. In general, core infrastructure investments (roads, transport, telecommunications) have higher output effects. In an Irish context, Fitz Gerald et al., (2003) found that returns to investment in physical infrastructure, in particular roads, were high.

The marked reductions in investment spending across the EU following the financial crisis has raised concerns in relation to longer-term growth implications (see OECD (2015), ECB (2016) and European Commission (2017)). The IMF (2014) noted sharp continued cuts in public investment may need to be reversed to avoid a depletion of public capital stocks and potentially adverse effects on long term growth. While data are available for economy wide capital stock levels, estimating the governments share is problematic due to data related issues (see IMF (2014), ECB (2016) and Kennedy (2016)). In order to assess the impact that recent spending developments have had in Ireland, we use the CSOs Non-Financial Assets of General Government (NFA) data series to produce an estimate of the Irish public capital stock. This is shown in Chart 6. The data includes a wide range of physical assets owned by government such as dwellings, buildings, stocks and equipment. In nominal terms, the stock of the Governments NFA is estimated to have declined sharply between 2007 and 2010 (by 19 billion), but subsequently recovered by 23 billion to reach an estimated 107 billion (57 per cent of GNI*) in 2016.

One problem with using the NFA data is that annual movements reflect both the net acquisition of assets (net investment) and other changes. The latter includes changes in the valuations of existing assets, driven in turn by factors such as market sentiment and cyclical conditions. These valuation changes have driven most of the movements in NFA in recent years, with only one-third of the increase since 2010 reflecting net investment. They are also not particularly relevant when it comes to determining the impact that the public capital stock will have on future growth. Accordingly, we construct an alternative stock of NFA adjusted NFA, also shown in Chart 3. We do this by taking the stock of NFA in 2000 as a base year and extrapolating this series forward based on the level of net government investment. This illustrative series highlights

solid and sustained growth in the stock of assets to 2008 (average annual growth of 5.5 per cent from 2001 to 2008) followed by very modest increases to 2017 (average annual growth of 1.5 per cent). Compared to total economic activity, however, the level of public capital fell sharply over the recent years.

In view of these developments, a new National Development Plan (NDP), announced in February 2018, commits to increase public capital investment to approximately 4 per cent of GNI* by 2025 up from 2.7 per cent in 2017 and to maintain it at that level thereafter. This figure includes central government investment and other spending. A sharp increase in the level of government investment is envisaged (by more than 50 per cent), from 5.4 billion in 2017 to 8.3 billion (3.7 per cent of GNI*) in 2021. We estimate that higher government net investment spending should result in a sizable increase in the stock of public capital. Based on current plans, the stock of public capital could increase by close to 16 per cent in the 4-year period to 2021. This compares to an increase of 5 per cent in the most immediate 4-year period.

The remainder of this paper attempts to analyse the effects of an increase in government investment, with a particular emphasis on how it is financed. The central scenario in the model assumes that government investment spending increases in line with the SPU projections out to 2021, after which it returns to close to its long-run average. Whilst the model necessarily simplifies some real world behaviour, it provides useful insights into channels through which public investment spending affects the wider economy.

3 The model

This section briefly describes the model setup and the main equations used. The model used is a variant of a global DSGE model of the euro area, the EAGLE (see Gomes et al. (2012) for details), which is adapted to distinguish between government investment and government consumption spending. Importantly, the model also accounts for the fact that in a small open economy, some government spending (either investment or consumption) is imported, as in Clancy et al. (2016).[2]

The model assumes the world economy consists of two regions, two of which constitute a monetary union. Each region is an open economy, following the Smets-Wouters (2003) model.

[2]This section is based on the model description in Clancy et al. (2016).

The various regions are modelled symmetrically and linked with each other through bilateral trade relations. The model has a proportion of non-Ricardian households and a number of real and nominal rigidities, such as habit formation, adjustment costs for investment and imports, rigid prices of final goods and rigid wages, with partial indexation. Final goods are aggregates of nontradable and tradable goods, with tradable goods themselves an aggregate of domestically-produced and imported goods. We use a version of the EAGLE that permits an import content of exports.[3]

The government generates revenue by levying distortionary and lump-sum taxes, and seigniorage earned on outstanding money balances. Debt is held in the form of government bonds, with a long-term target debt level in line with the Maastricht Treaty achieved via a smooth adjustment in lump-sum taxes.

The two EA blocs share a monetary authority (interest rate) and the exchange rate vis-a-vis the remaining two blocs of the model. All other regions have their own monetary authorities. All regions follow a Taylor-type interest rate rule, specified in terms of deviations of consumer price inflation and output gap from their target levels and allows for interest rate smoothing. Crucially, in the monetary union the interest rate reacts only to the EA-wide developments. This implies that, for all practical purposes, the EA-wide interest rate remains almost unchanged in response to Ireland-specific fiscal measures.

To permit government spending on imported goods, we assume that the government purchases a composite final good. This is produced by firms that assemble the final government consumption and investment bundles, $Q_t^{G_C}$ and $Q_t^{G_I}$ respectively, using intermediate tradable and non-tradable goods as inputs.[4] Final government investment goods are assembled according to a constant elasticity of substitution (CES) technology, using tradable goods, $TT_t^{G_I}$, and non-tradable goods, $NT_t^{G_I}$:

$$Q_t^{G_I} = \left[\nu_{G_I}^{\frac{1}{\mu_{G_I}}} \left(TT_t^{G_I} \right)^{\frac{\mu_{G_I}-1}{\mu_{G_I}}} + (1-\nu_{G_I})^{\frac{1}{\mu_{G_I}}} \left(NT_t^{G_I} \right)^{\frac{\mu_{G_I}-1}{\mu_{G_I}}} \right]^{\frac{\mu_{G_I}}{\mu_{G_I}-1}}. \quad (1)$$

Government demand for non-tradable goods is therefore:

[3] See Brzoza-Brzezina et al. (2010), for details.

[4] The equations are identical for the government consumption and investment goods, so we describe only equations for investment.

$$NT_t^{G_I} = (1-\nu_{G_I})\left(\frac{P_{NT,t}}{P_{G_I,t}}\right)^{-\mu_{G_I}} Q_t^{G_I}, \tag{2}$$

and analogously for government tradable goods. $P_{NT,t}$ is the price of non-tradable goods and $P_{G_I,t}$ is the price of final government goods. ν_{G_I} governs the share of each good in the bundle and μ_{G_I} is the elasticity of substitution between these goods. The tradable good consumed by the government is a bundle of home-produced tradable goods, $HT_t^{G_I}$, and imported goods, $IM_t^{G_I}$:

$$TT_t^{G_I} = \left[\nu_{TG_I}^{\frac{1}{\mu_{TG_I}}}\left(HT_t^{G_I}\right)^{\frac{\mu_{TG_I}-1}{\mu_{TG_I}}} + (1-\nu_{TG_I})^{\frac{1}{\mu_{TG_I}}}\left(IM_t^{G_I}\right)^{\frac{\mu_{TG_I}-1}{\mu_{TG_I}}}\right]^{\frac{\mu_{TG_I}}{\mu_{TG_I}-1}}. \tag{3}$$

Government demand for home-produced tradable goods is then:

$$HT_t^{G_I} = \nu_{TG_I}\left(\frac{P_{HT,t}}{P_{TTG_I,t}}\right)^{-\mu_{TG_I}} TT_t^{G_I}. \tag{4}$$

As above, ν_{TG_I} determines the share of each good in the bundle and μ_{TG_I} the elasticity of substitution between them. $P_{HT,t}$ is the price of home tradable goods and $P_{TTG_I,t}$ is the price of government-consumed tradable goods.

