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THE EFFECTS OF GOVERNMENT SPENDING IN A SMALL OPEN ECONOMY WITHIN A MONETARY UNION

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In 2014 all ECB publications feature a motif taken from the €20 banknote.

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Abstract

Small open economies within a monetary union have a limited range of stabilisation tools, as area-wide nominal interest and exchange rates do not respond to country-specific shocks. Such limitations imply that imbalances can be difficult to resolve. We assess the role that government spending can play in mitigating this issue using a global DSGE model, with an extensive fiscal sector allowing for a rich set of transmission channels. We find that complementarities between government and private consumption can substantially increase spending multipliers. Government investment, by raising productive public capital, improves external competitiveness and counteracts external imbalances. An ex-ante budget-neutral switch of government expenditure towards investment has beneficial effects in the medium run, while short-run effects depend on the degree of co-movement between private and government consumption. Finally, spillovers from a fiscal stimulus in one region of a monetary union depend on trade linkages and can be sizeable.

JEL classification: E22, E62, H54
Keywords: Fiscal policy, Public capital, Imbalances, Trade

Non-technical summary

Small open economies (SOEs) are extremely susceptible to external shocks. When SOEs are part of a monetary union, the response of nominal interest and exchange rates, based on area-wide aggregates, typically cannot be tailored to stabilise the impact of country-specific shocks. Fiscal policy is especially important for individual members of a monetary union, since it is the only standard stabilisation instrument available to national authorities to smooth business cycle fluctuations driven by these shocks. The recent financial crisis induced a severe recession and a large increase in the net foreign liabilities of many euro area (EA) countries. Addressing the accumulation of external imbalances is a key part of the post-crisis adjustment process. The incorporation of these imbalances into the EU economic governance structure via the Macroeconomic Imbalance Procedure further underlines their importance.

We assess the role that government spending can play in counteracting these imbalances using a global DSGE model, the EAGLE. The original model's fiscal sector is extended to allow for: a distinction between government consumption and investment; an import-content of government expenditure; the accumulation of public capital; and complementarities between government and private consumption. To illustrate the heterogeneity of responses to various shocks, we calibrate the extended EAGLE to Ireland and Slovenia. They are both small, very open, and members of the EA. However, they differ in several important respects, in particular with regard to trade orientation, where Ireland tends to trade mainly with non-EA regions and Slovenia trades mainly with the EA. This implies that, for instance, the sensitivity of trade flows with respect to the euro exchange rate will be very different for each country. There are also other differences regarding the great ratios, nominal and real rigidities, tax rates, etc. As a consequence, their reactions to shocks can be very different.

We find that when private consumption and government consumption are complementary, short run government consumption multipliers can be substantial. While government investment has somewhat less impact on GDP in the short run than government consumption, our results show that through an increase in productive public capital, government investment improves a SOEs external competitiveness in the medium run and thus can promote growth and counteract developing imbalances. This effect is magnified for a SOE in a monetary union, where the area-wide interest rate does not react strongly to the increase in demand in a SOE. Even a budget neutral re-orientation of public expenditure towards investment can have a large positive impact in the medium run. The extended model allows for a rich set of new transmission channels of foreign government expenditure shocks to other economies. Our analysis shows that the positive spillovers from a fiscal stimulus in one region of a monetary union can be sizeable,

with the sign and magnitude of the effect dependent on individual countries' trade linkages.

1 Introduction

SOEs are extremely susceptible to external shocks. When SOEs are part of a monetary union, the response of nominal interest and exchange rates, based on area-wide aggregates, typically cannot be tailored to stabilise the impact of country-specific shocks. Fiscal policy is especially important for individual members of a monetary union, since it is the only standard stabilisation instrument available to national authorities to smooth business cycle fluctuations driven by these shocks. The recent financial crisis induced a severe recession and a large increase in the net foreign liabilities of many EA countries. Addressing the accumulation of external imbalances is a key part of the post-crisis adjustment process.[1] The incorporation of these imbalances into the EU economic governance structure via the Macroeconomic Imbalance Procedure (MIP) further underlines their importance.[2]

We exploit the rich modelling environment provided by a global DSGE model, the EAGLE (Gomes et al., 2012), and attempt to account for some of the features frequently discussed in the literature, in particular those especially relevant for SOEs within a monetary union. First, we allow government spending to partly consist of imported goods, to replicate the reality of SOEs where a significant proportion of goods consumed or invested by the government is imported. This gives us the desirable feature that government spending in SOEs tends to have lower multipliers as a result of leakages from import expenditure. Second, we split government spending between consumption and investment goods. Regarding consumption goods, we maintain the assumption from many models that government consumption expenditure is wasteful. However, we follow Coenen et al. (2012b) and allow for complementarities between private and government consumption. This allows us to analyse the effects of such complementarities on both the size of government consumption multipliers and the spillovers of government expenditure shocks in their main trading partners. Finally, we follow Leeper et al. (2010) and allow government investment expenditure to contribute to public capital. Public capital increases the productivity of private capital and reduces the marginal costs of firms, which draws in private investment, improves external competitiveness, the current account and increases output in the medium run. This feature has particularly important consequences for SOEs within a monetary union, because the area-wide interest rate response to an output increase in a small country is negligible.

The extended version of the model allows us to analyse structural mechanisms that can lead to different sizes of fiscal multipliers. There are a multitude of

[1] Chen et al. (2012) explore the role of various factors on the evolution of external imbalances in EA countries.

[2] See Hickey and Kane (2014) for a discussion of the MIP.

factors which impact the size of fiscal multipliers, and consequently, there are wide disagreements about the size and even the sign of multipliers. In a review of the literature, Spilimbergo et al. (2010) conclude that the multiplier depends, amongst other things, on leakages into saving and imports and on the responses of monetary policy to the fiscal actions. Thus, smaller economies that are more open to trade and countries in which monetary policy offsets the fiscal stimulus will tend to have lower multipliers. In addition, the fiscal instruments used to induce a stimulus can have important consequences. Some argue (see, for example, Freedman et al., 2009) that expenditure rather than taxation measures have larger effects, as increased expenditure has a direct impact on demand, whereas individuals may save at least some part of a tax cut.

There is a great deal of uncertainty regarding the size even of spending multipliers (Alesina and Ardagna, 2009). This uncertainty derives not only from the usual limitations of empirical estimation, but also from different views on the proper theoretical framework and econometric methodology (Cogan et al., 2010). Both reduced-form and structural models have been used in the literature to examine the effects of fiscal policy.[3] In justifying the use of structural over reduced-form models, Coenen et al. (2012a) detail some of the issues facing the latter. In particular, identification and simultaneity issues make it difficult to accurately assess the effects of fiscal policies. As a result, the empirical estimates of fiscal multipliers are dispersed over a very broad range.

Structural models can address these issues.[4] Their main weakness surrounds the incomplete consensus on structural features and calibration. For instance, Benetrix and Lane (2009) argue that there are important differences between shocks to government investment and government consumption. This is due to the fact that the size of fiscal multipliers depends critically on key characteristics of the economy under study (llzetzki et al., 2013), such as the openness to trade, public indebtedness, but also nominal rigidities. In order to assess the importance of this problem, Coenen et al. (2012a) compare and contrast the effects of fiscal stimulus shocks in the structural models used by a number of policymaking institutions. Unlike in non-structural models, they find considerable agreement across the various models on both the absolute and relative sizes of multipliers from different types of fiscal innovations.

Neoclassical economic theory typically assumes that government expenditure is wasteful and that deficit-financed government spending reduces the loanable

[3]See Hemming et al. (2002) for a comprehensive review of the empirical literature regarding the effectiveness of fiscal policy. More recently, Mountford and Uhlig (2009) focus solely on those studies which use vector autoregressions (VARs) to analyse the effects of fiscal policy.

[4]Ramey (2011) finds that an empirical model that incorporates the timing of news on future government spending can explain some of the variation in VAR estimates. While this goes some way towards correcting the identification issue, the simultaneity issues remain.

funds available for private investment, thereby driving up interest rates (Mitra, 2006). The resulting negative wealth effect crowds out private consumption and investment. This completely cancels out the positive impact of increased government investment, and has a limited effect on output. By contrast, models that allow for non-Ricardian features can manage to explain the rise in consumption, the real wage, and productivity found in some empirical analyses of fiscal stimulus. For example, the presence of credit constrained households raises the marginal propensity to consume out of current net income and makes fiscal policy shocks that directly impact on households' purchasing power a more powerful tool for short run stabilisation (Roeger and in 't Veld, 2010).

The assumption that all government spending is unproductive, which is widespread in the literature (Leeper et al., 2010), is not very intuitive for government investment. Many researchers and policymakers believe that government investment can have a substantial positive impact on the economy, as it increases productivity and reduces costs, in particular in the medium run (see, for instance, Galstyan and Lane, 2009a and 2009b; Morgenroth, 2011). This has also been demonstrated in small structural models. Baxter and King (1993) find that the macroeconomic effects of government purchases depend importantly on whether these directly affect private marginal product schedules. They conclude that if government capital augments the productivity of private capital and labour, government investment policies can have dramatic effects on output and private investment. However, Baxter and King (1993) caution that if public capital is not sufficiently productive, then government investment can be contractionary in the long run. The disincentive to invest and work due to expected fiscal adjustments can dominate the higher productivity of private inputs from an expansion of public capital.

To assess the new transmission mechanisms introduced to the model and their consequences for fiscal policy, we calibrate the model to two different SOEs within the European Monetary Union, Ireland and Slovenia. The key differences between the two countries are with respect to trade linkages, as well as real and nominal rigidities. These differences permit us to control for many features discussed in both the empirical and theoretical literature that can give rise to different magnitudes of government spending multipliers. We demonstrate how country-specific features can give rise to heterogeneous responses to standardised shocks, even in a unified structural model. Accordingly, country-specific fiscal policy is the primary tool at a country's disposal to smooth out such shocks. We use our model to assess the impact of various policies aimed at stimulating the economy. This is especially relevant at the current juncture, since the recent financial crisis has resulted in a large government deficit and depressed economies in many European countries that tend to be relatively small, open, and belong to a monetary union.

Therefore, additional insights into the transmission of policy shocks would help policymakers to both better understand the workings of the economy and to design better policies. Fiscal consolidation, a policy induced episode of revenue raising or expenditure tightening, is often used as a means to restore budget balance (Weymes, 2012). In this view it is important to pick such consolidation measures which, given the desired amount of budgetary savings, result in the least harmful consequences for output, both in the short and medium run.

Our results show that in the short run, government consumption expenditure reductions can lead to substantial output losses if complementarities between private and government consumption are high.[5] In the medium run, the effects are smaller. This is not the case for government investment expenditure reductions, which lead to output losses both in the short and medium run. Moreover, a reduction in government investment expenditure reduces a country's external competitiveness in the medium run, thereby matching the empirical evidence from studies of the effects of fiscal policy on international competitiveness (Galstyan and Lane 2009a, 2009b). This is the case regardless of whether goods for government investment are imported or produced at home. Because government investment has positive effects on the productivity of private capital, private investment decreases in the medium run.

The key policy implication is that a reduction in government investment expenditure, while often being the first government spending component that is cut, may have undesirable consequences in the medium run. If complementarities between private and government consumption are low, and if the import content of government consumption expenditure is high, a reduction of government consumption may be a preferred (although often more difficult) option to minimise output loss during a fiscal consolidation. Since both Ireland and Slovenia face substantial and persistent decreases in private investment, a reduction in government investment could be an inappropriate policy action when private and government investment are complementary in the medium run.

Finally, we show that the extended model can have substantially different policy implications regarding spillovers of fiscal expenditure shocks between different blocs of the EA. While it is very difficult to find parameters in the original EAGLE that can generate positive effects of government expenditure increase in one EA region to another, the extended model allows for additional transmission channels that can give rise to significant spillovers. These effects depend on the structure of trade flows and the degree of co-movement between government and private expenditure. The ability of the extended model to generate positive co-movement between private and government consumption and investment in the medium run also generates significant spillovers of government expenditure changes to other

[5]For similar results in a closed economy, see Leeper et al., 2010.

blocs of the EA. This is consistent with empirical findings (see e.g., Beetsma and Giuliodori, 2011, Corsetti et al. 2010 or Corsetti and Müller, 2011).The following section provides an overview of the original EAGLE model and the extension to the fiscal sector and discusses the basic calibration of the model. Section 3 discusses the effects of government expenditure shocks in an individual country, the mechanisms behind the responses to shocks and policy implications. Section 4 demonstrates how government expenditure shocks in one bloc of the EA affect the other bloc and discusses the channels through which these shocks are transmitted. Some policy implications are given. The final section summarises and concludes with a discussion on possible future extensions to the model. We relegate the discussion of country heterogeneity and sensitivity analyses to the appendix.

2 The model

2.1 The EAGLE and its extension

The EAGLE model is structured as four regions of the world economy, two of which constitute a monetary union. Apart from monetary policy regimes and some parameter values (to be discussed in the next section), each region covered in the EAGLE is modelled in a symmetric fashion. The various regions are linked with each other through bilateral trade relations and participation in international financial markets. This formulation allows for a comprehensive treatment of the macroeconomic interdependences and spillovers present in the EA. Here only a brief overview of the main features of the EAGLE is provided, with the reader referred to Gomes et al. (2012) for greater details.

Each region is populated by two types of households, who can be differentiated by their ability to participate in asset markets. Ricardian (I-type) households can transfer their wealth intertemporally by holding money, trading bonds and accumulating physical capital. However, the remaining (J-type) households are liquidity constrained and so the only asset they can hold is money. Labour markets are assumed to be monopolistically competitive, thereby allowing households to act as wage setters for the differentiated labour service they supply to firms. This allows for the introduction of nominal rigidities in the labour and goods market. Wage rigidities are modelled using the Calvo (1983) framework, with wages for those households who cannot reoptimise during a given period augmented with an indexation scheme which links changes in pay to past and steady-state consumer price inflation.

The goods market is composed of several layers. An intermediate sector produces both tradable and nontradable goods. These are produced by

monopolistically competitive firms, who use labour and capital services supplied by households. Intermediate goods firms set prices for their differentiated output according to the Calvo-type scheme with indexation. Tradable intermediate goods are subject to international trade, with export prices denominated in the importing country's currency (local currency pricing assumption). A final goods sector contains perfectly competitive firms who aggregate different varieties of domestic nontradable, tradable and imported goods. Aggregation of imports into a homogeneous import good is subject to adjustment costs whenever a country's trade structure changes.

The fiscal authority (government) generates revenue through the imposition of both proportional and lump-sum taxes, as well as seigniorage earned on outstanding money holdings. In the original framework, these funds are used to purchase final goods (of an entirely nontradable content) and make transfer payments to households. Transfers and lump-sum taxes are not evenly distributed across the two types of households, with those having full access to asset markets receiving less and paying more in per-capita terms. Any fiscal debt accrued 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 home and the EA blocs share a monetary authority (central bank) reflecting their status as members of a common currency area, with the two remaining regions having separate monetary authorities. All regions follow a Taylor-type interest rate feedback rule, which is specified in terms of deviations of consumer price inflation and output from their target (steady-state) levels and allows for interest rate smoothing.

Although the original EAGLE features a sophisticated tax structure, the government spending component is relatively stylised. Government spending is focused exclusively on home nontradable consumption goods and transfers to households. An important implication of this is that the transmission of government spending shocks to the other sectors of the economy (home tradables and imported goods) is dependent on the degree of complementarity between these goods. This paper further develops the EAGLE model in several ways that significantly alter the responses of the model to government expenditure shocks. Extensions of the model introduce several new transmission channels that are particularly relevant for SOEs. For instance, government expenditure can contain an imported component. In a SOE many of the goods purchased by the government are simply not produced domestically, as the economy is not necessarily large enough to have all the necessary sectors. Moreover, as discussed below, complementarities between private and government consumption and the effect of public capital on the productivity of the private sector are especially relevant for very open economies, for which trade flows are extremely important.

A detailed derivation of the extension to the model is provided in appendix B. The details of new transmission channels for government expenditure shocks are discussed below.

2.2 Calibration

Despite being in the EA and sharing a common currency, the reactions of different economies to common shocks can be vastly different. Although this has been a topic of much discussion in the literature (see, for example, Beetsma and Jensen, 2005; Benigno, 2004; or Gali and Monacelli, 2008), it has gained prominence since the onset of the Great Recession and the sovereign debt crisis (see, for example, Erceg and Linde, 2010; Gomes et al., 2011; or Herz and Hohberger, 2013). To analyse the responses of SOEs to a set of standardised shocks, we calibrate a version of the EAGLE model to both Ireland and Slovenia. These countries differ, crucially, with respect to their trade linkages. Slovenia trades predominantly within the EA, whilst Ireland trades mainly outside of it. Therefore, *a priori*, it is expected that shocks originating in the EA will not have as strong an effect in Ireland as on Slovenia. Conversely, shocks emanating from outside the EA will impact on Ireland more than Slovenia. The other blocs in the model remain as in the original, namely, the rest of the euro area (REA), the United States (US) and the rest of the world (RW). The recalibration process involves the specification of key steady state (long run) ratios and model parameters which govern the dynamic adjustment to shocks.