Imports of government consumption goods, $IM_t^{G_I}$, consist of a bundle of (bilateral) imports of tradable goods, $IM_t^{G_I,CO}$, produced in all other regions:

$$IM_t^{G_I} = \left[\sum_{CO\neq H}\left(\nu_{MG_I}^{H,CO}\right)^{\frac{1}{\mu_{MG_I}}}\left(IM_t^{G_I,CO}\right)^{\frac{\mu_{MG_I}-1}{\mu_{MG_I}}}\right]^{\frac{\mu_{MG_I}}{\mu_{MG_I}-1}}, \tag{5}$$

where

$$\sum \nu_{MG_I}^{H,CO} = 1.$$

Government demand for imports from bloc CO is

$$IM_t^{G_I,CO} = \nu_{MG_I}^{H,CO}\left(\frac{P_{IM,t}}{P_{IMG_I,t}}\right)^{-\mu_{MG_I}} IM_t^{G_I}. \tag{6}$$

The superscript H indicates the home country and the superscript CO the bloc from which the good is imported. Again, $\nu_{MG_I}^{H,CO}$ is the share of goods from each bloc, μ_{MG_I} is the elasticity

of substitution between them, $P_{IM,t}$ is the price of imported goods and $P_{IMG_I,t}$ is the price of government consumption imports.

Prices are defined by equations which correspond to the CES-aggregated goods bundles. Prices of government consumption good, $P_{G_I,t}$, government tradable consumption good, $P_{TTG_I,t}$, and government imported consumption good, $P_{IMG_I,t}$, respectively are:

$$P_{G_I,t} = \left[\nu_{G_I}(P_{TTG_I,t})^{1-\mu_{G_I}} + (1-\nu_{G_I})(P_{NT,t})^{1-\mu_{G_I}}\right]^{\frac{1}{1-\mu_{G_I}}}, \tag{7}$$

$$P_{TTG_I,t} = \left[\nu_{TG_I}(P_{HT,t})^{1-\mu_{TG_I}} + (1-\nu_{TG_I})(P_{IMG_I,t})^{1-\mu_{TG_I}}\right]^{\frac{1}{1-\mu_{TG_I}}}, \tag{8}$$

and

$$P_{IMG_I,t} = \left[\sum_{CO\neq H} \nu_{MG_I}^{H,CO}\left(P_{IM,t}^{CO}\right)^{1-\mu_{MG_I}}\right]^{\frac{1}{1-\mu_{MG_I}}}, \tag{9}$$

where $P_{IM,t}^{CO}$ is the price of imports from bloc CO.

The equations for government consumption are analogous, but, importantly, in this paper we depart from Clancy et al. (2016) in that we assume that government consumption is *not* complementary to private consumption.

The extended model explicitly accounts for the fact that government investment, $G_{I,t}$ contributes to public capital, $K_{G,t}$:

$$K_{G,t+1} = (1-\delta_G)K_{G,t} + G_{I,t}, \tag{10}$$

where δ_G is the depreciation rate. $K_{G,t}$ enters the private sector's production function in a non-rival way:

$$Y_{T,t}^S = z_{T,t}K_{G,t}^{\alpha_G}(K_{T,t}^D)^{\alpha_T}(N_{T,t}^D)^{1-\alpha_T} - \psi_T \tag{11}$$

and analogously for the non-tradable sector.[5]

[5]Here, $Y_{T,t}^S$ is output, $z_{T,t}$ is the level of productivity, α_G determines the productivity of public capital, $K_{T,t}^D$ is private capital rented, $N_{T,t}^D$ is labour hired, α_T is the capital share in the tradable sector and ψ_T fixed cost.

Government capital enhances the productivity of private capital in a similar manner as technological progress. This means that an increase in government capital will reduce marginal costs, $MC_{T,t}$, of the intermediate goods' sector:

$$MC_{T,t} = \frac{1}{z_{T,t} K_{G,t}^{\alpha_G} (\alpha_T)^{\alpha_T} (1-\alpha_T)^{1-\alpha_T}} \left(R_t^K\right)^{\alpha_T} \left((1+\tau_t^{W_f}) W_t\right)^{1-\alpha_T}. \tag{12}$$

The same holds for non-tradable goods.[6] The corresponding market clearing conditions and shock processes are reported in the technical appendix.

3.1 Calibration

We calibrate our model to Ireland. The main steady-state ratios (the Great Ratios) are calibrated based on the mix of national accounts data (for the volume of trade) and input-output tables (for the composition, consumption or investment, of traded goods and the bilateral component of trade). The remaining parameters in the model are either based on country specific empirical evidence, where available, or kept consistent with the original EAGLE model. The values of the calibrated parameters and steady-state ratios are reported in Tables 1 to 3. The relative size of the home bloc is recalibrated to reflect the GDP share in the world economy.

We opt for a calibration of government goods with a low elasticity of substitution between non-tradable and tradable goods, but with relatively high substitution between tradable goods and imported goods from the different blocs. The quasi-share of imported government consumption goods is calibrated to achieve a 2 percent of GDP government consumption that is spent directly on imports in the steady state. This amounts to about 15 percent of government consumption in Ireland. We assume that the share of imported government investment goods is higher, as investment goods tend to be very specific and less likely to be produced domestically in a SOE. We therefore calibrate the quasi-share of imported government investment goods to achieve a 25 percent share of government investment spending.[7] Finally, we assume that the dynamic

[6] The parameter $\tau_t^{W_f}$ accounts for labour taxes paid by firms, W_t are wages and R_t^K is the rental cost of capital.

[7] In calibrating the import content of government consumption and investment expenditure we rely on estimates by Corsetti and Müller (2006), in particular on their guideline that home bias is stronger in government expenditure than in private consumption or investment. We used the values reported in their Table 1 and relied on the

adjustment of government consumption and investment goods is not subject to adjustment costs.

The calibration of the other blocs of the model follows Gomes et al. (2012) and is in line with the calibration of models such as the GEM (Laxton and Pesenti, 2003, Pesenti, 2008) and the NAWM (Christoffel et al., 2008).