The first stage in recalibrating the model is to adjust key steady state ratios which represent the underlying structure of the economy. Data from the national account statistics are used for this purpose. Next, the parameters required for establishing the trade linkages between the model blocs are based on a mix on national account 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). Finally, the remaining parameters in the model are either based on country specific empirical evidence, where available, or kept consistent with the original model.[6] For parameters for which there are no valid grounds for making a change, the original calibration was kept. The values of the calibrated parameters and steady-state ratios for both countries are reported in Tables 1 to 4. There are key differences in terms of the share of investment and government consumption spending, which is higher in Slovenia. The differences are also with

[6]The EAGLE primarily uses standard values, prevalent in the literature (e.g. Smets and Wouters, 2003, 2007; Laxton and Pesenti, 2003; Christiano et al., 2005; Adolfson et al., 2007; Christoffel et al., 2008), for the majority of parameters.

respect to the shares of imports in GDP and the structure of imports (for instance, higher import content of exports in Ireland). Real and nominal rigidities also differ between the two countries. In conjunction with their respective trade channels, it is these heterogeneous features which are exploited to examine the differential reactions of the countries to common shocks.[7]

The relative size of the home bloc is recalibrated to reflect an SOEs GDP share in the world economy. Consequently, the size of the EA bloc increases relative to the original calibration, as it now absorbs Germany, the home bloc in the original EAGLE. The large amount of trade between Germany and the EA means that this bloc is now more closed than in the original model. Another feature is that the macroeconomic interdependencies within the EA are now almost entirely one-directional. Previously, the large size of Germany relative to the EA meant that there was some spillover to the EA from shocks emanating in the home bloc. The small size of the recalibrated home bloc means that this channel is effectively removed.

As the original model structure does not account for imported intermediate inputs in exports, we follow Coenen and Vetlov (2009), Brzoza-Brzezina et al. (2010) and Kolasa (2010) in correcting the total imports of each region for the import content of exports. This feature is very representative of SOEs in the EA. In particular, the import-content of exports in both economies is close to 50 percent. In order to match empirical evidence that the nontradable sector tends to be more labour intensive, the production function of the tradable sector is permitted a higher share of capital than the nontradable.

The benchmark calibration of parameters that determine the aggregation of private and government consumption expenditure follows Coenen et al. (2012b). The elasticity of substitution between private and government consumption is set to 0.20, and the quasi-share of government consumption expenditure in the aggregator is set to 0.25. This ensures that the observed responses of consumption to government spending shocks are in line with either country-specific or EA evidence (see, e.g., Kirchner et al., 2010) and close to the estimates of Coenen et al., 2012b). As such, government and private consumption are strong, but not perfect, complements. We opt for a calibration of government goods with a low elasticity of substitution between nontradable and tradable goods, but with relatively high substitution between tradable goods and imported goods from different blocs. The

[7]Given the large fluctuations in the Irish economy in recent years, the elicitation of appropriate steady state values is challenging. The data are the long run (1980-2010) averages from the national account statistics, as gathered from the ESRI model database. This dataset allows for the longest possible horizon to be used, while omitting the large structural changes to the economy that took place prior to this period. Calibration for Slovenia relies on the national accounts and trade data averages from 2010-2013 to reflect substantial structural changes since the 2008 recession. The key findings are robust to calibration using the 2000-2010 period.

quasi-share of imported government consumption goods is calibrated to achieve a 2 percent of GDP government consumption proportion that is spent directly on imports in the steady state. This amounts to about 10 and 15 percent of government consumption in Slovenia and Ireland, respectively. We assume that the share of imported government investment goods is much 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 good to achieve a 25 percent share of government investment spending on imported investment goods (which is equivalent to 1 percent of GDP).[8] Persistence parameters for all shocks considered are set to 0.9 and the fiscal rule is such that lump-sum taxes are adjusted to close the model. The preference parameter for home tradables of the other blocs in the model varies according to the trade matrix of the home bloc (either Ireland or Slovenia) in question.

Finally, it is assumed that the dynamic adjustment of government consumption and investment goods is not subject to real rigidities.[9] The investment adjustment costs from the original EAGLE are adjusted in order to replicate the well-known (see, for example, King and Rebelo, 1999) variability of investment over the course of the business cycle.

2.3 Model comparison

To illustrate the differences between the original EAGLE model (with import content of exports) and the extended version (with different types of government spending, including government spending on foreign goods, complementarities between private and government consumption, and productive government

[8] 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 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 Rest of the EA and the Rest of the World, and the exact value of 5.8% for the United States. For both Ireland and Slovenia 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 both countries are 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.

[9] In new-Keynesian models, investment-adjustment costs are often used to achieve the hump-shaped responses of private investment found in empirical work. As government investment is the decision of the government, it does not necessarily follow a hump-shaped path.

capital), we report the responses to a one percent ex-ante GDP government expenditure shock. We increase government expenditure in the original model and compare the responses with responses to increases in government consumption and government investment (one-by-one) in the extended version of the model. It should be noted that only the government consumption expenditure shock in the extended version of the model is directly comparable to the government spending shock in the original model.[10]

The results for Ireland are displayed in Figures 3 and 4, with the results for Slovenia in Figures 5 and 6. Notably, the original EAGLE is unable to replicate the co-movement between government expenditure and private consumption and investment, which is sometimes observed in the data (for the EA, see, for instance Kirchner et al. (2010), who find positive co-movement between government expenditure and private consumption, but also investment in the short run).[11] This is not the case in the extended version of the model. Most notably, the model can generate positive co-movement between government expenditure (either consumption or investment) and private consumption. Moreover, the model can generate positive co-movement between private and government investment in the medium run (but has more difficulties doing so in the short run). A crowding-out of private investment can occur following a government consumption increase, as this consumption is wasteful in the model and leads to no benefits in the future. Changes in government consumption expenditure tend to have stronger effects in the short run in both economies, while the effects are more persistent than in the original model, but also much less persistent than after a government investment expenditure increase (see appendix D for details).

Heterogeneities in the strength of responses of both countries stem mainly from trade orientation, nominal rigidities, and the size of particular fiscal variables. Ireland, for instance, imports a larger proportion of consumption goods and has a higher content of imports in government consumption spending. This leads to a stronger deterioration of the trade balance after a government consumption expenditure shock compared to Slovenia. Moreover, prices in Ireland are less rigid, which implies a stronger inflation increase following a government consumption shock and a stronger appreciation of the real effective exchange rate.[12] The main benefit of the extended model is that it allows us to analyse the effect of heterogeneities on the impact of fiscal policies used in each economy (e.g. the

[10]Government expenditure in the national accounts (government final consumption expenditure) is equivalent to government consumption expenditure in the extended model. Government investment in the national accounts does not constitute government expenditure and is included in investment. A comparison of a government consumption increase in the original and the extended model is therefore fair only for the government consumption expenditure shock.

[11]Empirical evidence for Slovenia shows similar results (see Jemec et al., 2013).

[12]We discuss in detail the issues related to heterogeneity in the appendix.

strength of the effects of a certain type of government expenditure will depend on issues such as the import-content of a particular type of expenditure, the degree of substitution between government and private consumption, etc.).

3 Country-specific shocks

3.1 Government expenditure shocks

Heterogeneity of responses to common shocks within the monetary union raises the question of stabilisation policies and the instruments available to individual Member States to smooth macroeconomic fluctuations after an adverse shock. Moreover, the recent crisis poses a question as to whether there are fiscal policies that help with the stabilisation of a SOE, without breaching the budget rules set within the monetary union.

Although the EAGLE already possesses an elaborate taxation structure, the government spending component of the model is relatively simplistic. All government spending in the original EAGLE model is on home nontradable goods. We use the EAGLE's flexible structure and elaborate on government spending possibilities. In particular, we: (i) introduce a distinction between government investment spending and government consumption spending; (ii) allow for an import content of government expenditure; (iii) permit complementarities between government and private consumption (following Leeper et al., 2010 and Coenen et al., 2012b); and (iv) permit the accumulation of public capital. These features give us a much richer expenditure side of the government sector, which allows us to analyse the effects of different government spending policies. As it turns out, these features have important consequences regarding the multipliers from fiscal spending, both in terms of their magnitudes and dynamics.

To understand the effects of the model's fiscal extension, we perform simulations of shocks to government consumption and investment spending. These are used to illustrate the functioning of the extended model, as well as the channels through which these shocks are transmitted through the economy.[13]

3.1.1 Government consumption increase

We analyse a 1 percent GDP ex-ante increase in the government consumption expenditure share, G_C/Y. The effects of this shock are detailed in Figures 7 and 8. In the benchmark calibration G_C/Y is approximately 20 percent of GDP

[13]The simulations are fully anticipated under perfect foresight using a Newton-type algorithm available in DYNARE (Adjemian et al., 2012). All the shocks are for one period, with the persistence of the shock equal to 0.90 in every case.

for Slovenia and about 13 percent in Ireland, and therefore the shock amounts to a roughly 5 percent increase in government consumption spending in Slovenia and about 8 percent in Ireland (recall that the share of government consumption spending in GDP differs between both countries). The import content of the government consumption good is calibrated to 2 percent of GDP in both economies. The rationale for this relatively small number is that consumption goods purchased by the government are to a large extent domestically produced, even in SOEs.[14]

As the aggregate consumption that enters the utility function is a CES-bundle of government and private consumption expenditure (see equation 10 in appendix B), we observe a co-movement between the two. Depending on the exact calibration, this co-movement does not necessarily occur on impact, where for calibrations with high elasticity of substitution between private and government consumption goods, private consumption can decline before rising in the following quarter. This initial negative co-movement can happen because of households desire to smooth the bundle of private and government consumption, combined with the fact that private and government consumption are not perfect complements. The three parameters that play an important role in these interactions are the intertemporal elasticity of substitution, the degree of habit formation, and the complementarity between private and government consumption. The stronger the desire of households to smooth their consumption bundle, the more tendency there is to decrease private consumption on impact after a sudden temporary increase in government consumption. Similarly, the lower the complementarity between private and government consumption, the stronger the initial decrease in private consumption will be.[15] Given that many empirical studies (see above) indicate that private consumption exhibits positive co-movement with government consumption, we opted for a calibration that generates such co-movement (see appendix D for the results from an alternative calibration).

The increase in government consumption spending stimulates domestic demand through several channels. The standard channel is through the direct impact of government demand on production, as domestic output needs to increase to meet this additional demand.[16] This stimulates hours worked, as aggregate capital is fixed in the short run. As government consumption expenditure is largely

[14]Shock sizes for government consumption and investment have been standardised to 1 percent of ex-ante GDP to facilitate comparison. As long as the model is (approximately) linear, the effects of different shock sizes can be assessed by appropriately rescaling the impulse responses.

[15]While a reduction in (real and nominal) rigidities can help to increase the reaction speed of resources, the elasticity of substitution between private and government consumption expenditure remains the main parameter that governs the reaction of private consumption.

[16]These goods can also, of course, be imported. However, the low value for the import share of government consumption goods means that they will primarily be produced domestically.

oriented towards domestically-produced goods, this results in an initial reallocation of production (and input resources) from tradable to nontradable goods.

The non-standard channel of such a fiscal stimulus is due to the complementarity between private and government consumption expenditure, resulting in an increase in private consumption. This is different than in many models (and the original EAGLE), where an increase in government expenditure crowds-out both investment and private consumption. The increase in private consumption is strong and persistent, further stimulating domestic demand. Because the private consumption bundle contains a relatively high share of nontradable goods, the increase in consumption results in a temporary increase in the production of nontradable goods. The response of private investment to a government consumption shock differs in Ireland and Slovenia, and is primarily the consequence of the differences in price rigidity in their nontradable sectors. More rigid nontradable good prices in Slovenia imply that after a government consumption increase, nontradable goods become cheaper relative to tradable goods. Demand for nontradable goods increases relatively more (both because government spending is largely biased towards domestic goods and because private demand shifts toward relatively less expensive nontradable goods), which leads to more demand for labour from firms that wish to satisfy the increased demand. Wages increase, which further increases domestic demand, especially from the non-Ricardian consumers. This increased demand also stimulates private investment, which increases initially.[17] Without rigid prices in the nontradable sector, these effects are less pronounced and wages and private investment decrease (as is the case in Ireland). However, negative effects on home tradables production due to the improvement in the terms of trade and the appreciation of the real effective exchange rate (as a result of the increase in domestic marginal costs and prices) prevail in the medium run. Exports decrease, while imports increase from a combination of the favourable exchange rate movements and high domestic demand for tradable goods.

3.1.2 Government investment increase

At the onset of the crisis, many countries decided to cut their government investment spending. This was mainly due to automatic stabilisers increasing government consumption expenditure during the recession, while the requirement to keep the budget deficit under control, combined with undesirable and harmful tax increases, forced governments to save. Therefore, the obvious candidate for cuts is government investment. Figure 2 shows that this was indeed the case in Ireland and Slovenia. Government investment in Ireland fell from approximately

[17] This holds especially if investment-adjustment and import-adjustment costs are lower, as is the case for Slovenia.

5.25 percent of GDP during the peak, to as little as 2 percent of GDP at the end of 2012. Similarly, government investment in Slovenia decreased from 4.6 percent of GDP at the peak to 2.9 percent of GDP at the end of 2012. According to our model, such large government investment decreases may lead to negative consequences for both economies in the medium run. This is especially the case if the decrease in government investment spending is sustained for a longer period.

To show the effect of a change in government investment expenditure, we analyse a 1 percent ex-ante increase in government investment expenditure share, G_I/Y. The effects of this shock are displayed in Figures 9 and 10. Unlike the government consumption expenditure shock, government investment expenditure is both much smaller (4 percent of GDP in our benchmark calibration) and has a very high import content (1 percent of GDP, or a quarter of all government investment expenditure). The rationale for these differences in composition is that government investment expenditure in a SOE is often directed to goods of a very specific nature, and hence are not typically produced domestically.

These features have two direct consequences. First, a 1 percent of GDP ex-ante increase in government investment expenditure amounts to a roughly 25 percent increase of government investment spending (Figure 10). Second, a very high import content will have a significant immediate impact on imports and the trade balance.

The government investment expenditure shock affects the economy through very different channels than government consumption expenditure. As government investment does not directly affect household utility, there are no immediate effects on consumption, except indirectly through the wealth effect. On impact, output and hours worked increase as the economy has to produce the portion of government investment good that is not imported. With the government investment good consisting of both home tradable and nontradable goods, production increases in both sectors. Resources are diverted away from the private sector as government investment spending increases, which would typically result in a decrease in private consumption and investment.[18] However, in our modelling framework, the effects are more involved. Initially, the increase in consumption by liquidity constrained households, who are immune to the wealth effect, tends to alleviate the decrease in consumption by Ricardian households. In the medium run, however, it is Ricardian households who increase consumption. Because they represent a larger share of households, total consumption increases in the medium run.

The key mechanism behind these results is the contribution of the public capital stock to the productivity of the private sector. The accumulation of public capital

[18]The reason for this is the wealth effect, which reduces consumption and investment amongst Ricardian households.

reduces marginal costs (see equations 14 and 15 in appendix B) and improves the competitiveness of the domestic economy in the medium run.[19] This results in a reduction of domestic inflation, after the initial demand driven increase, and in a depreciation of the real effective exchange rate (Figure 10), which stimulates production in the domestic tradable sector. Improved competitiveness draws in private investment, which further contributes to the increase in output. Due to the higher productivity induced by the public capital increase, the substitution effect prevails over the wealth effect and Ricardian households both work more and increase consumption. This implies that the model with productive government investment does not need to rely on the existence of non-Ricardian households to generate positive co-movement between private consumption and government (investment) expenditure in the medium run. Moreover, the build-up of public capital acts as the key mechanism that induces co-movement between private and government investment and consumption in the medium run. The key difference between government investment and consumption expenditure shocks is that government investment has much more persistent effects, which governs the dynamics in the medium run.

The size of the immediate effect of government investment expenditure on the trade balance depends mainly on the government investment goods import content. If the import content is high, an increase in government investment expenditure will result in an immediate increase in imports and a deterioration of the trade balance. When government capital accumulation takes effect, exports increase and the trade balance moves into surplus.

The mechanism that drives the results of the model is in line with the intuition that government expenditure focused on the improvement of infrastructure reduces costs to the private sector and that these benefits accrue over a longer period of time. This has been used to strengthen the case for greater infrastructural spending. In the case of Ireland, for instance, Morgenroth (2011) states that there are positive effects of government infrastructure investment over the short and long run if additional infrastructure benefits the private sector. However, he also notes that government investment can have no or even negative effects if the additional infrastructure is not needed. Our model provides a structural framework for such reasoning - the parameter α_G for such additional infrastructure investment should be (close to) zero.

[19] The effects of a government investment increase are persistent due to the accumulation of public capital, but in the long run, the economy returns to the initial steady state.

3.2 Policy implications

In order to ensure the sustainability of their public debt levels, many European countries are currently undergoing a period of fiscal consolidation.[20] We have shown that, depending on the degree of complementarity between private and public consumption, such measures can have a substantial impact on the economy and that the impact does not depend only on the number of non-Ricardian households in the economy. As part of this consolidation process, government capital (investment) expenditure may come under pressure, as it is often argued that, for political economy reasons, investment is the easiest component of government spending to cut in the short run (Gali and Perotti, 2003). We have shown above that cuts in government investment can have undesirable consequences in the medium run, especially if public capital can improve private sector productivity. However, government investment can also be an undesirable instrument for fiscal stimulus, especially if there are little or no investments that directly benefit the productivity of the private sector.

The modifications of the model have interesting policy implications regarding fiscal adjustments. Not only are government spending multipliers different than in the standard EAGLE model, but the modified version of the model allows us to analyse the effect of a government expenditure switch that is ex-ante budget neutral. This experiment is similar to a fiscal devaluation in the sense that with a fiscal devaluation one type of tax is replaced by another. A fiscal expenditure switch works in a similar manner, where one type of government expenditure is replaced by another.[21]

We first present a set of output multipliers for a variety of fiscal measures. Given the relative magnitude of output multipliers, we analyse the effects of an ex-ante budget-neutral re-orientation of government expenditure away from government consumption in favour of government investment.

3.2.1 Fiscal multipliers

We examine the effect of various fiscal policy measures on output by performing the following exercise: each government spending component is assumed to increase by 1 percent GDP ex-ante and each tax rate is assumed to decrease by the amount

[20] As part of its formal assistance programme with international lenders, Ireland has specified fiscal consolidation measures totalling 21 percent of GDP over the 2008-2015 period.

[21] We also performed a fiscal devaluation experiment. We found that the effect on output was similar in both countries, with output increasing by approximately 1.5 percent at the peak. There are some differences between the countries related to the relative importance of individual components to the output increase. As our model extension has little bearing on the effects of fiscal devaluation compared to the original EAGLE, we do not report these results here. They are available from the authors upon request. See also Gomes et al. (2014).

that would ensure a 1 percent GDP ex-ante reduction in revenues collected by means of that tax. The responses of output in both economies are shown in Tables 5 and 6. Tax multipliers, with the exception of social security contributions paid by firms, tend to be of approximately the same magnitude and persistence in both economies. However, government spending multipliers and social security contributions paid by firms tend to have stronger effects in Ireland. The reason for this difference is the higher degree of price and wage rigidity in Slovenia, which tends to attenuate the benefits from government spending in the short run.

The results tend to be different in the medium run as regards government investment. In the medium run, most of the price effects dissipate and the productivity of public capital begins to play the key role. Because government investment contributes to the build-up of public capital, its persistent effect through the public capital stock continues even when price effects disappear. This bolsters our claim that in the medium run, public capital contributes positively to output, the real effective exchange rate and the trade balance.

3.2.2 Government expenditure reorientation

This section examines whether an ex-ante budget neutral government expenditure reorientation could stimulate output, given the different sizes of output multipliers for government consumption and investment expenditure shocks. We consider the following experiment: The government increases its investment expenditure by one percentage point of GDP (ex-ante), and obtains the funds to finance this by reducing government consumption expenditure by the same amount. The result of the experiment is presented in Figures 11 and 12. With the chosen calibration of the model, a reorientation of government spending away from consumption and towards government investment has negative consequences for output in the short run in both economies. This effect depends mostly on the strength of the link between government and private consumption and rigidities in the model. The effect is stronger for Ireland in the short run, mainly due to higher price rigidity of the nontradable sector in Slovenia. In the medium run, however, the improvement in competitiveness due to the increase in public capital begins to show. The trade balance improves substantially, output increases persistently by about 0.25 percent and nominal public debt starts to decrease.[22] The increase in output, decrease in public debt and improvement in the external balance tend to persist. This persistence is the result of the increase in public capital, which causes a long-lasting reduction in marginal costs.

We emphasise that the short-run effect of such a government expenditure shift depends on the degree of complementarity between government and private

[22]Note that the increase in the public-debt-to-GDP ratio in Figure 12 is mostly due to the decrease in output and not due to government borrowing.

consumption. The decrease in output in the short run is primarily driven by the strong decrease of private consumption that follows the decrease in government consumption. If this complementarity is weaker, a reduction of government consumption can cause an increase in private consumption which results in an increase in output both in the short and medium run. For instance, if the elasticity of substitution between private and government consumption is 0.5, and private consumption is slightly more rigid, the reorientation of government expenditure away from consumption towards investment causes an immediate increase of output that tends to persist at about the same level as above. Importantly, the medium-run effects are robust as they do not hinge on the calibration of the complementarity between private and government consumption, but on the positive effects of public capital. The effects of a government expenditure reorientation in the short run, therefore, depend on the complementarity between government and private consumption, while the medium-run effects are robust and beneficial, both in terms of output, external balance and public debt.

4 Spillovers

This section illustrates the main channels of fiscal policy spillovers within a monetary union. There is not much empirical evidence on the spillovers of foreign fiscal policy actions to very SOEs within a monetary union, but we can still use as a guide studies that apply to larger economies. Beetsma and Guiliodori (2011) find that fiscal expansions in (large) European countries tend to have expansionary effects on their main trading partners. Similar findings are reported by Corsetti and Müller (2011) for the effects of fiscal expansions in the U.S. on the EA and UK (i.e. countries not sharing a common currency), although they find that the trade channel does not appear to be responsible for these spillovers.[23]

Structural models can feature several channels of cross-country transmission of fiscal policy shocks, many of which can operate in different directions. For instance, a fiscal expansion in one part of the EA leads to an increase in area-wide interest rate that has a negative effect on parts that did not engage in fiscal expansion. However, if such a fiscal expansion leads to an increase in imports, then there can be a benefit to those parts that did not engage in the fiscal expansion. We investigate the strength of spillovers and the main transmission channels by considering an expansionary fiscal policy in the rest of the EA and analyse the effects of these actions on the country within the EA that does not engage in fiscal expansion. We contrast the effects of spillovers in the original EAGLE model with

[23]They find that U.S. imports tend to remain constant after the fiscal expansion, while U.S. exports actually increase, which indicates that fiscal expansion in the U.S. does not lead to higher exports of the EA to the U.S.

those in the extended model and discuss the policy implications of the results from the extended model.

4.1 Spillovers from a government expenditure shock in the original EAGLE

It is quite difficult to generate positive spillovers from a government spending shock in the rest of the EA to either Ireland or Slovenia in the original EAGLE model. The reason is that government spending in the original EAGLE is oriented entirely on nontradable goods, without any import content. This stimulates only the production of nontradables in the region that engages in fiscal expansion. Stimulus to demand for tradables (and hence imports) can come only through private consumption or private investment. However, these two components of aggregate spending both decrease (are crowded-out) after a fiscal expansion. This implies that the only channel through which spending on imported goods can increase comes through higher inflation in the region that engages in fiscal expansion and the resulting (real) exchange rate appreciation, which switches some of the private spending to imports. This channel is unlikely to be strong enough to counter the decrease in private consumption and investment spending (in fact, tradable output in the part of the EA that engages in a fiscal expansion decreases and imports of consumption and investment goods decrease).

The trade channel in the original EAGLE therefore seems to work in the opposite direction to that necessary to generate expected positive spillovers. Another factor that prevents positive spillovers is the area-wide interest rate, which increases in response to the fiscal expansion in the large region of the EA, accompanied by a real appreciation of the euro, which both harm the region that does *not* engage in fiscal expansion. These effects can be especially strong for a SOE when the rest of the EA engages in fiscal expansion, as this leads to a large interest rate increase and strong area-wide real exchange rate appreciation. Figure 13 shows the effects of expansionary fiscal policy in the rest of the EA bloc by one percentage point of GDP ex-ante. Increased government spending causes an increase in inflation that induces the central bank to increase the interest rate and consequently reduce domestic demand in the entire EA (i.e. in both the bloc that engages in fiscal expansion and the bloc that does not).

The size of the negative effect on both SOEs under consideration depends on several factors, but the most important are the reaction of the real effective exchange rate, the initial current account balance, and the flexibility of imports. A fiscal expansion in the rest of the EA causes a recession in both SOEs via the increase of the area-wide interest rate that depresses domestic consumption and investment. Lower demand in the rest of the EA reduces exports to this region,

while the appreciation of the euro is detrimental to exports to other blocs. As expected, Slovenia is more affected because the rest of the EA is its main export market, which can explain the stronger decrease of output in Slovenia.

4.2 Spillovers from a government consumption expenditure shock

The extended EAGLE differentiates between government investment and government consumption expenditure and permits us to analyse the effects of fiscal expansions conditional on the type of expenditure targeted for increase. Complementarity between private and government consumption generates an increase in private consumption following the increase in government consumption. Private investment still typically decreases in the short run. Because private consumption in the region that engaged in the fiscal expansion increases, there is now a new transmission channel that can have a positive influence on exports from the bloc that does not engage in fiscal expansion. The strength of this effect depends on the degree of complementarity between government and private consumption (i.e. the magnitude of the domestic multiplier), the trade matrix and import demand elasticities. Moreover, the possibility of direct purchases of imported goods by governments provides an additional channel for spillovers.

The question is whether these channels are strong enough to dominate the negative effects of a fiscal expansion. The area-wide interest rate still increases and the euro still appreciates, while at the same time the typical decrease in private investment in the bloc that engages in fiscal expansion provides no stimulus to demand for imports of investment goods (which tend to have a high import content). The key issue is therefore whether private consumption of the bloc that engages in fiscal expansion and direct government imports of foreign goods can provide enough stimulus via demand for exports to dominate all the previously discussed negative effects. The effects of a government consumption increase by one percentage point of GDP in the rest of EA on Ireland and Slovenia are shown in Figures 14 and 15.

The difference compared to the foreign fiscal expansion in the original EAGLE is that in the short run, output increases in both Ireland and Slovenia, while in the medium run the output responses are similar to the original EAGLE. Direct imports of government consumption goods contribute to the initial increase in trade balance and output, and the contemporaneous increase in foreign private consumption increases exports of consumption goods. However, the intensity of these two effects is different in Ireland and Slovenia. This is due to two features. First, because of higher price rigidity of the nontradable sector in Slovenia, nontradable goods become relatively cheaper than tradable goods, which leads

to less of a reduction in demand for these goods and therefore a lower decrease in nontradable output and wages.[24] Strong foreign demand for tradable goods increases demand for labour in this sector, but because labour does not shift from the nontradable sector in Slovenia as much as in Ireland, marginal costs in Slovenia increase by more in both sectors and are more persistent. Real wages still decrease because of higher inflation, but less than in Ireland.

The positive effects of strong foreign demand on output in Slovenia are partly offset by a stronger decrease in private consumption and investment, which is driven by lower investment adjustment costs. The greater openness of Slovenia towards the EA shows in the somewhat more persistent trade balance, which closely follows the path of private consumption in the EA. This is not the case in Ireland, where the price of nontradable goods are more flexible and where the decrease in wages is stronger. Second, Ireland's trade balance increases to a larger extent because it starts with a larger current account surplus, which, given the approximately same difference between the increase in exports and in imports in both countries (about 0.6 p.p.), results in a stronger contribution of the trade balance to GDP.[25] In both countries the export of consumption goods to the EA increase, while exports to other blocs decrease due to an appreciation of the euro (not shown). Overall, the increase in output is predominantly driven by foreign government demand for consumption goods in both countries.[26]

4.3 Spillovers from a government investment expenditure shock

The extended EAGLE model has somewhat different implications for a government investment expenditure shock than for a government consumption expenditure shock. The mechanisms through which the transmission works are similar to the government consumption increase, with the difference being that the contribution of private investment to the increase in exports is delayed (because private investment in the rest of the EA increases only in the medium run) and small, despite the high import content of investment goods. The effects of a government investment increase by one percentage point of GDP in the rest of EA on Ireland and Slovenia are shown in Figures 16 and 17. The strong initial increase in

[24]Rigid prices in the nontradable sector imply that some of the effects of a foreign stimulus on the domestic tradable sector spill over by means of increased wages to higher demand for nontradable goods, which have become relatively less expensive due to their higher price rigidity.

[25]Recall that in models with a high import content of exports, both imports and exports tend to move together after foreign demand shocks.

[26]Note that for small economies within the monetary union, a fiscal expansion of the rest of the union leads to a very strong increase in interest rates. This interest rate channel is very strong and tends to dominate the other transmission channels in the model.

exports and (tradable) output of Ireland and Slovenia is the result of the higher direct import content of government investment goods in the rest of the EA. This effect is strong enough to prevail over the initial decrease in private demand for foreign goods in the EA bloc that engages in fiscal expansion. Recall that after a government investment increase (see section 3.1.2), private consumption and investment decrease initially and then increase in the medium run. This implies that the private demand of this bloc for imports will initially decrease and then increase in the medium run, which explains the more protracted increase in the trade balance and output in both Ireland and Slovenia.

Importantly, given the model's implication that government investment increases competitiveness of the bloc that invests, the model does not indicate that this has immediate adverse consequences for blocs that become less competitive (relative to the bloc that increased its public capital). These blocs benefit from the more competitive bloc, if their trade linkages with this bloc are strong enough to exploit the higher demand for consumption and investment in the medium run. Nevertheless, the initial positive response of output and the trade balance in Ireland and Slovenia still hinges on direct imports of investment goods by foreign governments.

4.4 Policy implications of spillovers from fiscal expansions

The key implication of the extended model for policy is that a government expenditure increase in a part of the EA can be beneficial for the region that does not change its fiscal policy. The benefits depend on the strength of the fiscal multipliers in the expanding region. The stronger and the more positive is the effect of fiscal expansion on private consumption and investment in the region that engages in fiscal expansion and the more import content they have, the more beneficial is the spillover to the region that does not engage in fiscal expansion. In this respect, policies such as, for example, subsidies for the replacement of old cars in Germany were beneficial for regions that supply car parts to German manufacturers (or that manufacture cars themselves).[27] Generating positive spillovers becomes even more straightforward if government expenditure has a high import component, which results in the cross-border effect of fiscal expansion that is immediate and strong.

Nevertheless, the interest rate and exchange rate channels tend to be very strong, especially if a large bloc in the EA engages in fiscal expansion. These effects are very difficult to dominate with trade linkages within the EA and in such cases, a positive spillover hinges on a large share of direct imports of domestic goods by foreign governments.

[27]We are grateful to Gabriel Fagan for pointing this out.

5 Conclusions

This paper describes an extension to the EAGLE model, and provides some simulations to highlight its increased fiscal policy analysis capabilities. Our key findings can be summarised as follows. First, a high import content of government expenditure in SOEs has direct negative effects on government spending multipliers, as part of the government spending increase ends as a stimulus to foreign exporters. Second, depending on the degree of complementarity between government and private consumption, government consumption expenditure can have strong effects on private consumption and output. These effects tend to be relatively short-lived. Finally, government investment expenditure has a persistent positive effect on the domestic economy, even if a large portion of government investment is imported. This boost is provided through the build-up of public capital. If public capital is productive, it lowers the marginal costs of firms in the medium run (after increasing them in the short run). This causes a real effective exchange rate depreciation and stimulates exports, which is a particularly strong channel in a SOE. Productive public capital also draws in (after a delay) private investment. The result is that after an initial negative reaction, private investment, private consumption and output exhibit positive co-movement.

The extended model provides for new channels for the transmission of government expenditure shocks to other economies. Unlike in the original EAGLE model, an increase in government expenditure in one bloc of the EA can have either positive or negative effects on the other EA bloc. The sign and magnitude of the effect depends on trade linkages and the degree of co-movement between private and government spending in the bloc that increased government expenditure, and on the type of expenditure. The results show that fiscal stimulus in one bloc can have beneficial effects on the other bloc if it generates an increase in private spending (and hence imports), and if these imports come from the other EA bloc. The effects will be stronger and more persistent if monetary policy keeps interest rates low in response to a fiscal expansion in one bloc.

However, a review of the literature shows there are a number of outstanding issues as yet to be analysed. This analysis focused exclusively on the impact of temporary fiscal measures to promote the economy. Future work could examine the effect of permanent policy changes. Coenen et al. (2012a) note that there is an asymmetry between the fiscal multipliers of a temporary stimulus and the multipliers of a permanent fiscal consolidation. Fiscal consolidations are likely to have short term negative output effects, but as government debt is reduced this creates space for cuts in distortionary taxes which can boost growth in the medium and long run. Designing consolidations in such a way as to maximise the long term growth benefits from tax reforms can help to minimise the short term costs (Coenen et al., 2012a).