An important part of calibration is how the productivity of public capital, α_G, is set. This parameter has no universally-agreed value, so we present the results for two cases. In the benchmark case, we pick the relatively low level of 0.05, in line with Leeper et al. (2010). As the alternative we consider the estimate from the meta-analysis of Bom and Ligthart (2014), who estimate the productivity of public investment at a higher level, 0.08.

4 Results

In this sections we examine the results of the effects of an increase of government investment, financed in four different ways:

- Debt-financed increase in government investment
- Other-consumption-financed increase in government investment
- Labour-tax-financed increase in government investment
- VAT-financed increase in government investment

In all cases, we assume that the government temporarily raises investment, in line with the Government Investment Plan, by approximately 0.3% GDP per quarter in the first year and 0.4% GDP per quarter during the second, third, and fourth year. Afterwards, government investment returns gradually to the initial level.[8] This scenario implies that the public capital increases by about 5% at the peak.

approximate relation that government expenditure has about half the import content of private expenditure. For the REA, RW, and the US we assumed a 10% import content of government investment, which is consistent with the estimate by Corsetti and Müller, who state 12% as the upper bound for government imports. For the import content of government consumption we use Corsetti and Müller's lower bound of 6% for the REA and the RW, and the exact value of 5.8% for the US. For Ireland we set the import content of government consumption to 12%, the highest value reported by Corsetti and Müller, while for government investment we use a 25% import content. The reason is that Ireland is very open, especially regarding investment goods. Note that these ratios should be modified for policy simulations when governments consider a particular policy action that is known to be more biased towards foreign or domestic goods.

[8]The persistence of government investment after the 4th year is 0.9.

Except in the debt-financed government investment case, we assume that government investment increase is ex-ante budget-neutral, i.e., that the government offsets the expenditure increase by a tax increase that would, ex-ante, lead to a balanced budget (note that ex-post, this may not be the case).

For each simulation, we report results for two levels of productivity of public capital, "low" (with $\alpha_G = 0.05$) and "high" (with $\alpha_G = 0.08$).

4.1 Debt-financed increase in government investment

The first and in many ways simplest case is when government investment is financed by issuing debt. In this case the government decides to increase investment and finances it mainly by issuing debt, with the fiscal rule specified in terms of lump-sum taxes kicking in in the long run. The results of this exercise are shown in Figure 4.

During the period when the government is increasing investment, the associated stimulus to aggregate demand directly increases output and marginal costs of firms. During this initial period, government investment has similar effects as the standard debt-funded fiscal stimulus: there is some crowding-out of private consumption, real appreciation, and a decrease in exports due to higher marginal costs and deterioration of external competitiveness. Imports increase because government investment consists in part of imported goods. However, government investment also gradually increases public capital, and the associated increase in productivity starts pushing marginal costs of firms down. More public capital and hence higher productivity allows more goods to be produced, at lower marginal costs despite somewhat higher wages, which improves the external competitiveness (real effective exchange rate depreciates) of the economy and increases exports over the medium and longer run. This is the reason why private investment is not crowded-out in the beginning - in order to benefit from higher public capital in the future, households begin investing immediately.[9]

Overall, over the medium and longer run, the gains from higher public capital stimulate the economy. This, however, comes at the expense of increasing public debt by about 1.5 p.p. over the medium run. In addition, such policy markedly reduces the trade balance in the short run.

[9]Note that there are investment-adjustment costs in the model; if these costs were absent, investment would decrease initially.

Because of these side effects, such policy might not be the best during the boom or when the country's external balance is weak, at least not in the short run. In the long run, the beneficial effects of productive public capital prevail and trade balance improves, while higher tax revenues (and the fiscal rule) stabilise public debt.

4.2 Other-consumption-financed increase in government investment

The second scenario we consider is also the first budget-neutral scenario. In this case, government finances the increase in investment by reducing government consumption. The results of this scenario are shown in Figure 5.

Compared to the debt-financing scenario, there are several marked differences. First, the sharp initial stimulus to output is absent, as government consumption decrease offsets the demand effects of government investment increase. Public debt does not increase initially, and decreases in the medium to long run (the latter is due to the increase in economic activity caused by more public capital). As a result, consumption and private investment are not crowded-out, not even in the short run.

Lower demand stimulus also implies that marginal costs increase substantially less than in the case of debt financing, which preserves the external competitiveness of the economy. Real effective exchange rate does not appreciate, exports increase almost immediately and trade balance deteriorates only in the very short run.

In the medium and longer run, beneficial effects of higher public capital reduce marginal costs of firms, which causes real effective exchange rate depreciation and higher exports. The latter exceed higher imports, so that the trade balance improves for a long period of time.

4.3 Labour-tax-financed increase in government investment

In this scenario the government finances its investment increase using distortionary labour taxes. The results are shown in Figure 6.

Higher labour taxes reduce labour supply, despite higher wages. Lower labour supply is the main reason why output increases by less than with debt financing or with other consumption financing. Moreover, higher labour taxes increase wages, which in turn raise marginal costs of

firms, which now increase more persistently then with debt financing.[10] This leads to a worsening of the external competitiveness of the economy (the real effective exchange rate appreciates) and exports decrease. Combined with the import increase (due to direct import-content of government investment), this markedly reduces the trade balance. Note that the increase in labour taxes, even though budget-neutral ex-ante, turns out to be somewhat too high in the short run and public debt decreases somewhat. This happens because the wage increase is brought forward by higher labour taxes, which offsets the effect of the lower labour supply on the tax base.

As in the previous cases, benefits from higher public capital begin to kick in the medium and longer run, resulting in an improvement of the trade balance and a reduction of public debt.

4.4 VAT-financed increase in government investment

The final scenario we consider is the VAT-financed government investment increase. The results are shown in Figure 7.

The VAT affects the relative price of consumption and leads to a drop in households' consumption, which falls about twice as much compared to the labour-tax-financed government investment increase. While the reduction in consumption is partly reoriented towards investment, output does not increase as much as with debt financing, but it increases more than when labour taxes are used to fund investment. The main reason for this is the response of wages, marginal costs, and exports. While with labour tax financing wages increase relatively quickly, and in particular already during the phase when government is investing, this worsens external competitiveness substantially. With VAT financing, the wage increase is more delayed and marginal costs do not increase as much (and drop faster). The external competitiveness of the economy is not much affected and exports drop only marginally and for a short period. Trade balance improves quickly after the initial worsening. The lower reduction in foreign demand offsets the main part of consumption decrease, which is why output increases by more than in the case of labour tax financing.

In the medium and longer run, the effects of higher public capital bring benefits. In particular,

[10] Note that if government financed investment using social security contributions borne by firms, then this would increase marginal costs of firms directly and have even more negative consequences for external competitiveness of the economy.

productivity gains from higher public capital offset the persistent wage increase. Trade balance improves persistently and public debt falls.