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A Tables and Figures

TABLE 1. Steady-state national accounts and trade matrix (as % of nominal GDP)

	IE	**SI**
Great Ratios		
Private consumption	0.5791	0.5692
Private investment	0.1760	0.1506
Target public debt (% of annual GDP)	0.6000	0.6000
Trade linkages		
Imports	0.6300	0.6981
Consumption goods	0.1498	0.2203
From REA	0.0543	0.1758
From RW	0.0737	0.0436
From US	0.0218	0.0009
Investment goods	0.0972	0.1297
From REA	0.0343	0.1011
From RW	0.0465	0.0252
From US	0.0164	0.0034
Imports of exports	0.3530	0.3181
From REA	0.1130	0.2340
From RW	0.1532	0.0693
From US	0.0868	0.0148
Government expenditure		
Consumption expenditure	0.1290	0.2080
Imports	0.0200	0.0200
Investment expenditure	0.0400	0.0400
Imports	0.0100	0.0100
Country size		
Size (as % of world GDP)	0.03	0.02

TABLE 2. Calibration - Households and Firms

	IE	SI
Households		
Subjective discount factor	$1.03^{\frac{1}{4}}$	$1.03^{\frac{1}{4}}$
Depreciation rate (private capital)	0.025	0.025
Depreciation rate (public capital)	0.025	0.025
Int. elasticity of substitution	1.00	1.00
Habit formation	0.60	0.60
Frisch elasticity of labour (inverse)	2.00	2.00
Intermediate goods firms		
Tradable - bias toward capital	0.35	0.42
Nontradable - bias toward capital	0.30	0.30
Final cons. goods		
Subst. btw. domestic and imported	2.50	2.50
Subst. imported	2.50	2.50
Bias toward domestic tradables	0.3872	0.3601
Subst. btw. tradable and nontradable	0.50	0.50
Bias toward tradable	0.475	0.70
Final inv. goods		
Subst. btw. domestic and imported	1.50	1.50
Subst. imported	2.50	2.50
Bias toward domestic tradables	0.2336	0.0024
Subst. btw. tradable and nontradable	0.50	0.50
Bias toward tradable	0.75	0.89
Final government cons. goods		
Subst. btw. domestic and imported	2.50	2.50
Subst. imported	2.50	2.50
Bias toward domestic	0.2084	0.5247
Subst. btw. tradable and nontradable	0.50	0.50
Bias toward tradable	0.80	0.80
Final government inv. goods		
Subst. btw. domestic and imported	2.50	2.50
Subst. imported	2.50	2.50
Bias toward domestic	0.4252	0.3787
Subst. btw. tradable and nontradable	0.50	0.50
Bias toward tradable	0.60	0.60

TABLE 3. Calibration - Real and Nominal Rigidities

	IE	SI	REA	US	RW
Real rigidities					
Investment adjustment	6.00	3.00	5.00	5.00	5.00
Import adjustment (cons.)	5.00	1.00	5.00	5.00	5.00
Import adjustment (inv.)	2.00	1.50	2.00	2.00	2.00
Quasi-share of govt cons.	0.25	0.25	0.20	0.20	0.20
Complementarity of consumptions	0.20	0.20	0.29	0.33	0.33
Nominal rigidities					
Wage stickiness	0.80	0.81	0.75	0.75	0.75
Wage indexation	0.75	0.75	0.75	0.75	0.75
Price stickiness (domestic)	0.75	0.75	0.75	0.75	0.75
Price indexation (domestic)	0.50	0.50	0.50	0.50	0.50
Price stickiness (imported)	0.75	0.75	0.75	0.75	0.75
Price indexation (imported)	0.50	0.50	0.50	0.50	0.50
Price stickiness (services)	0.75	0.93	0.75	0.75	0.75
Price indexation (services)	0.50	0.50	0.50	0.50	0.50

TABLE 4. Calibration - Tax Rates

	IE	SI	REA	US	RW
Consumption tax	0.1200	0.1535	0.1830	0.0770	0.0770
Labour income tax	0.1600	0.1289	0.1220	0.1540	0.1540
Capital tax	0.1000	0.1363	0.1900	0.1600	0.1600
SSC paid by firms	0.0900	0.1388	0.2190	0.0710	0.0710
SSC paid by households	0.0700	0.1519	0.1180	0.0710	0.0710

TABLE 5. Output multipliers - Ireland

Shock	**Q1**	**Q4**	**Q8**	**Q12**	**Q16**
Government consumption	1.892	1.412	0.4695	0.1983	0.1439
Government investment	0.7955	0.4558	0.3042	0.2969	0.3111
Consumption tax	0.1613	0.1070	0.0584	0.0574	0.0631
SSC paid by firms	0.4967	0.9990	0.7934	0.4264	0.1875
Labour income tax	0.0749	0.1313	0.1580	0.1713	0.1637

TABLE 6. Output multipliers - Slovenia

Shock	**Q1**	**Q4**	**Q8**	**Q12**	**Q16**
Government consumption	1.0910	0.6066	0.1677	0.0979	0.1023
Government investment	0.6195	0.3156	0.2621	0.2925	0.3133
Consumption tax	0.1252	0.1102	0.1264	0.1475	0.1525
SSC paid by firms	0.3765	0.6568	0.4170	0.1957	0.0822
Labour income tax	0.0317	0.0501	0.0722	0.0931	0.0994

FIGURE 1. Key macroeconomic aggregates as a percent of GDP

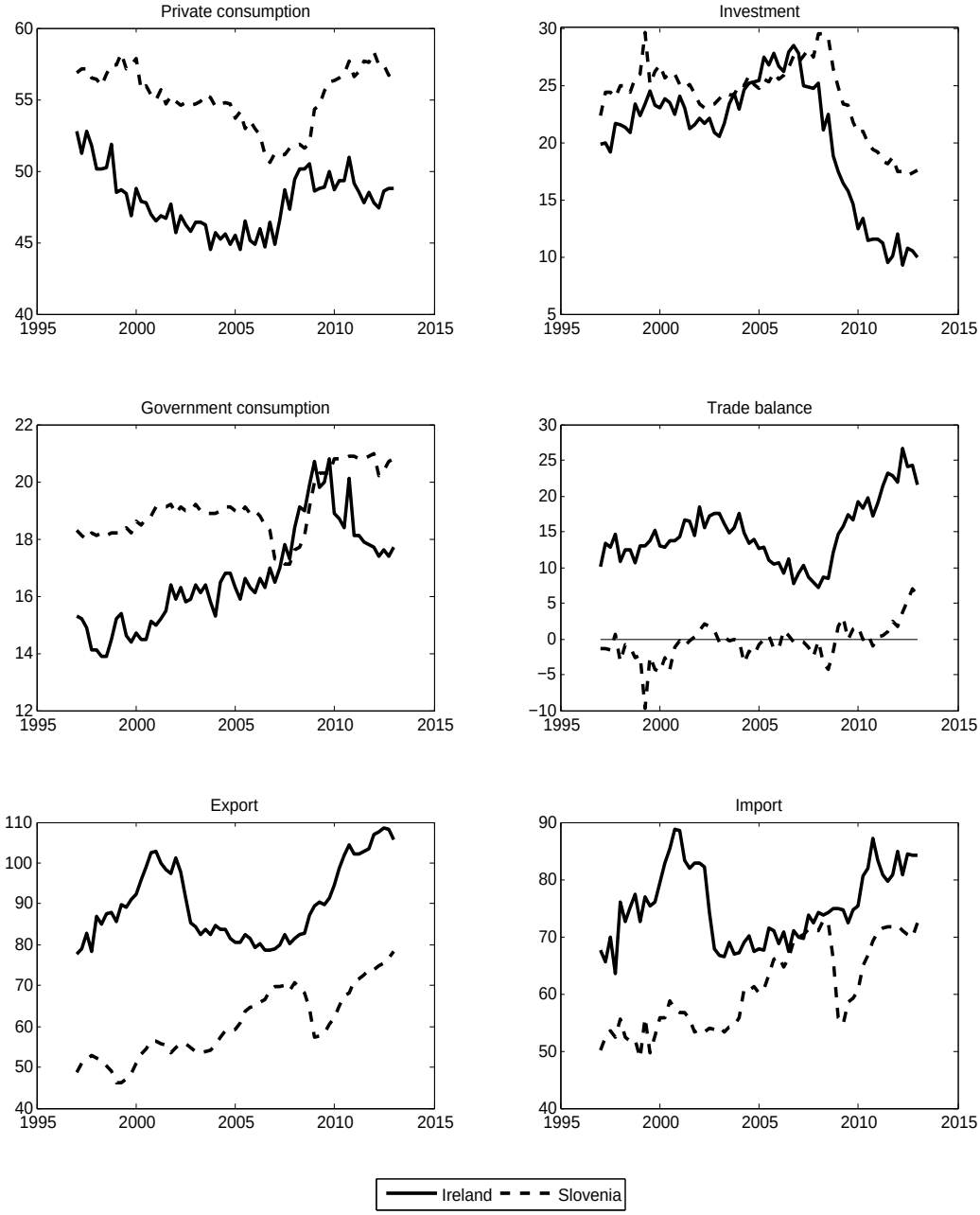


FIGURE 2. Government investment expenditure in Ireland and Slovenia as a share of GDP

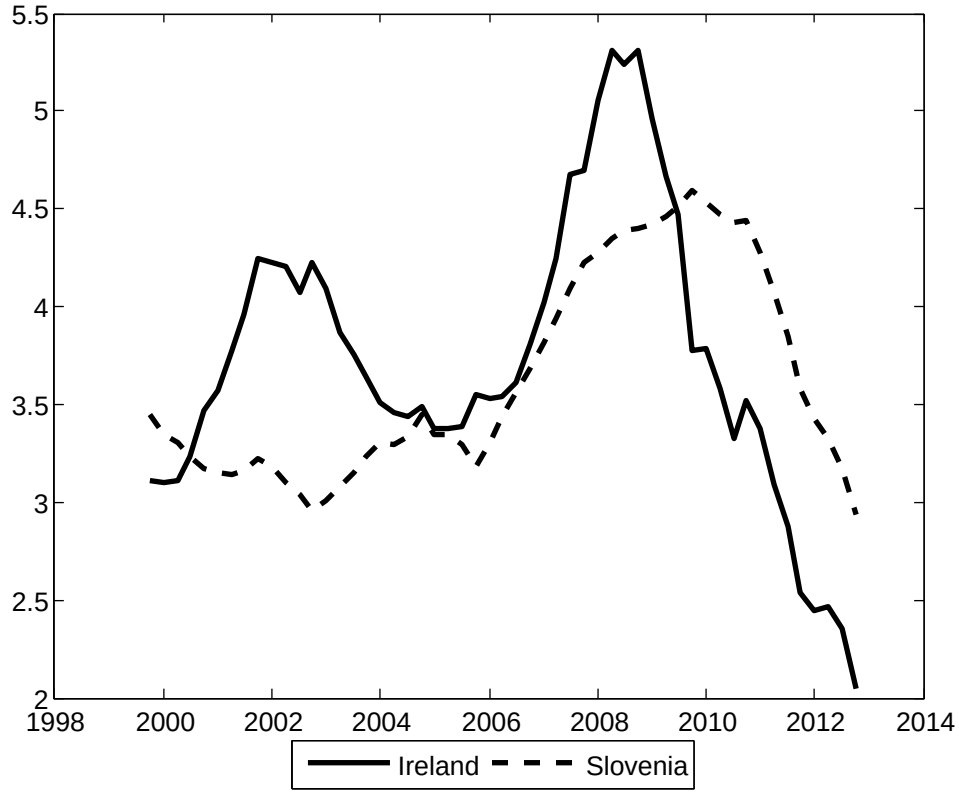
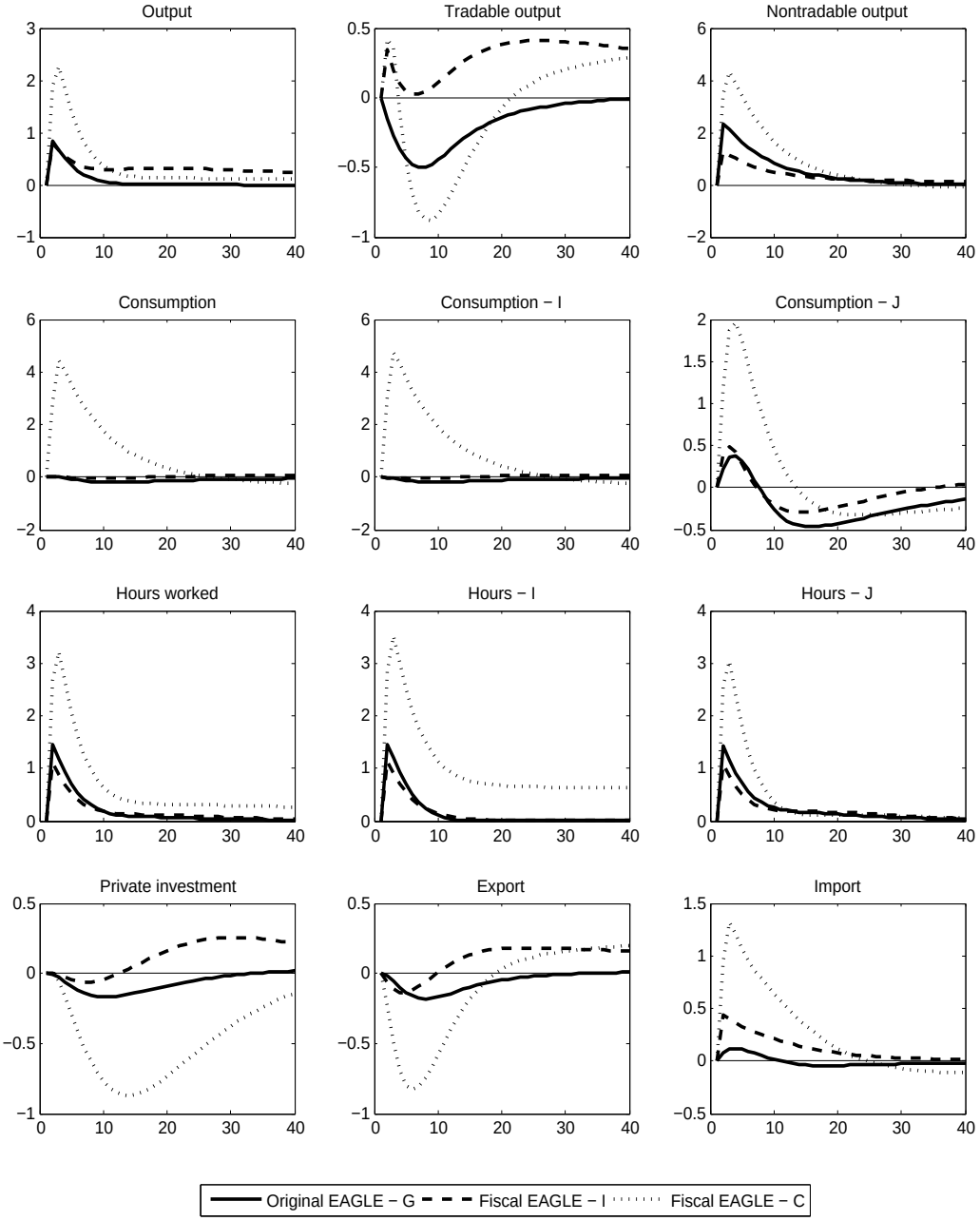
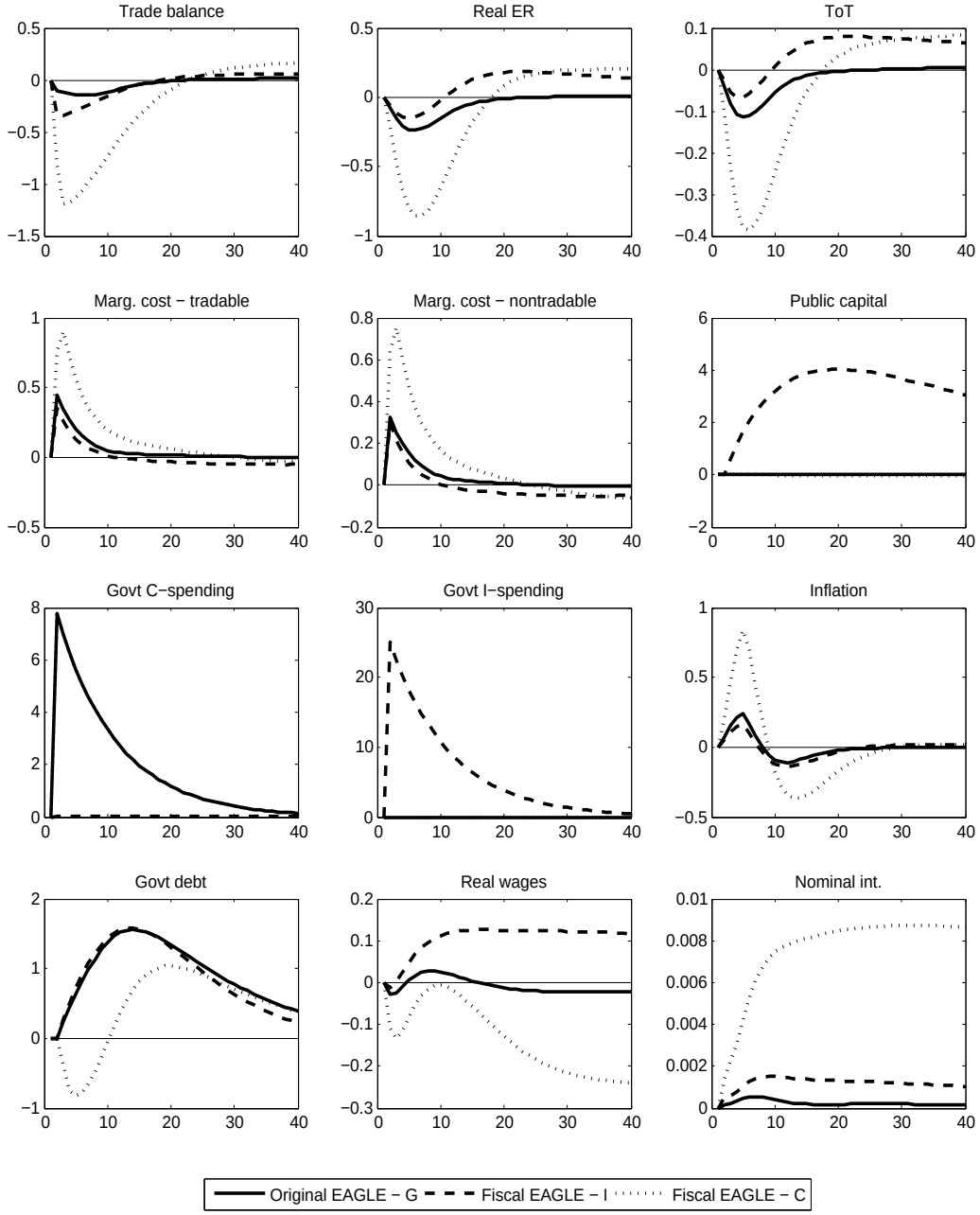


FIGURE 3. Model comparison - government spending increase (IE)



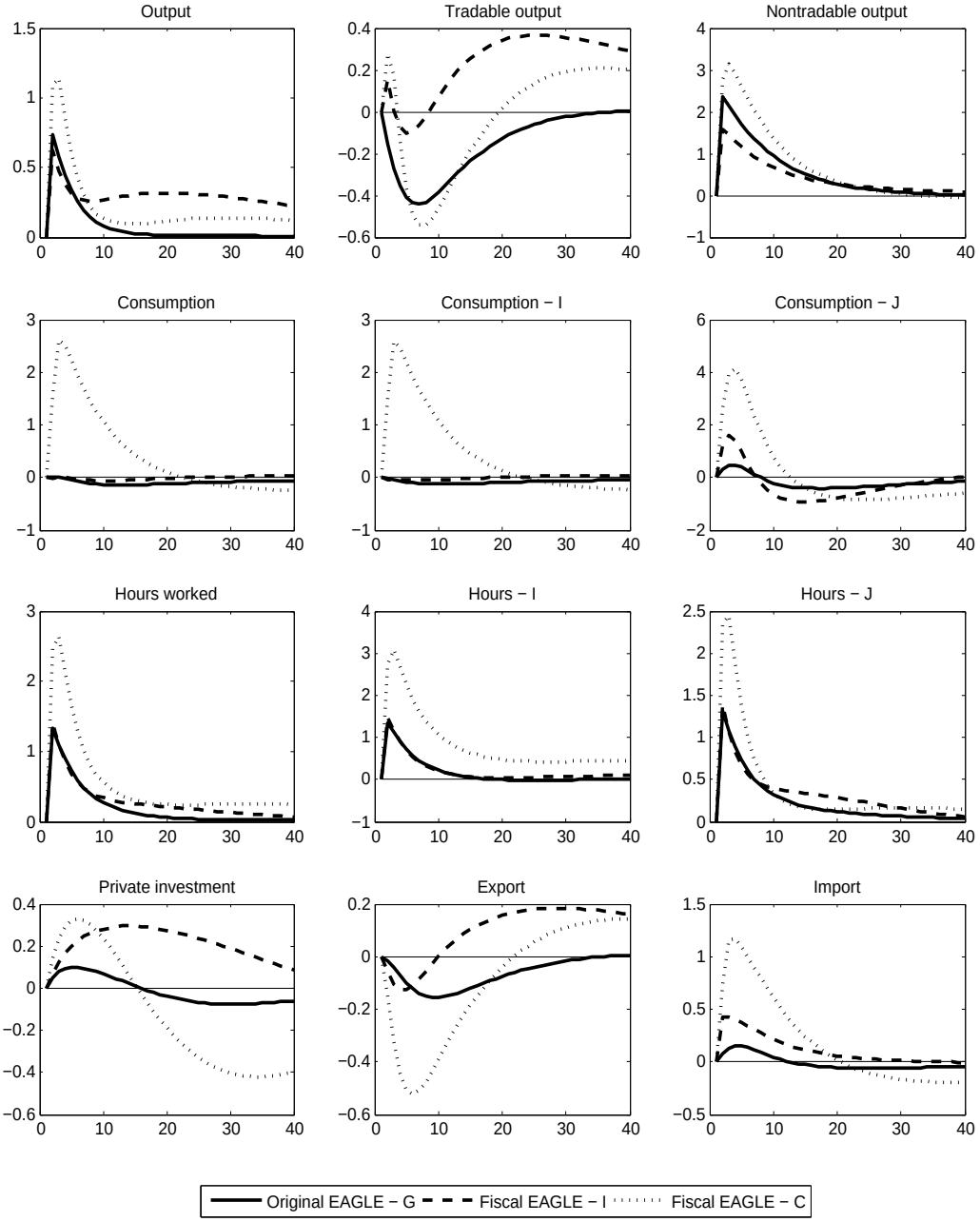
Notes: Impulse responses to a 1 percentage point ex-ante GDP increase in government expenditure. All variables are in percentage deviations from the steady state, except trade balance, government spending and government debt (all defined as ratios to GDP), inflation, and nominal interest rate. The impulse responses of these variables are in percentage-point deviations.

FIGURE 4. Model comparison - government spending increase (IE)



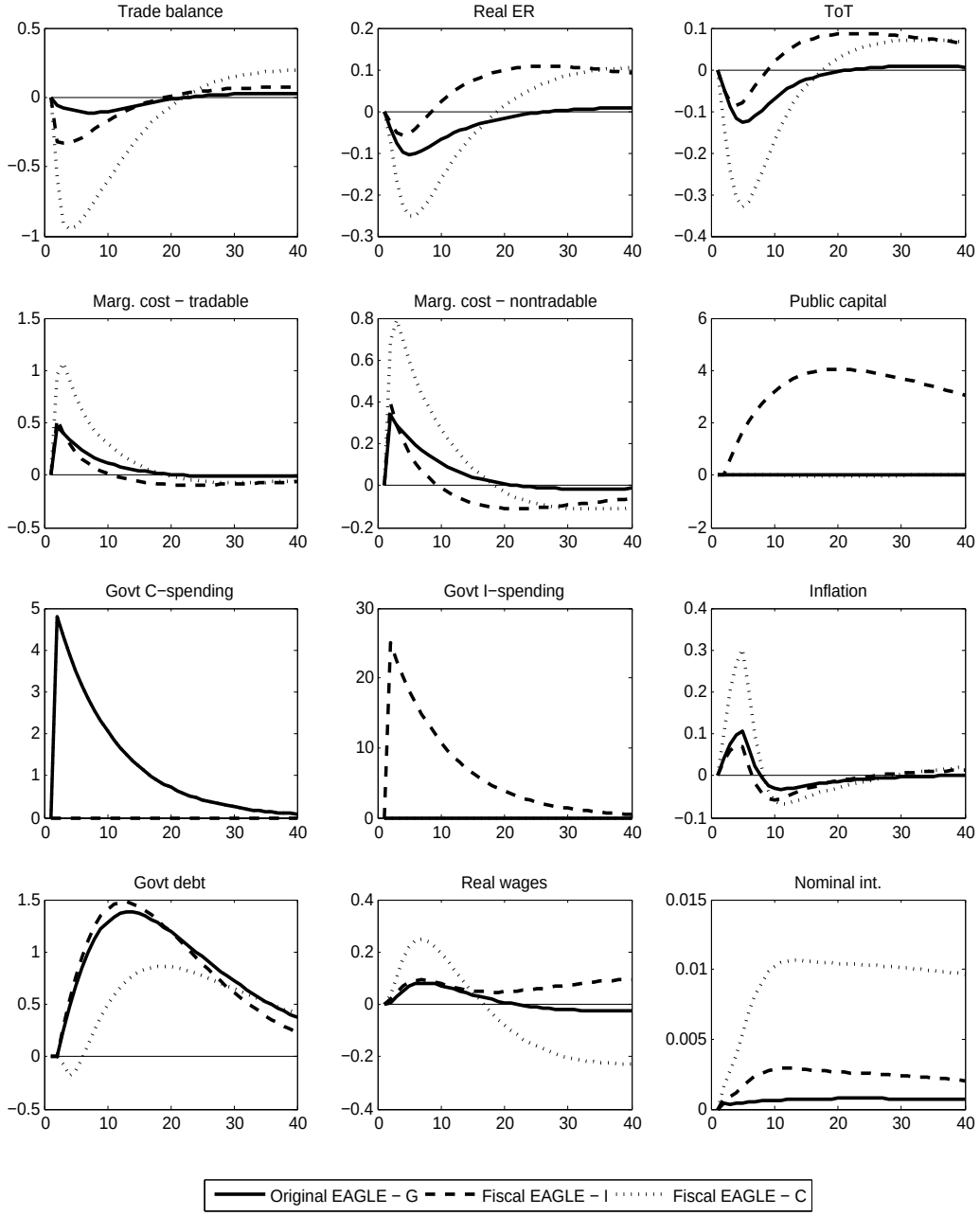
Notes: Impulse responses to a 1 percentage point ex-ante GDP increase in government expenditure. All variables are in percentage deviations from the steady state, except trade balance, government spending and government debt (all defined as ratios to GDP), inflation, and nominal interest rate. The impulse responses of these variables are in percentage-point deviations.

FIGURE 5. Model comparison - government spending increase (SI)



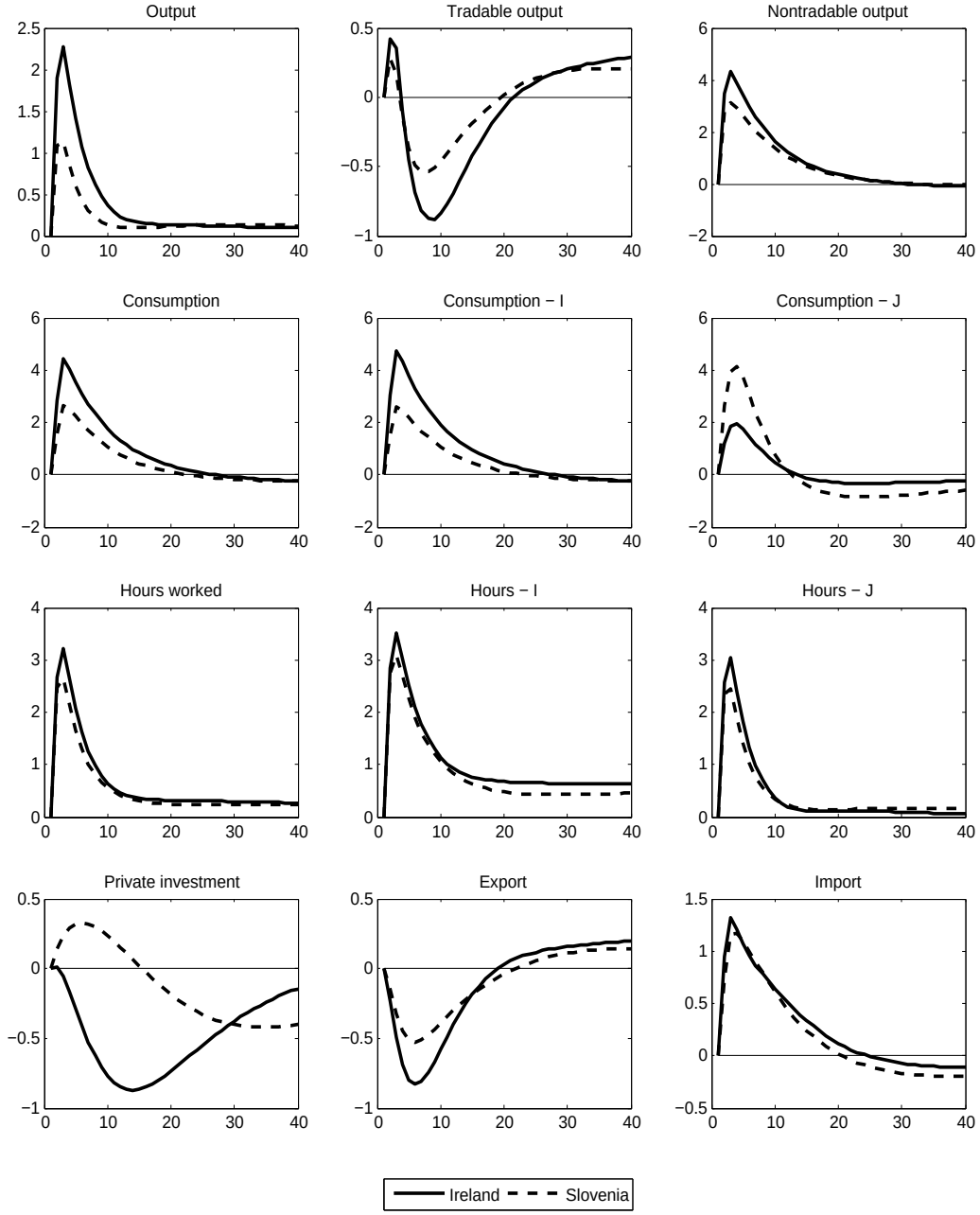
Notes: Impulse responses to a 1 percentage point ex-ante GDP increase in government expenditure. All variables are in percentage deviations from the steady state, except trade balance, government spending and government debt (all defined as ratios to GDP), inflation, and nominal interest rate. The impulse responses of these variables are in percentage-point deviations.

FIGURE 6. Model comparison - government spending increase (SI)



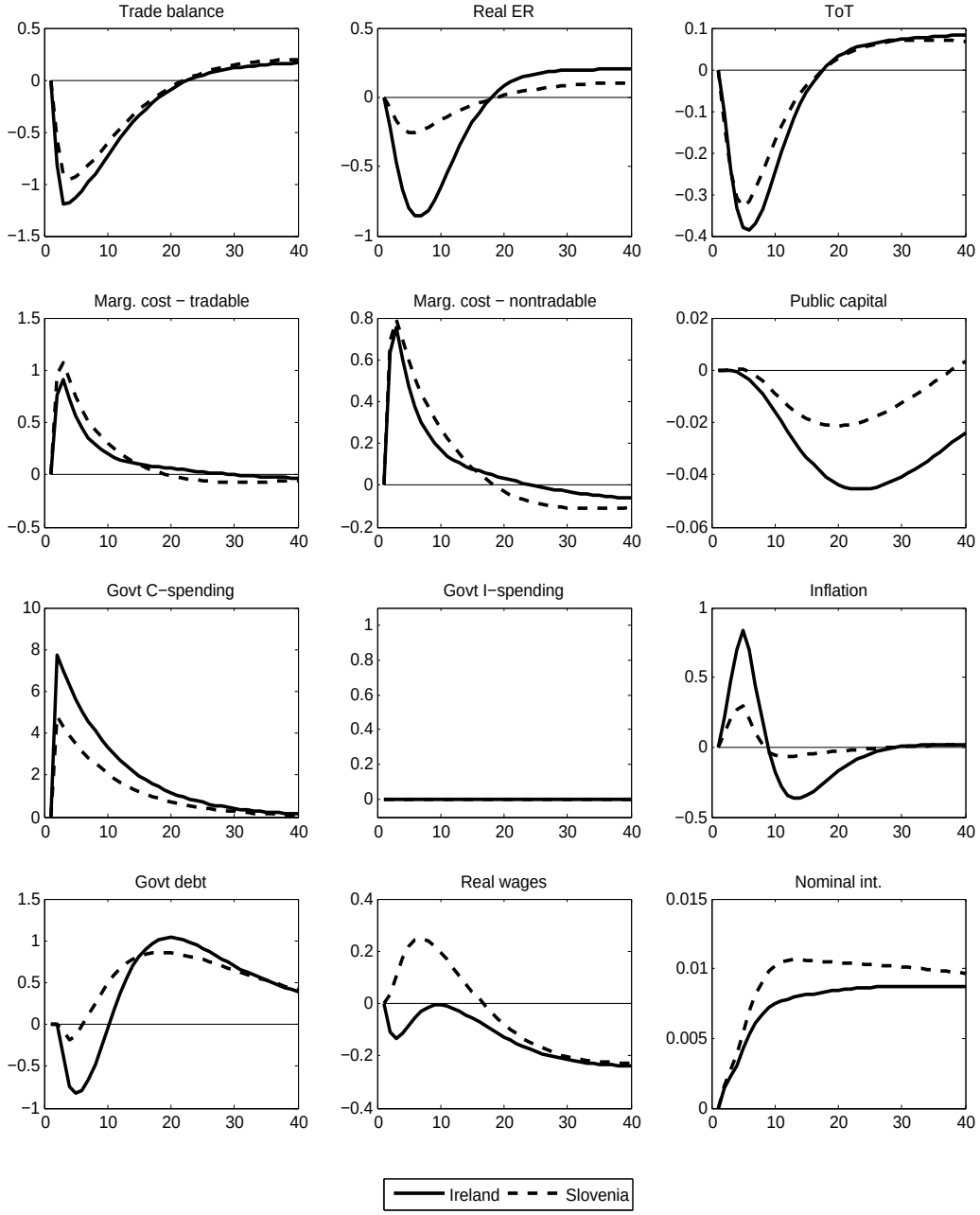
Notes: Impulse responses to a 1 percentage point ex-ante GDP increase in government expenditure. All variables are in percentage deviations from the steady state, except trade balance, government spending and government debt (all defined as ratios to GDP), inflation, and nominal interest rate. The impulse responses of these variables are in percentage-point deviations.