5 Conclusions

Most European countries that were severely affected by the recent crisis and whose public finances have come under stress have responded by strongly decreasing public investment. This has been particularly marked in countries that were in the programme, such as Greece, Ireland, Portugal and Spain. After several years of low government investment, public capital levels in these countries are depleted to a various extent, which may affect the growth potential of these countries. In this paper, we examine the plan of the Irish government to increase investment in public capital. We focus on the different possibilities regarding how such investment could be financed and their macroeconomic consequences.

Our main findings are that, from the perspective of maintaining fiscal and external balances, the best option seems to be to finance investment by reducing other government consumption expenditure. Pure debt financing is the worst in the sense that it worsens both external and fiscal balances. Financing with labour taxes maintains fiscal balance, but it worsens external balance. Financing investment with the VAT performs only slightly worse than financing by reducing other consumption expenditure in terms of both external and fiscal balances.

References

[1] Bayoumi, Tamim, Douglas Laxton, and Paolo Pesenti (2004), 'Benefits and Spillovers of Greater Competition in Europe: A Macroeconomic Assessment,' NBER Working Paper 10416, National Bureau of Economic Research.

[2] Bedogni, J., and R. Scott (2017), 'The Irish Experience: Fiscal Consolidation 2008-2014,' Department of Public Expenditure and Reform, Irish Government Economic and Evaluation Services, May 2017.

[3] Bom, Pedro R.D., and Jenny Ligthart (2014), 'What Have We Learned from Three Decades of Research on the Productivity of Public Capital?' *Journal of Economic Surveys*, vol. 28(5), pages 889-916.

[4] Brzoza-Brzezina, M., P. Jacquinot, and M. Kolasa. 2010. 'Can we prevent boom-bust cycles during EA accession?' ECB Working Paper No. 1280.

[5] Christoffel, Kai, Günter Coenen, and Anders Warne (2008), 'The New Area-Wide Model of the Euro Area: A Micro-Founded Open-Economy Model for Forecasting and Policy Analysis,' ECB Working Paper 944, European Central Bank.

[6] Clancy, Daragh, Pascal Jacquinot, and Matija Lozej (2016), 'Government Expenditure Composition and Fiscal Policy Spillovers in Small Open Economies within a Monetary Union,' *Journal of Macroeconomics*, vol. 48(C), pages 305–326.

[7] Coenen, Günter, Peter McAdam, and Roland Straub (2008), 'Tax Reform and Labour-Market Performance in the Euro Area: A Simulation-Based Analysis using the New Area-Wide Model,' *Journal of Economic Dynamics and Control*, vol. 32, pages 2543–2583.

[8] Corsetti, G., A. Meier, and G.J. Müller (2010). 'Cross-Border Spillovers from Fiscal Stimulus,' *International Journal of Central Banking*, vol. 6(1), pages 5-37.

[9] De Jong, J., Ferdinandusse, M., Funda, J., and Vetov, I. (2017): The effect of public investment in Europe: a model-based assessment, ECB Working Paper 2021, February 2017.

[10] Department of Finance (2011): Medium Term Fiscal Statement, November 2011.

[11] ECB (2016): Public Investment in Europe, Article in ECB Economic Bulletin, Issue 2 / 2016.

[12] Erceg, Christofer J., Dale Henderson, and Andrew T. Levin (2000), 'Optimal Monetary Policy with Staggered Wage and Price Contracts,' *Journal of Monetary Economics*, vol. 64(2), pages 281-313.

[13] European Commission (2017): European Economic Forecast Spring 2017, May 2017.

[14] Everaert, Luc and Werner Schule (2008), 'Why it Pays to Synchronize Structural Reforms in the Euro Area across Markets and Countries,' *IMF Staff Papers,* vol. 55(2), pages 356-366. International Monetary Fund.

[15] Faruqee, Hamid, Douglas Laxton, Dirk Muir, and Paolo A. Pesenti (2007), 'Smooth Landing or Crash? Model-Based Scenarios of Global Current Account Rebalancing.' In: R. Clarida (ed.) G7 Current Account Imbalances: Sustainability and Adjustment, Chicago, IL: University of Chicago Press.

[16] Faruqee, Hamid, Douglas Laxton, Dirk Muir, and Paolo A. Pesenti (2008), 'Would protectionism defuse global imbalances and spur economic activity? A scenario analysis' *Journal of Economic Dynamics and Control*, 32(8), pages2651-2689.

[17] Fitz Gerald, J., McCarthy, C., Morgenroth, E. and OConnell, P. (2003): The Mid-term Evaluation of the National Development Plan and Community Support Framework for Ireland 2000 to 2006, ESRI Policy Research Series Number 50, October 2003.

[18] Gomes, Sandra, Pascal Jacquinot, and Massimiliano Pisani (2010), 'The EAGLE. A Model for Policy Analysis of Macroeconomic Interdependence in the Euro Area,' ECB Working Paper 1195, European Central Bank.

[19] Gomes, Sandra, Pascal Jacquinot, and Massimiliano Pisani (2012), 'The EAGLE. A Model for Policy Analysis of Macroeconomic Interdependence in the Euro Area,' *Economic Modelling*, vol. 29(5), pages 1686-1714.

[20] IMF (2014): Fiscal Monitor, Chapter 2 Public Expenditure Reform: Making Difficult Choices, April 2014.

[21] Kennedy, A. (2016): Public Capital: Investment, Stocks and Depreciation, Irish Fiscal Advisory Council, Analytical Note No. 9, June 2016.

[22] Laxton, Douglas, and Paolo Pesenti (2003), 'Monetary Policy Rules for Small, Open, Emerging Economies,' *Journal of Monetary Economics,* vol. 50(5), pages 1109–1146.

[23] Leeper, E.M., T.B. Walker, and S-C.S. Yang (2010), 'Government investment and fiscal stimulus,' *Journal of Monetary Economics* 57, pages 1000-12.

[24] Lane, Philip (2003), 'The Cyclical Behaviour of Fiscal Policy: Evidence from the OECD,' *Journal of Public Economics* vol. 87(12), pages 2661–2675.

[25] OECD (2015): OECD Economic Outlook 2015/1, Chapter 3 - Lifting Investment for Higher Sustainable Growth, June 2015.

[26] Pesenti, Paolo (2008), 'The Global Economy Model (GEM): Theoretical Framework,' *IMF Staff Papers*, vol. 55(2), pages 243–284, International Monetary Fund.

[27] Smets, Frank, and Raf Wouters (2003), 'An Estimated Dynamic Stochastic General Equilibrium Model of the Euro Area,' *Journal of the European Economic Association,* vol. 1(5), pages 1123–1175.

A Tables and Figures

Table 1: Steady-state Ratios and Trade Matrix (as % of nominal GDP)

	IE
Great Ratios	
Private consumption	0.5791
Private investment	0.1760
Target public debt (% of annual GDP)	0.6000
Trade linkages	
Imports	0.6300
Consumption goods	0.1498
From REA	0.0543
From RW	0.0737
From US	0.0218
Investment goods	0.0972
From REA	0.0343
From RW	0.0465
From US	0.0164
Imports of exports	0.3530
From REA	0.1130
From RW	0.1532
From US	0.0868
Government expenditure	
Consumption expenditure	0.1290
Imports	0.0200
Investment expenditure	0.0400
Imports	0.0100
Country size	
Size (as % of world GDP)	0.03

Table 2: Calibration - Households and Firms

	IE
Households	
Subjective discount factor	$1.03^{\frac{1}{4}}$
Depreciation rate (private capital)	0.025
Depreciation rate (public capital)	0.025
Int. elasticity of substitution	1.00
Habit formation	0.60
Frisch elasticity of labour (inverse)	2.00
Intermediate goods firms	
Tradable - bias toward capital	0.35
Nontradable - bias toward capital	0.30
Final cons. goods	
Subst. btw. domestic and imported	2.50
Subst. imported	2.50
Bias toward domestic tradables	0.3872
Subst. btw. tradable and non-tradable	0.50
Bias toward tradable	0.475
Final inv. goods	
Subst. btw. domestic and imported	1.50
Subst. imported	2.50
Bias toward domestic tradables	0.2336
Subst. btw. tradable and non-tradable	0.50
Bias toward tradable	0.75
Final government cons. goods	
Subst. btw. domestic and imported	2.50
Subst. imported	2.50
Bias toward domestic	0.2084
Subst. btw. tradable and non-tradable	0.50
Bias toward tradable	0.80
Final government inv. goods	
Subst. btw. domestic and imported	2.50
Subst. imported	2.50
Bias toward domestic	0.4252
Subst. btw. tradable and non-tradable	0.50
Bias toward tradable	0.60

Table 3: Calibration - Real and Nominal Rigidities, Tax Rates

	IE	**REA**	**US**	**RW**
Real rigidities				
Investment adjustment	6.00	5.00	5.00	5.00
Import adjustment (cons.)	5.00	5.00	5.00	5.00
Import adjustment (inv.)	2.00	2.00	2.00	2.00
Quasi-share of govt cons.	0.25	0.20	0.20	0.20
Complementarity of consumptions	0.20	0.29	0.33	0.33
Nominal rigidities				
Wage stickiness	0.80	0.75	0.75	0.75
Wage indexation	0.75	0.75	0.75	0.75
Price stickiness (domestic)	0.75	0.75	0.75	0.75
Price indexation (domestic)	0.50	0.50	0.50	0.50
Price stickiness (imported)	0.75	0.75	0.75	0.75
Price indexation (imported)	0.50	0.50	0.50	0.50
Price stickiness (services)	0.75	0.75	0.75	0.75
Price indexation (services)	0.50	0.50	0.50	0.50
Tax rates				
Consumption tax	0.1200	0.1830	0.0770	0.0770
Labour income tax	0.1600	0.1220	0.1540	0.1540
Capital tax	0.1000	0.1900	0.1600	0.1600
SSC paid by firms	0.0900	0.2190	0.0710	0.0710
SSC paid by households	0.0700	0.1180	0.0710	0.0710