FIGURE 7. An increase in government consumption expenditure (I)



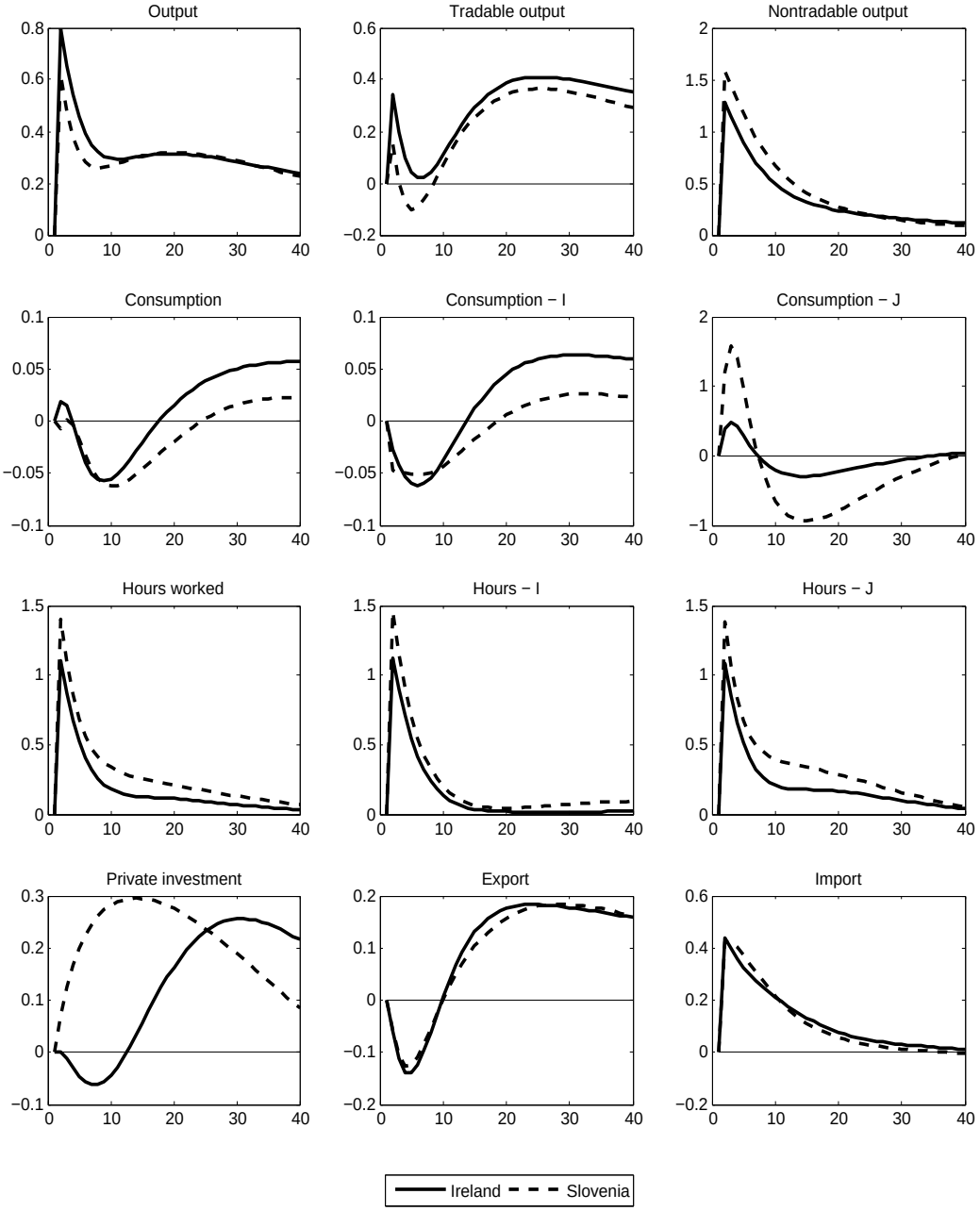
Notes: Impulse responses to a 1 percentage point ex-ante GDP increase in government consumption expenditure. All variables are in percentage deviations from the steady state, except trade balance, government spending and government debt (all defined as ratios to GDP), inflation, and nominal interest rate. The impulse responses of these variables are in percentage-point deviations.

FIGURE 8. An increase in government consumption expenditure (II)



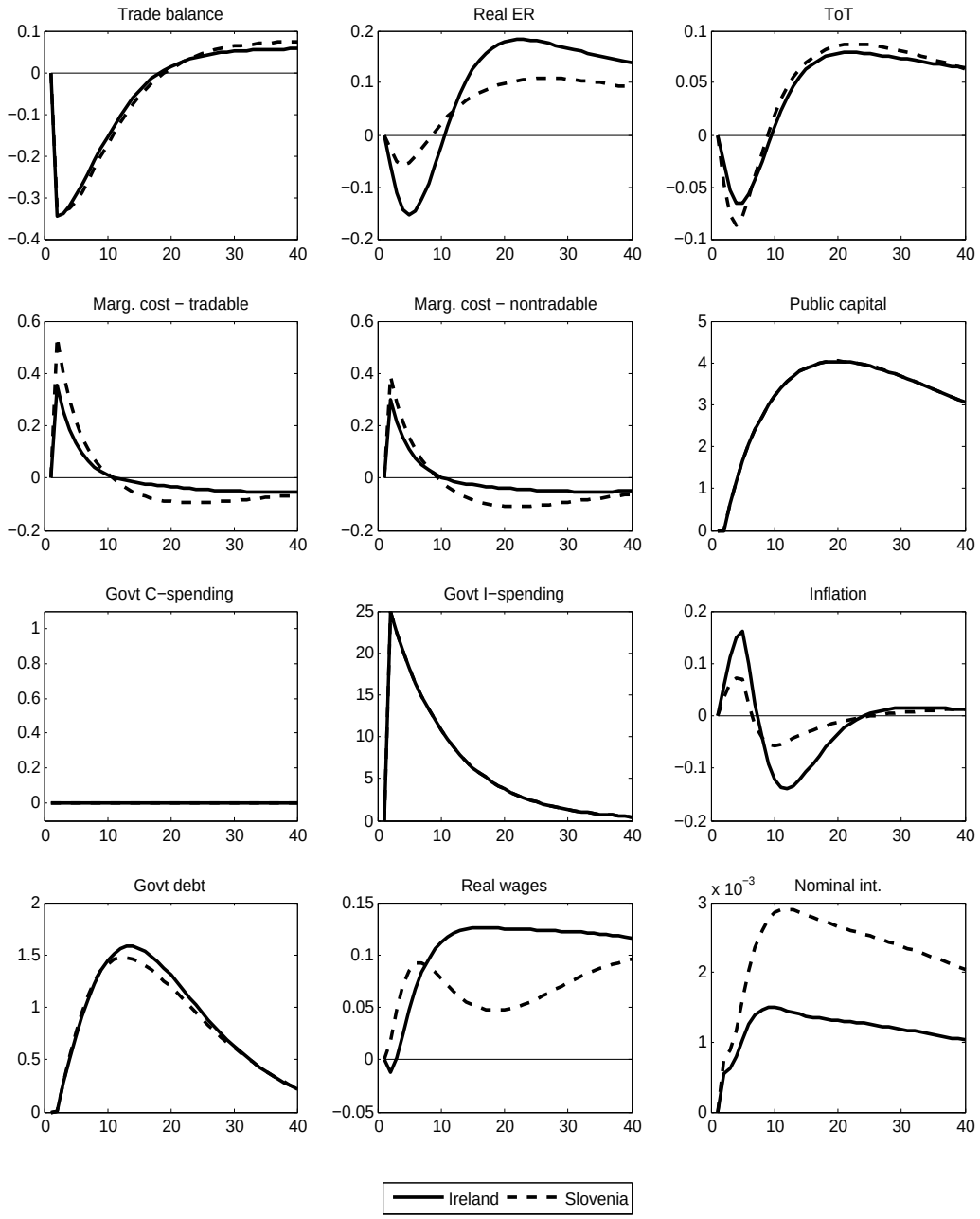
Notes: Impulse responses to a 1 percentage point ex-ante GDP increase in government consumption expenditure. All variables are in percentage deviations from the steady state, except trade balance, government spending and government debt (all defined as ratios to GDP), inflation, and nominal interest rate. The impulse responses of these variables are in percentage-point deviations.

FIGURE 9. An increase in government investment expenditure (I)



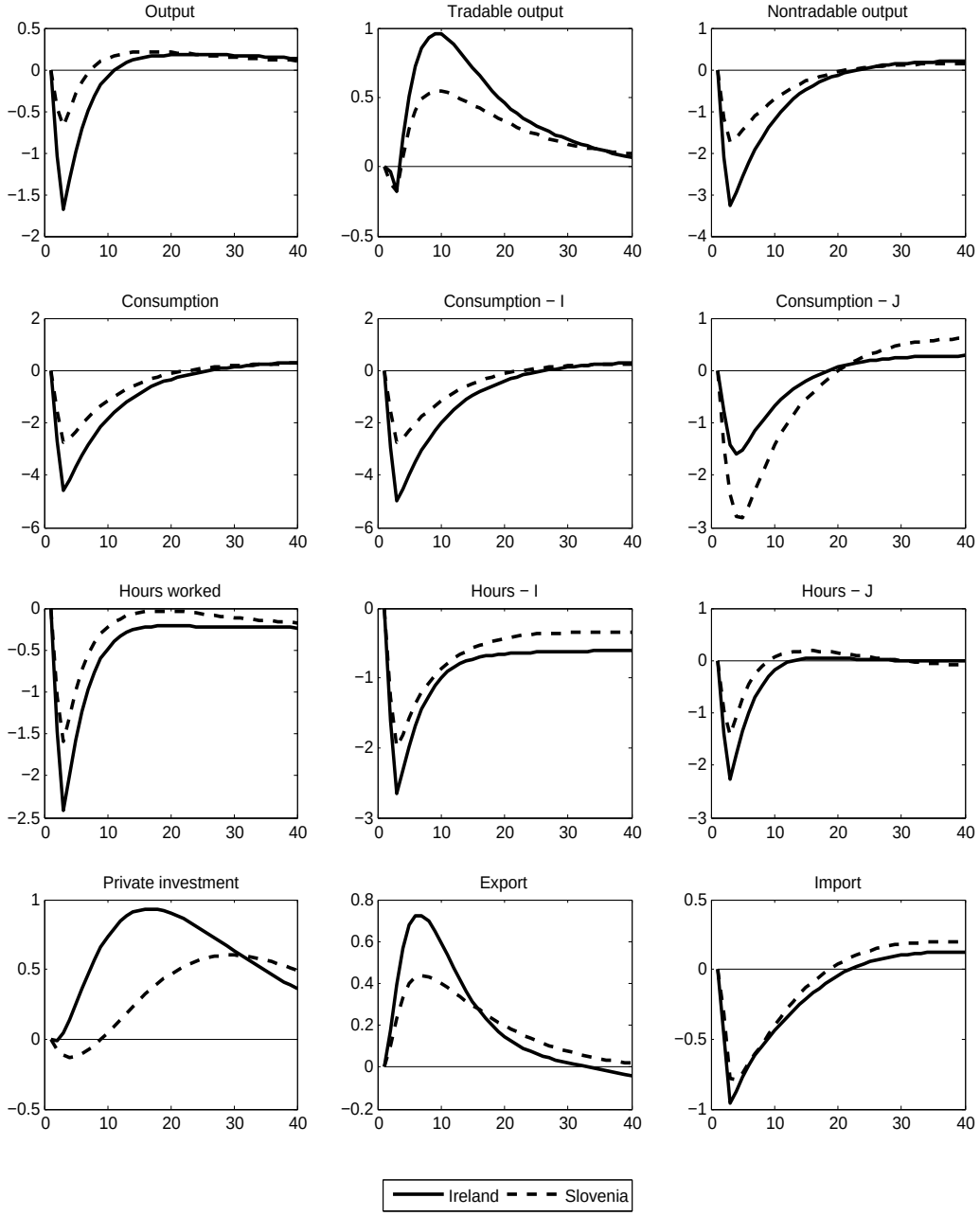
Notes: Impulse responses to a 1 percentage point ex-ante GDP increase in government investment expenditure. All variables are in percentage deviations from the steady state, except trade balance, government spending and government debt (all defined as ratios to GDP), inflation, and nominal interest rate. The impulse responses of these variables are in percentage-point deviations.

FIGURE 10. An increase in government investment expenditure (II)



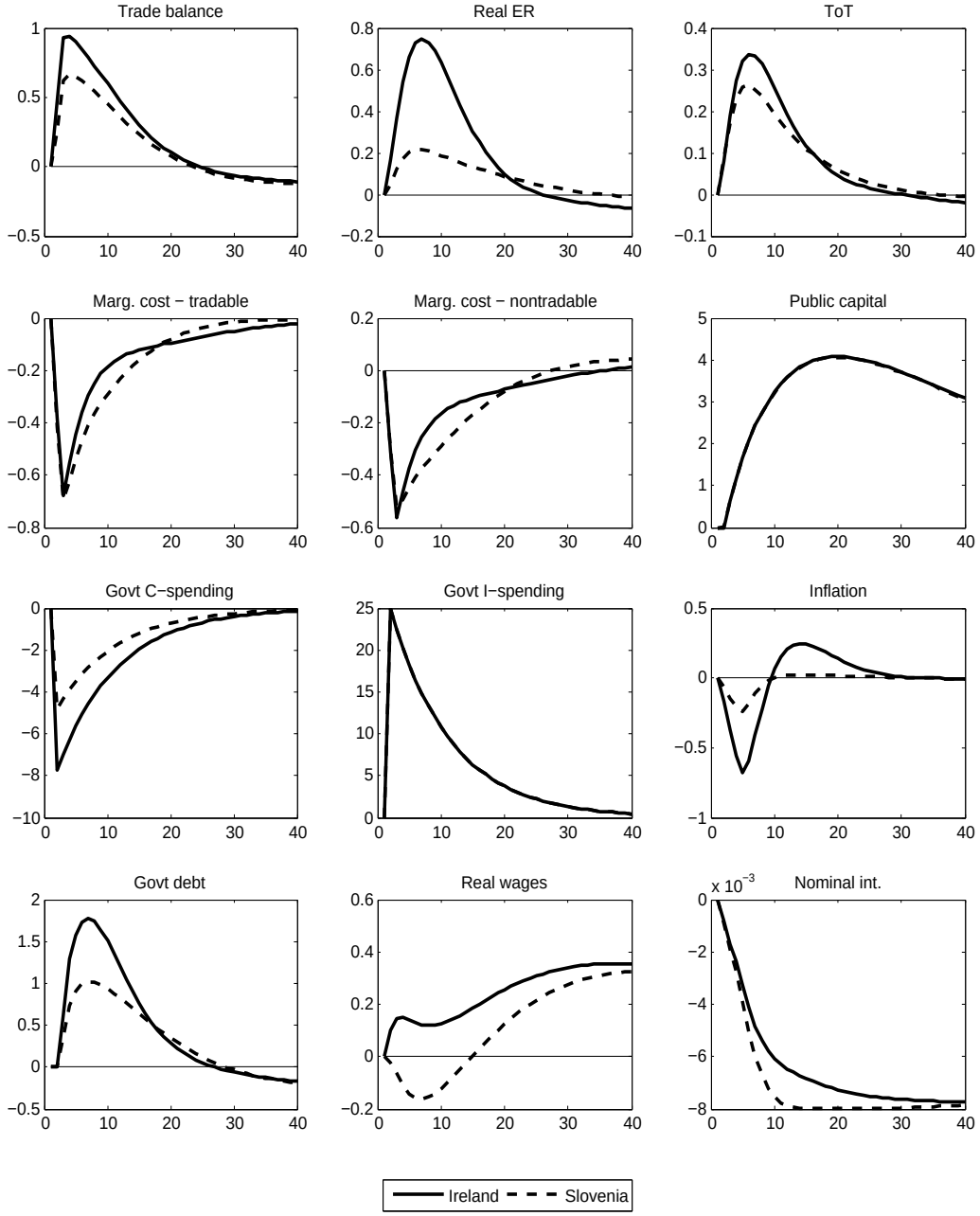
Notes: Impulse responses to a 1 percentage point ex-ante GDP increase in government investment expenditure. All variables are in percentage deviations from the steady state, except trade balance, government spending and government debt (all defined as ratios to GDP), inflation, and nominal interest rate. The impulse responses of these variables are in percentage-point deviations.