Figure 1: Government expenditure

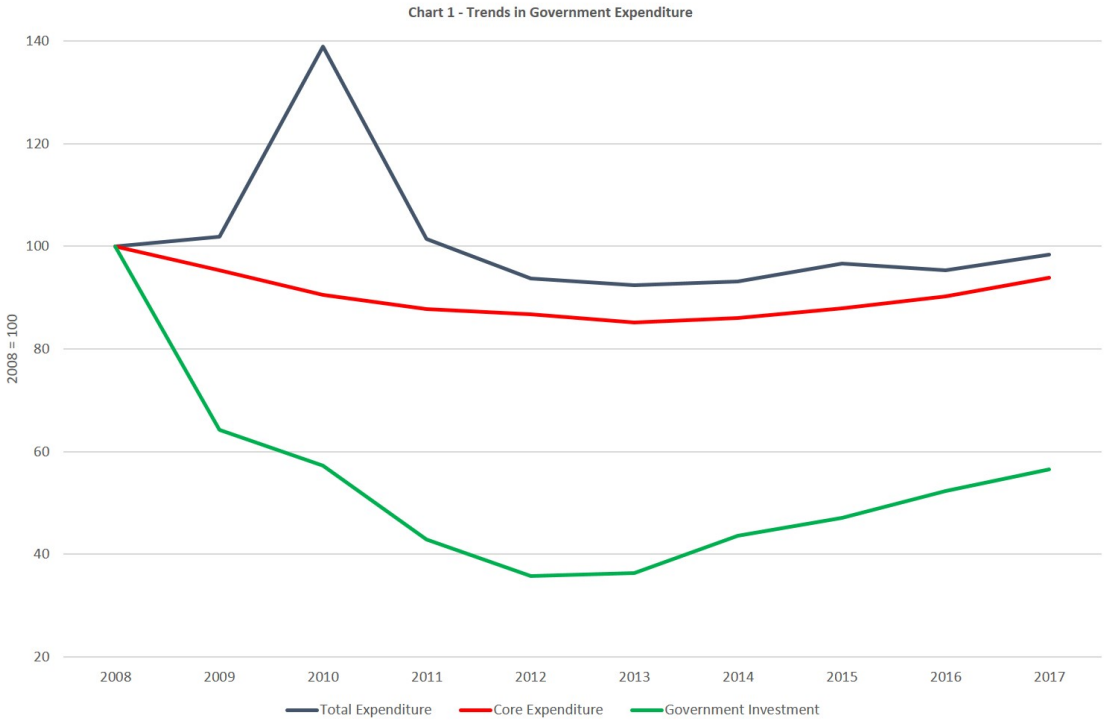


Figure 2: Government investment and depreciation as percent of GNI*

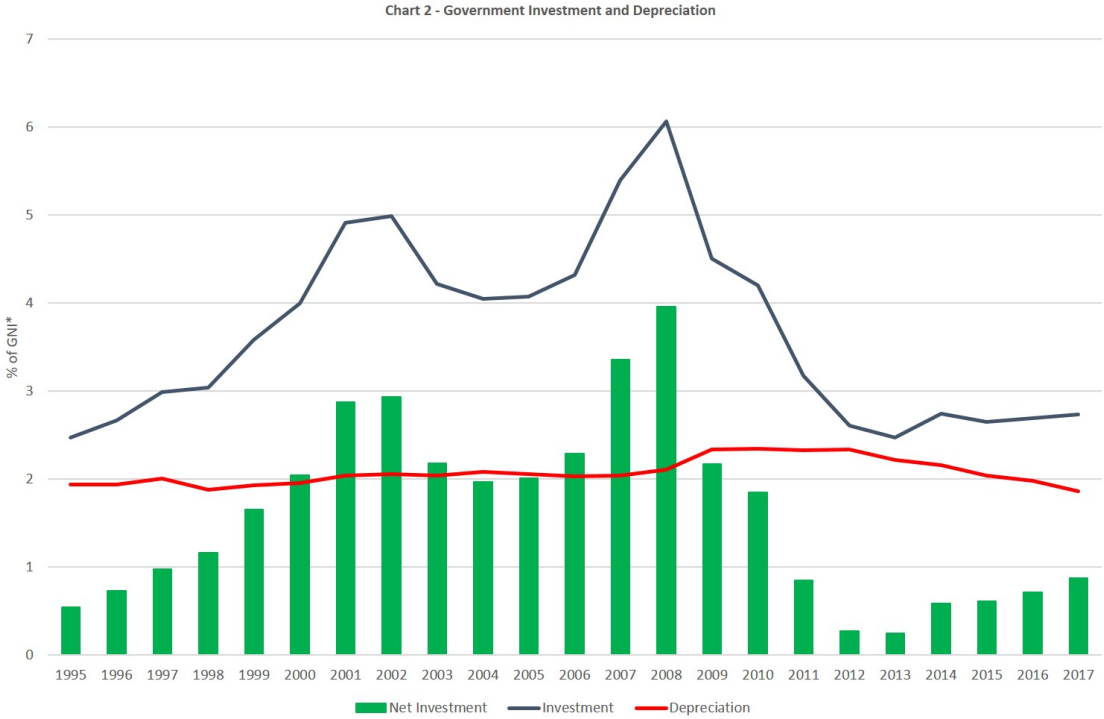


Figure 3: Public capital in levels and compared to domestic economic activity

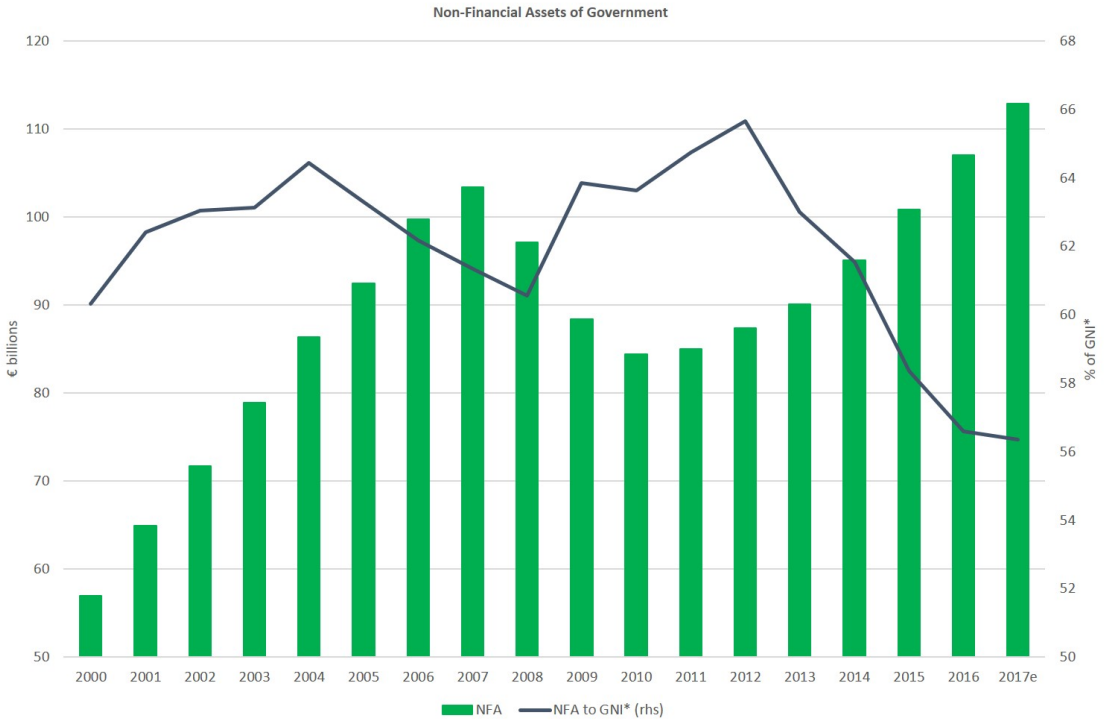
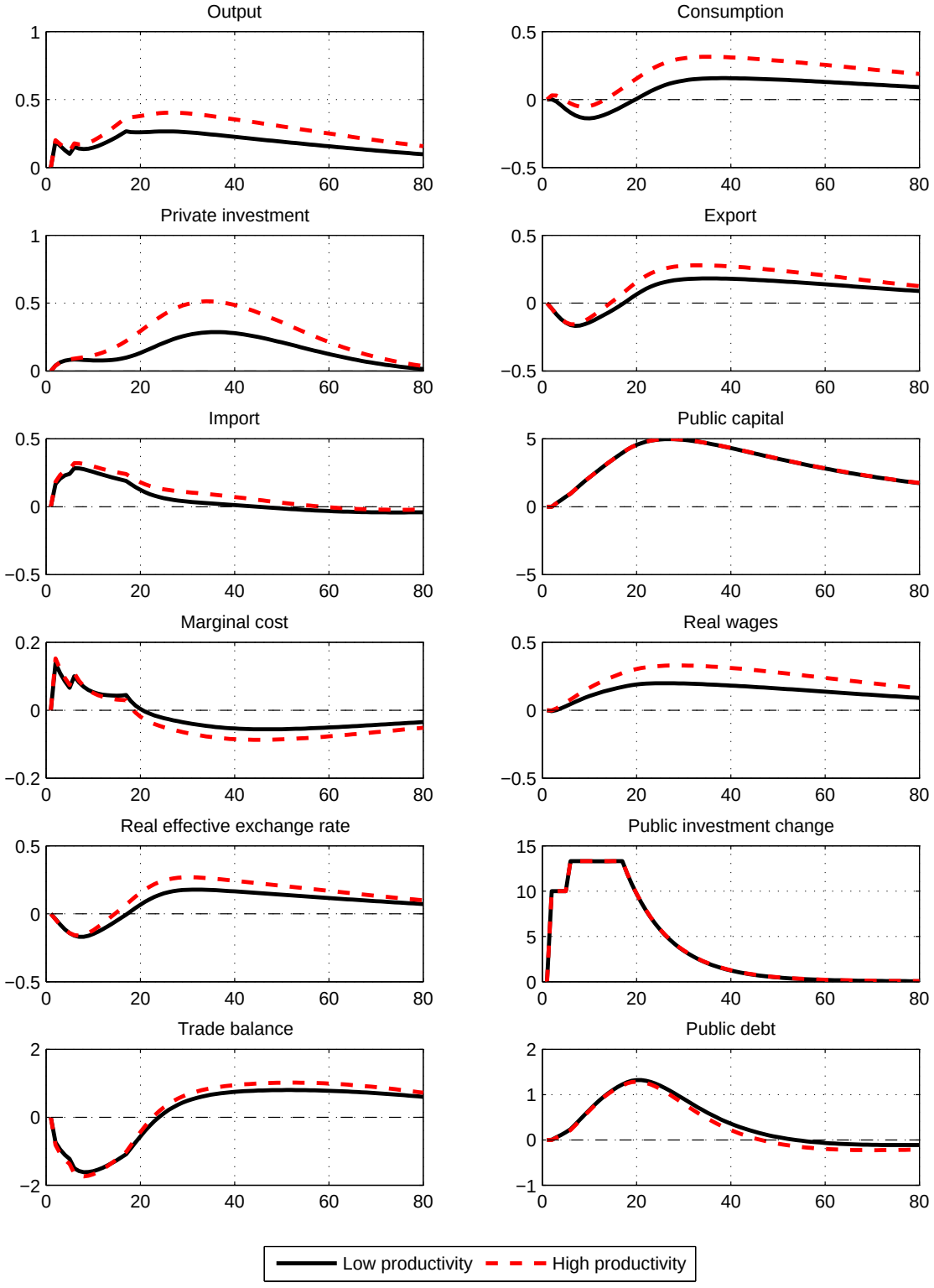
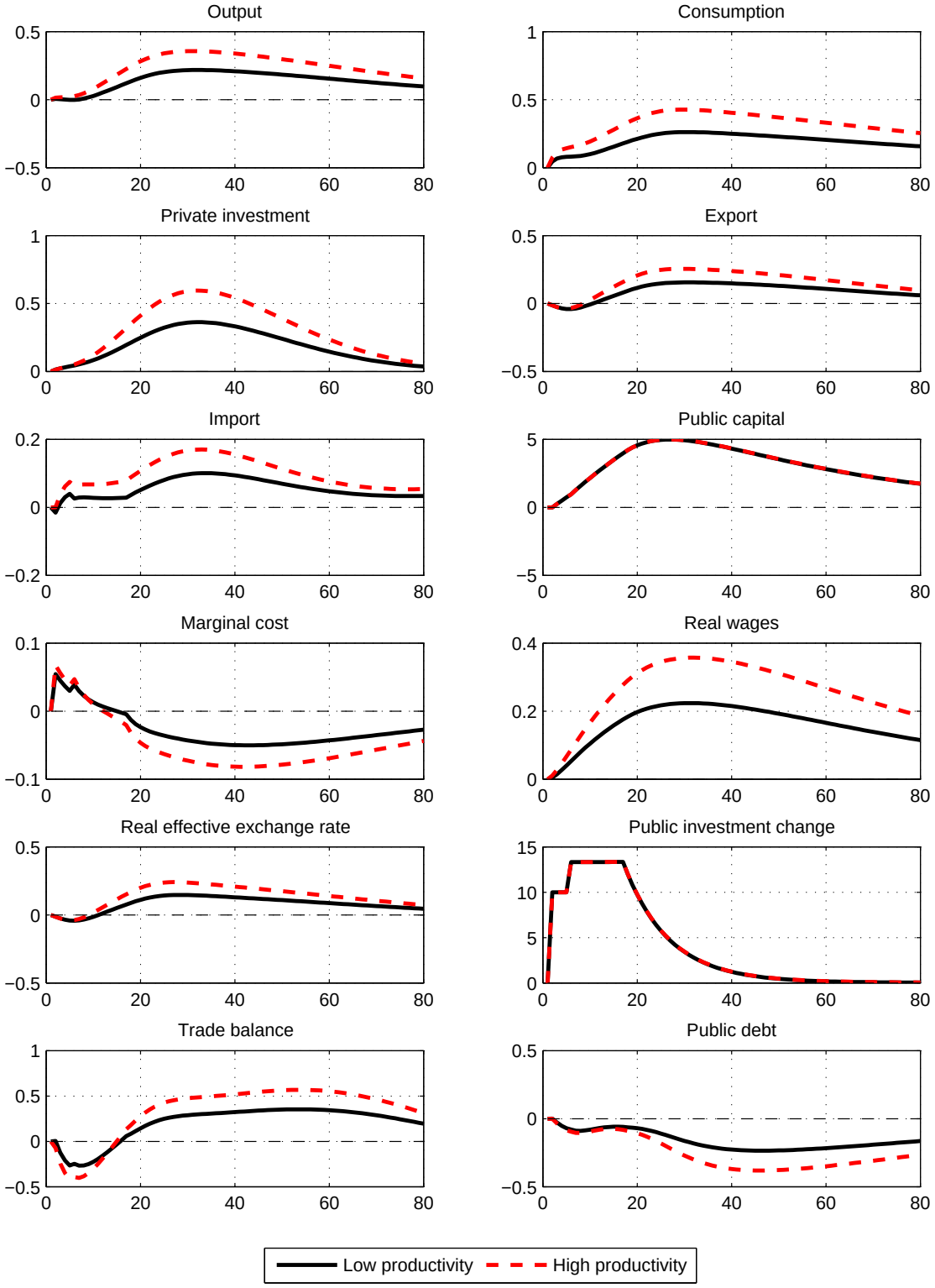