FIGURE 11. Switch in government expenditure (I)



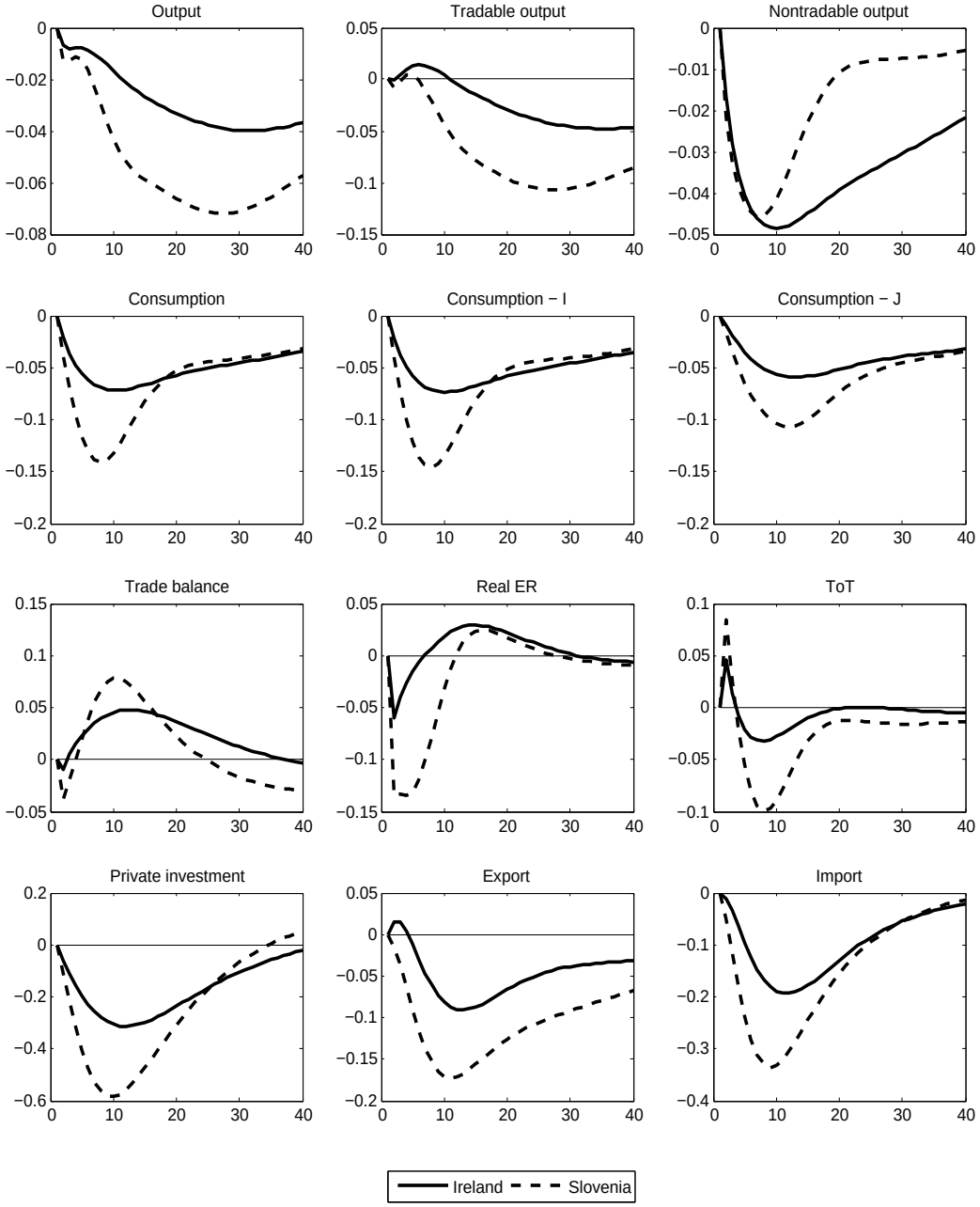
Notes: Impulse responses to a 1 percent ex-ante increase in government investment expenditure and simultaneous decrease of government consumption expenditure by the same amount. All variables are in percentage deviations from the steady state, except trade balance, government spending and government debt (all defined as ratios to GDP), inflation, and nominal interest rate. The impulse responses of these variables are in percentage-point deviations.

FIGURE 12. Switch in government expenditure (II)



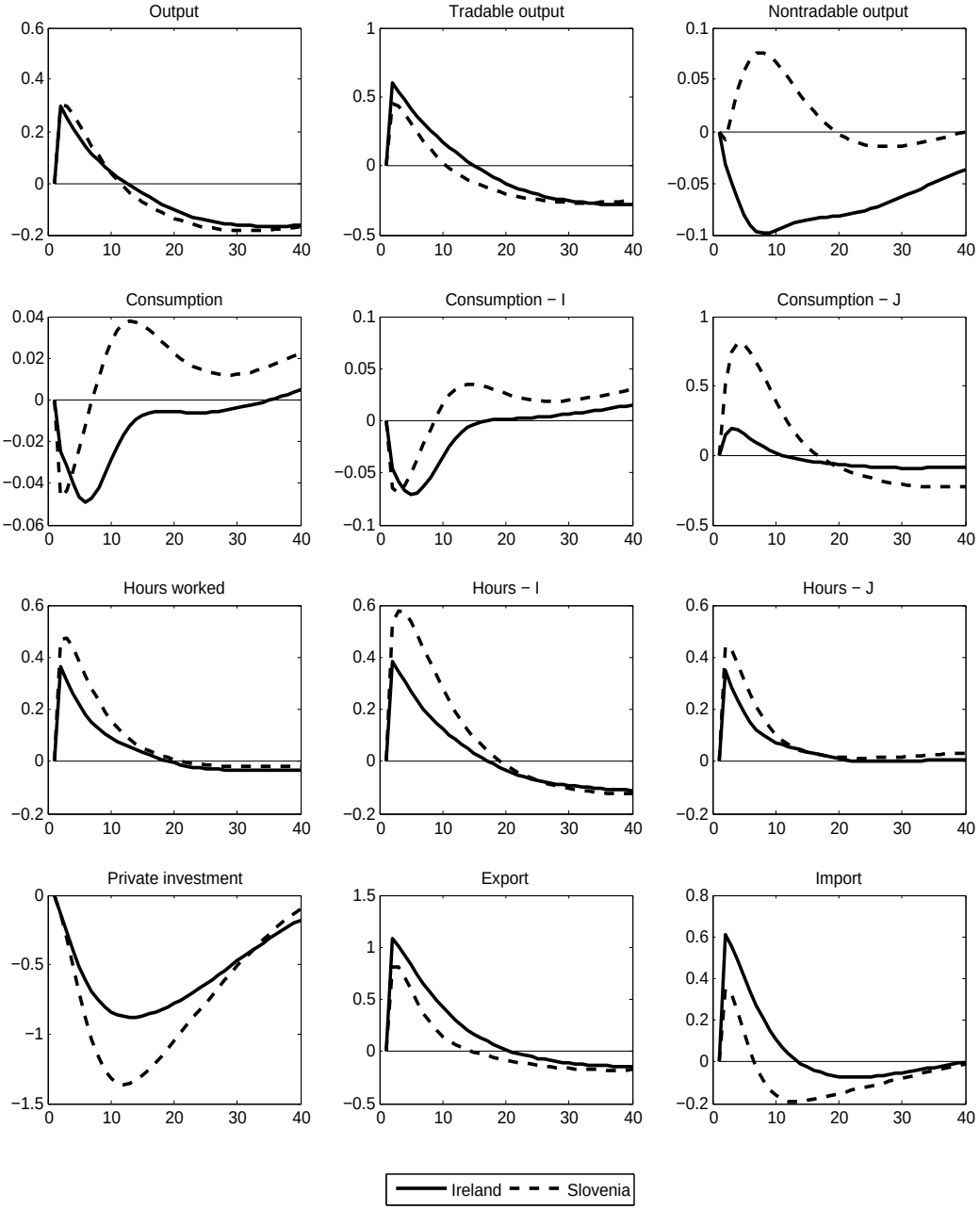
Notes: Impulse responses to a 1 percent ex-ante increase in government investment expenditure and simultaneous decrease of government consumption expenditure by the same amount. All variables are in percentage deviations from the steady state, except trade balance, government spending and government debt (all defined as ratios to GDP), inflation, and nominal interest rate. The impulse responses of these variables are in percentage-point deviations.

FIGURE 13. REA government spending shock in the original EAGLE



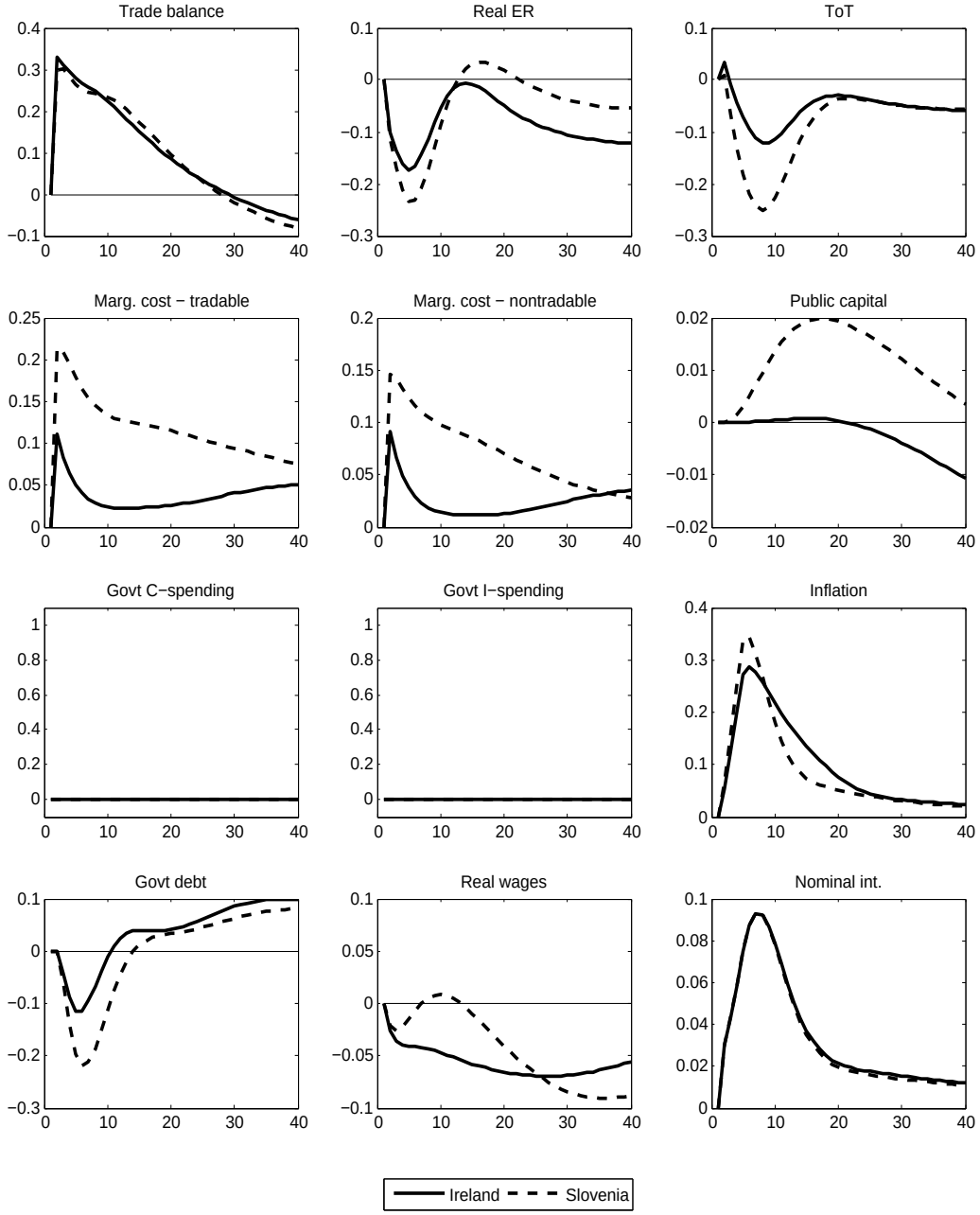
Notes: Impulse responses to positive government expenditure shock in the rest of the EA. All variables are in percentage deviations from the steady state, except trade balance, which is defined as the ratio of trade balance to GDP and its impulse response is expressed in percentage-point deviations.

FIGURE 14. REA government consumption increase (I)



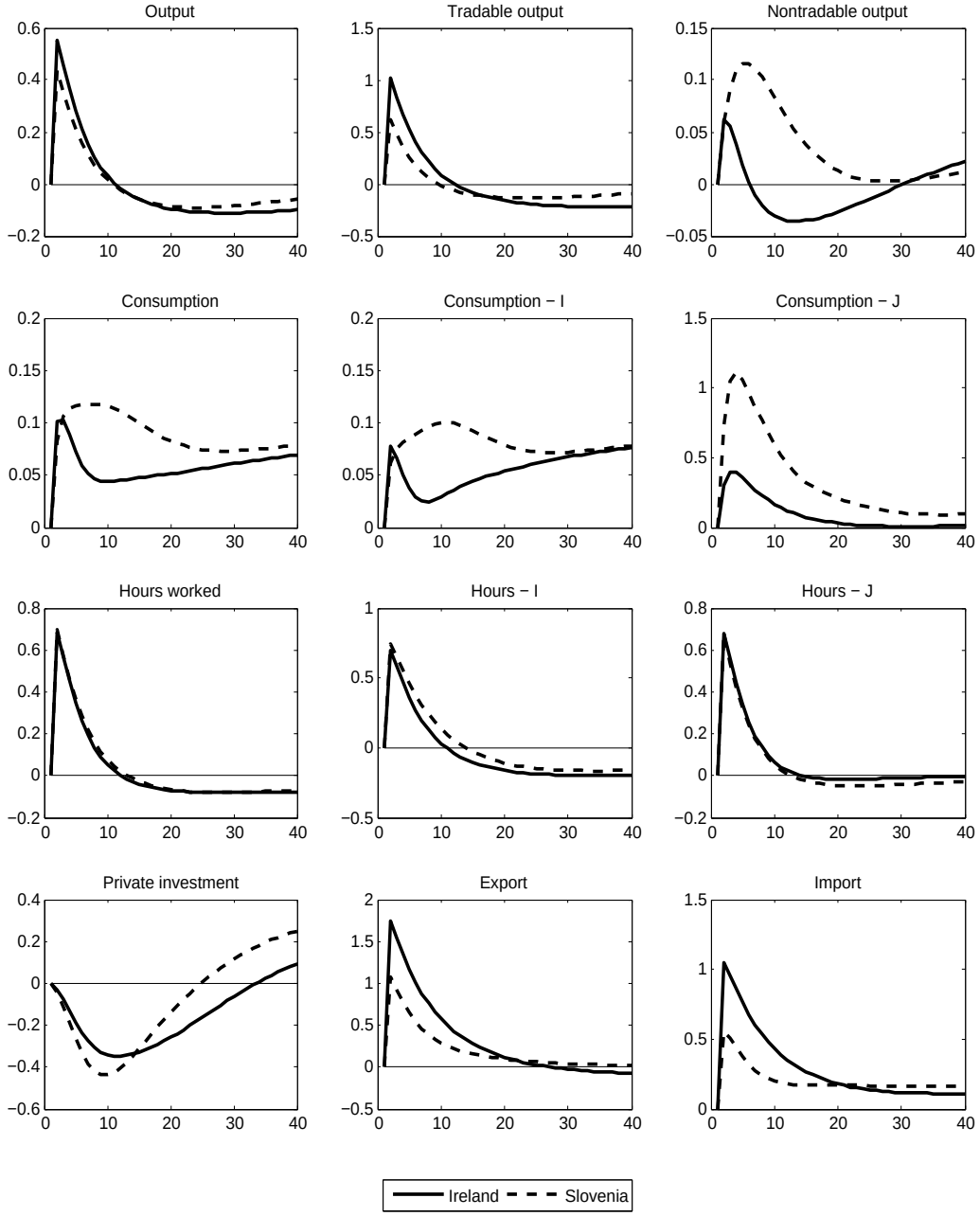
Notes: Impulse responses to a 1 percentage point ex-ante GDP increase in government consumption expenditure. All variables are in percentage deviations from the steady state, except trade balance, government spending and government debt (all defined as ratios to GDP), inflation, and nominal interest rate. The impulse responses of these variables are in percentage-point deviations.