Figure 4: Debt-financed increase in government investment



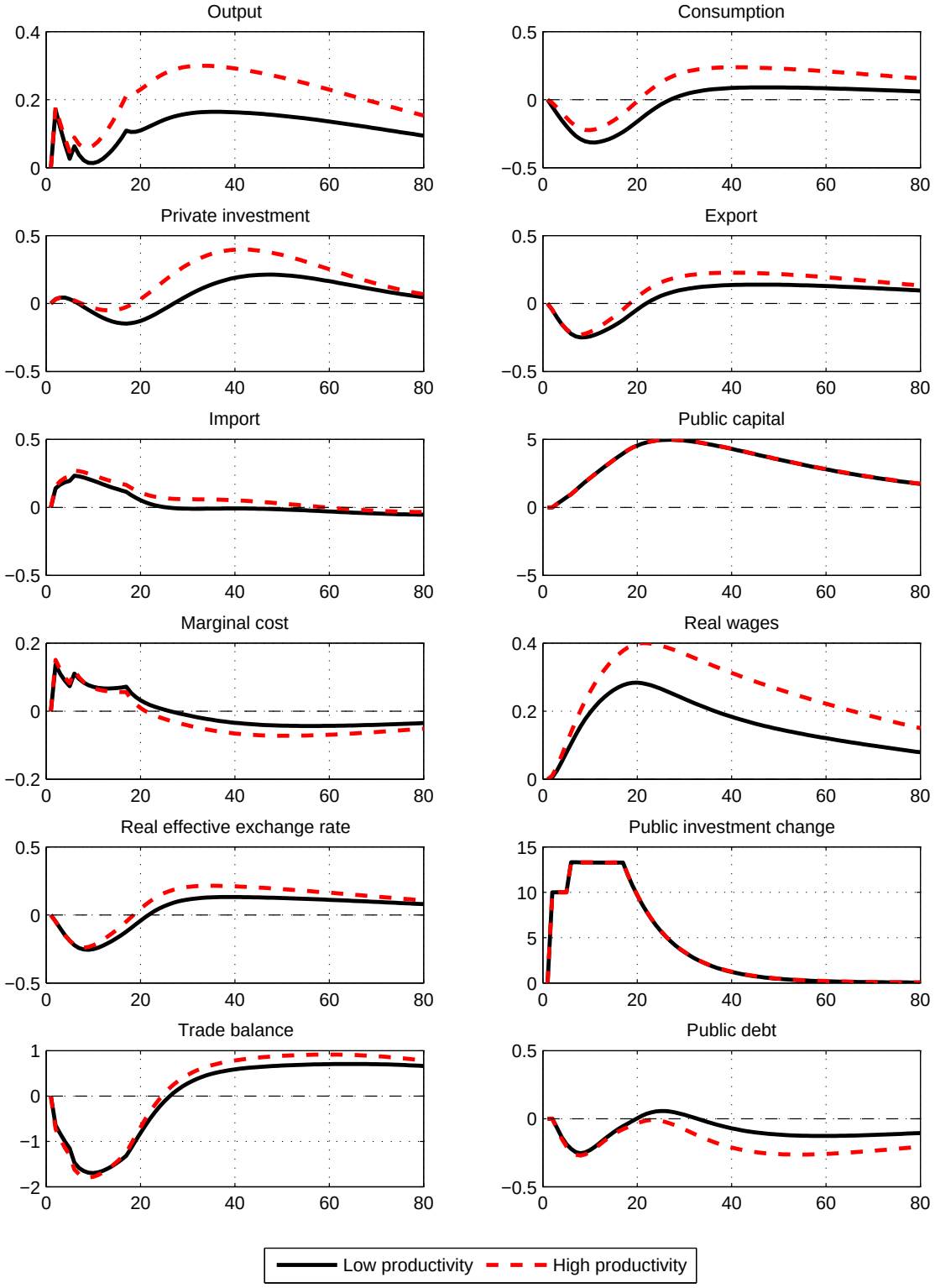
Notes: All variables are reported in percent deviations from the steady state. Units on the horizontal axis are quarters.

Figure 5: Other-consumption-financed increase in government investment



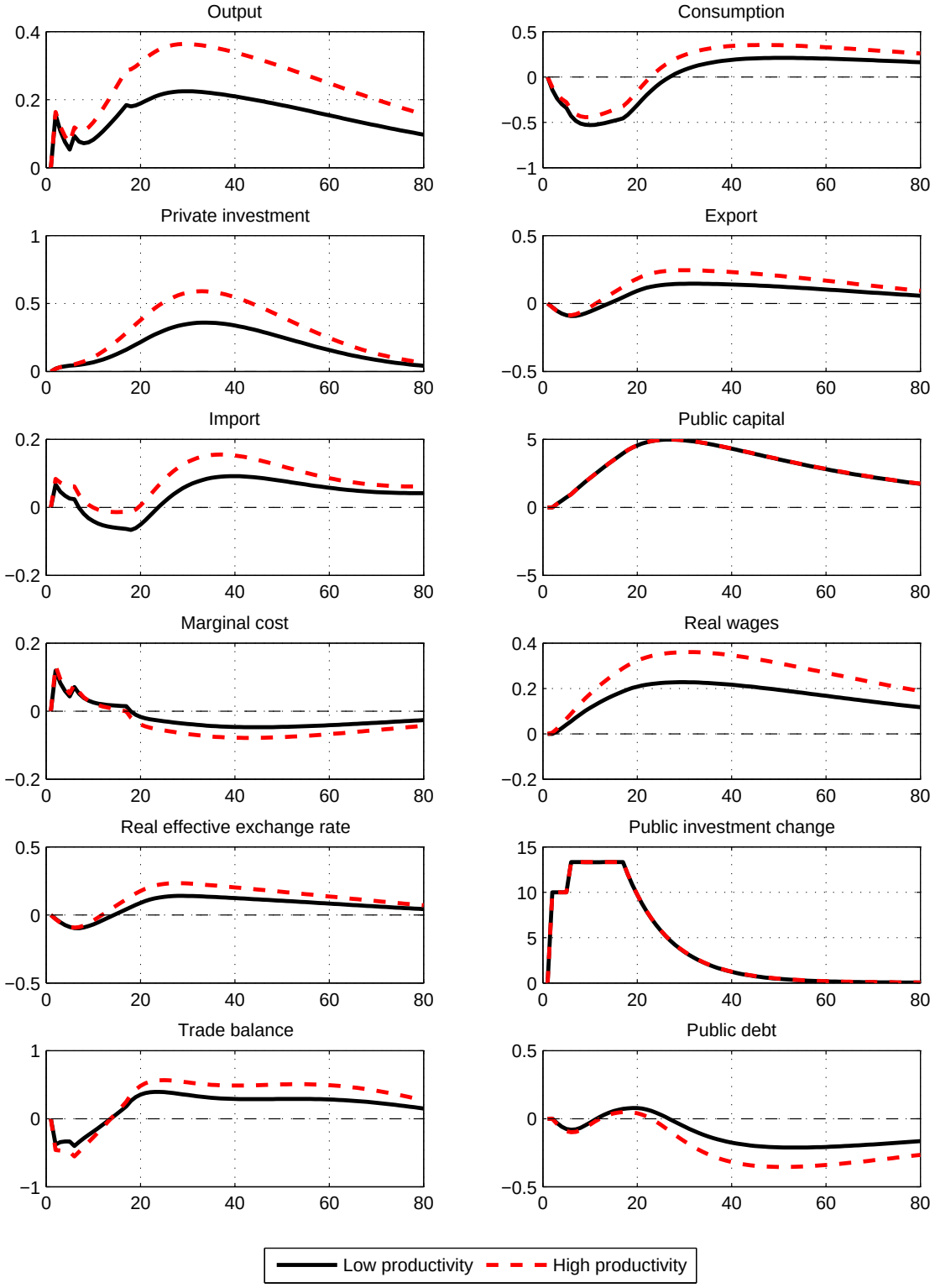
Notes: All variables are reported in percent deviations from the steady state. Units on the horizontal axis are quarters.

Figure 6: Labour-tax-financed increase in government investment



Notes: All variables are reported in percent deviations from the steady state. Units on the horizontal axis are quarters.

Figure 7: VAT-financed increase in government investment



Notes: All variables are reported in percent deviations from the steady state. Units on the horizontal axis are quarters.