FIGURE 15. REA government consumption increase (II)



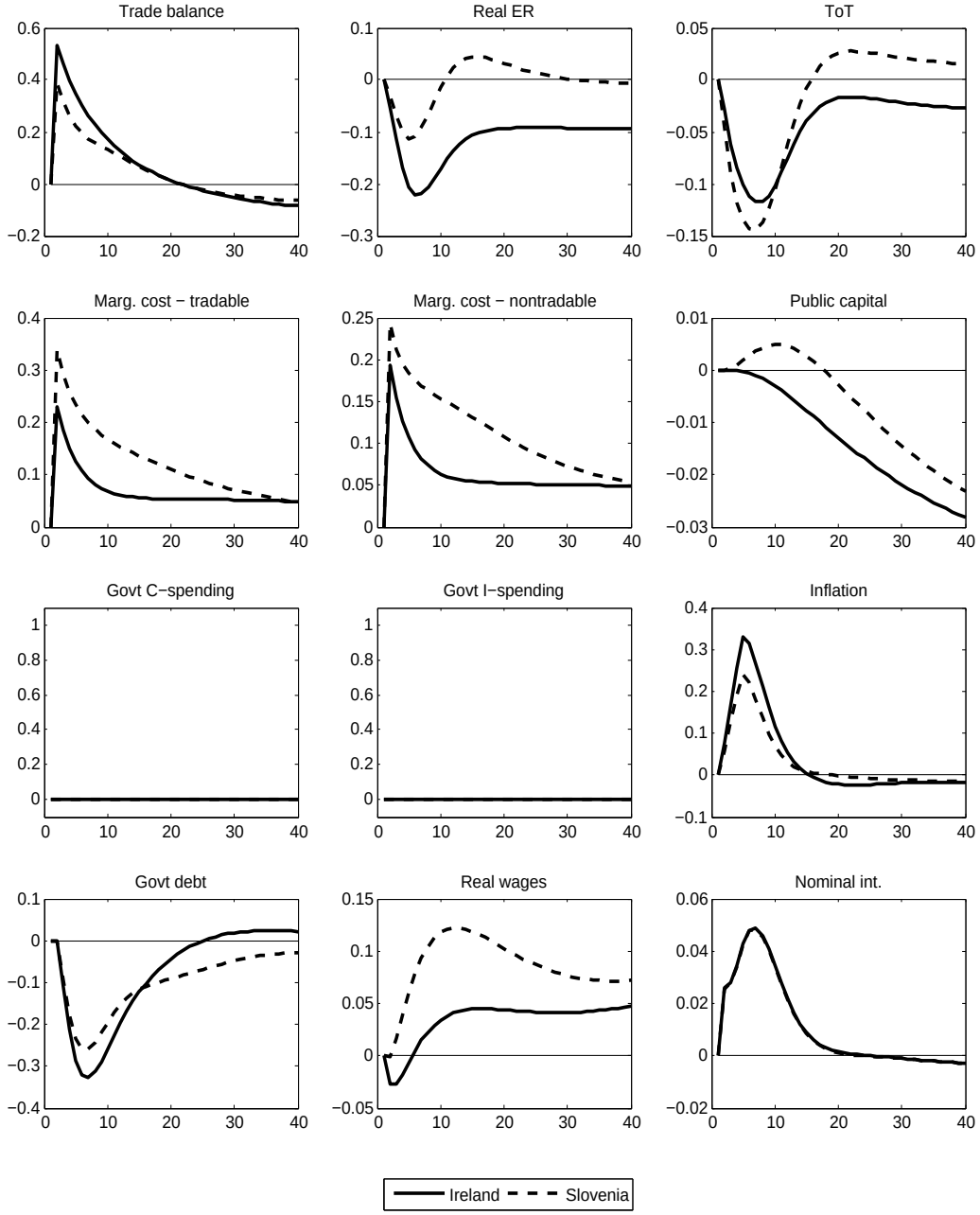
Notes: Impulse responses to a 1 percentage point ex-ante GDP increase in government consumption expenditure. All variables are in percentage deviations from the steady state, except trade balance, government spending and government debt (all defined as ratios to GDP), inflation, and nominal interest rate. The impulse responses of these variables are in percentage-point deviations.

FIGURE 16. REA government investment increase (I)



Notes: Impulse responses to a 1 percentage point ex-ante GDP increase in government investment expenditure. All variables are in percentage deviations from the steady state, except trade balance, government spending and government debt (all defined as ratios to GDP), inflation, and nominal interest rate. The impulse responses of these variables are in percentage-point deviations.

FIGURE 17. REA government investment increase (II)



Notes: Impulse responses to a 1 percentage point ex-ante GDP increase in government investment expenditure. All variables are in percentage deviations from the steady state, except trade balance, government spending and government debt (all defined as ratios to GDP), inflation, and nominal interest rate. The impulse responses of these variables are in percentage-point deviations.

B The EAGLE's extended fiscal sector

B.1 Government consumption

The details of the structure of the core EAGLE model can be found in Gomes et al. (2012) and in Brzoza-Brzezina et al. (2010). The extension of the model requires the introduction of an additional sector that produces final goods for the government. The firms in this sector are assumed to be symmetric, act under perfect competition and produce the final government consumption and investment bundles, $Q_t^{G_C}$ and $Q_t^{G_I}$, using intermediate tradable and nontradable goods as inputs. As the equations are identical for the government consumption and investment goods, only the consumption goods are provided here to save space. The final consumption goods are assembled according to a constant elasticity of substitution (CES) technology,

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

Government demand for nontradable goods is

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

and so when $\nu_{G_C} = 0$ we are back to the properties of the original EAGLE, whereby all government consumption is spent on nontradable goods. The tradable good consumed by the government is a bundle of home-produced tradable goods and imported goods

$$TT_t^{G_C} = \left[\nu_{TG_C}^{\frac{1}{\mu_{TG_C}}} \left(HT_t^{G_C} \right)^{\frac{\mu_{TG_C}-1}{\mu_{TG_C}}} + (1-\nu_{TG_C})^{\frac{1}{\mu_{TG_C}}} \left(IM_t^{G_C} \right)^{\frac{\mu_{TG_C}-1}{\mu_{TG_C}}} \right]^{\frac{\mu_{TG_C}}{\mu_{TG_C}-1}}. \quad (3)$$

This in turn implies the following government demand for home-produced tradable goods

$$HT_t^{G_C} = \nu_{TG_C} \left(\frac{P_{HT,t}}{P_{TTG_C,t}} \right)^{-\mu_{TG_C}} TT_t^{G_C}. \quad (4)$$

Imports of government consumption goods consist of a bundle of (bilateral) imports of tradable goods, produced in all other blocs

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

where

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

and

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

Prices are defined by the following equations that correspond to the CES-aggregated bundles

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

where

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

and

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

Another element of the fiscal extension involves allowing government and private consumption to be, to a degree, complementary. We follow Coenen et al. (2012b) and Leeper et al. (2009) and introduce government consumption in the utility function in a non-separable manner. In particular, utility depends on $\tilde{C}$, which is a CES-aggregate of government and private consumption

$$\tilde{C}_t = \left[\nu_{CCES}^{\frac{1}{\mu_{CCES}}} (C_{I,t})^{\frac{\mu_{CCES}-1}{\mu_{CCES}}} + (1-\nu_{CCES})^{\frac{1}{\mu_{CCES}}} (G_{C,t})^{\frac{\mu_{CCES}-1}{\mu_{CCES}}} \right]^{\frac{\mu_{CCES}}{\mu_{CCES}-1}}. \tag{10}$$

In this setup, changes in government consumption affect optimal private consumption decisions directly, as opposed to the indirect wealth effect observed with separable government consumption.

B.2 Government investment

The key difference between the government spending options is that government investment is not wasteful. It contributes to public capital, by cumulating government investment according to a law of motion

$$K_{G,t+1} = (1 - \delta_G)K_{G,t} + G_{I,t}, \tag{11}$$

and enters the private sector's production function in a nonrivalrous way. The new production functions are

$$Y^S_{T,t} = z_{T,t}K^{\alpha_G}_{G,t}(K^D_{T,t})^{\alpha_T}(N^D_{T,t})^{1-\alpha_T} - \psi_T \tag{12}$$

for the tradable sector and

$$Y^S_{N,t} = z_{N,t}K^{\alpha_G}_{G,t}(K^D_{N,t})^{\alpha_N}(N^D_{N,t})^{1-\alpha_N} - \psi_N \tag{13}$$

for the nontradable sector.

Importantly, government capital enhances the productivity of private capital, as it acts in a similar manner to technological progress. This implies that an increase in government capital will lower the marginal costs of the intermediate goods' sector

$$MC_{T,t} = \frac{1}{z_{T,t}K^{\alpha_G}_{G,t}(\alpha_T)^{\alpha_T}(1-\alpha_T)^{1-\alpha_T}} \left(R^K_t\right)^{\alpha_T} \left((1+\tau^{W_f}_t)W_t\right)^{1-\alpha_T}. \tag{14}$$

The same holds for nontradable goods,

$$MC_{N,t} = \frac{1}{z_{N,t}K^{\alpha_G}_{G,t}(\alpha_N)^{\alpha_N}(1-\alpha_N)^{1-\alpha_N}} \left(R^K_t\right)^{\alpha_N} \left((1+\tau^{W_f}_t)W_t\right)^{1-\alpha_N}. \tag{15}$$

B.3 Market clearing

Naturally, these changes to the modelling framework mean that the market clearing conditions have to be modified accordingly. The new market clearing conditions read:

$$Q^{G_C}_t = G_{C,t}, \tag{16}$$

$$Q^{G_I}_t = G_{I,t}, \tag{17}$$

$$NT_t = NT^C_t + NT^I_t + NT^{G_C}_t + NT^{G_I}_t, \tag{18}$$

$$HT_t = HT^C_t + HT^I_t + HT^{G_C}_t + HT^{G_I}_t. \tag{19}$$

Total imports now include government imports of consumption and investment goods,

$$IM^{H,CO} = \sum_{j=C,I,X} IM_t^{j,H,CO} \frac{1-\Gamma_{IM^j}}{\Gamma_{IM^j}^{H,CO,\dagger}} + IM_t^{G_C} + IM_t^{G_I}. \quad (20)$$

We assume that there are no adjustment costs associated with these goods. The government budget constraint is also modified to reflect government spending on consumption and investment goods, with these quantities multiplied by their corresponding prices

$$\begin{aligned} &P_{G_C,t}G_{C,t} + P_{G_I,t}G_{I,t} + TR_t + B_t + M_{t-1} \\ &= \tau_t^C P_{C,t}C_t + (\tau_t^N + \tau_t^{W_h}\frac{1}{s^H}\left(\int_0^{s^H(1-\omega)} W_t(i)N_t(i)di + \int_{s^H(1-\omega)}^{s^H} W_t(j)N_t(j)dj\right) \\ &\quad + \tau_t^{W_f} W_t N_t + \tau_t^K(R_{k,t}u_t - (\Gamma_u(u_t)+\delta)P_{I,t})K_t \\ &\quad + \tau_t^D D_t + T_t + R_t^{-1}B_{t+1} + M_t. \quad (21) \end{aligned}$$

The amended aggregate resource constraint is

$$\begin{aligned} P_{Y,t}Y^t = P_{C,t}Q_t^C + P_{I,t}Q_t^I + P_{NT,t}Q_t^{G_C} + P_{HT,t}Q_t^{G_I} \\ + \sum_{CO\neq H} S_t^{H,CO}P_{X,t}^{H,CO}X_t^{H,CO} - \sum_{CO\neq H} P_{IM,t}^{H,CO}IM_t^{H,CO}. \quad (22) \end{aligned}$$

Finally, the autoregressive shocks to government consumption and investment are, respectively,

$$g_t^C = (1-\rho_{g^C})\bar{g}^C + \rho_{g^C}g_{t-1}^C + \epsilon_{g^C,t}, \quad (23)$$

and

$$g_t^I = (1-\rho_{g^I})\bar{g}^I + \rho_{g^I}g_{t-1}^c + \epsilon_{g^I,t}. \quad (24)$$

C Heterogeneity in shock responses

To illustrate the heterogeneity of responses to various shocks, we calibrate the original EAGLE to Ireland and Slovenia. They are both small, very open (imports and exports in excess of 70 percent of GDP; import-content of exports close to 50 percent), and members of the EA. However, they differ in several important respects, in particular with respect to trade orientation, where Ireland tends to trade mainly with non-EA regions and Slovenia trades mainly with EA (see Table 1). This implies that, for instance, the sensitivity of trade flows with respect to the euro exchange rate will be very different for each country. There are also other differences regarding the great ratios, nominal and real rigidities, tax rates, etc. As a consequence, their reactions to shocks can be very different. For example, after the onset of the recession during 2008, the proportion in GDP of both imports and exports in Slovenia decreased substantially more than in Ireland (see Figure 1).[28]

In line with the different structures of the economies, policy responses have also been different in each country. As Figure 1 shows, governments increased the proportion of their consumption expenditure in GDP at the onset of the crisis, with Ireland reversing this process since 2010. Figure 2 shows that the countries also differ with respect to the strength of fiscal policy reactions regarding government investment expenditure. We analyse the responses of both countries to a set of standardised structural shocks using the original EAGLE model, adjusted to allow for an import content of exports, in order to test the validity of the hypothesis that SOE heterogeneity plays a crucial role in fiscal policy effectiveness. This model is particularly suitable for SOEs within the EA, because it incorporates a high import content of exports and features the very weak reaction of area-wide monetary policy to country-specific shocks, as well as a large degree of openness towards different blocs in the model. To illustrate the diversity of reactions to common structural shocks, we plot the responses of key variables to a world demand shock and an external risk premium shock.

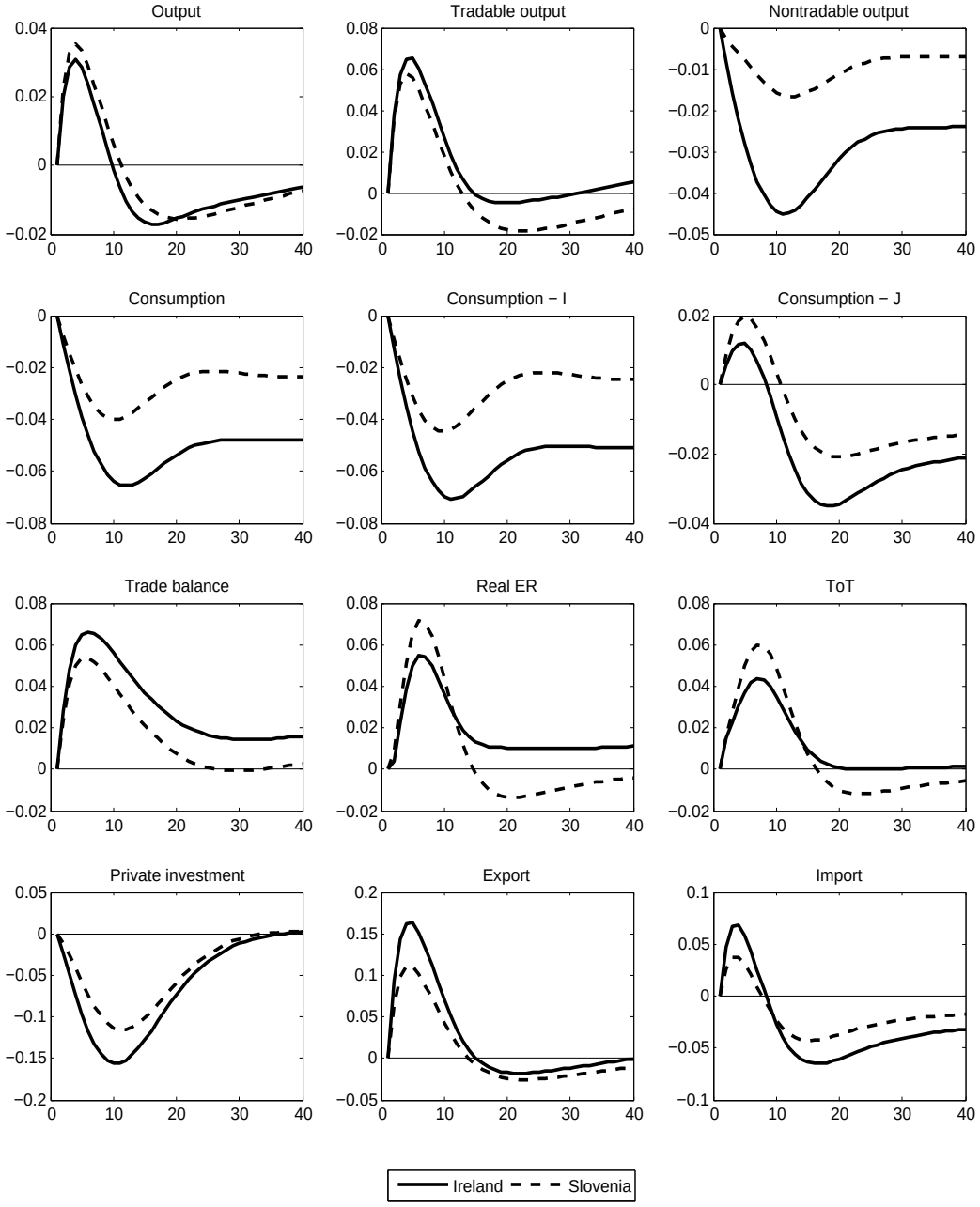
Figure 18 displays the responses to a world demand shock, modelled here as a positive shock to consumption preferences in the rest-of-the-world and U.S. model blocs.[29] The result is an increase in non-EA aggregate demand, which stimulates exports to blocs outside the EA. The differences in responses can be explained by the trade linkages of the two economies. Ireland is much more open to non-EA blocs, and thus benefits more from an increase in aggregate demand in these

[28] In both countries, exports have recovered and since increased. While imports in Slovenia recovered their proportion of GDP in 2008 and then stagnated, they continued to increase (but less than exports) in Ireland. Consequently, the trade balance has improved substantially in both countries.

[29] The shock increases the weight of consumption preferences in both regions by one percentage point ex-ante.

regions. This increases exports and imports (due to the import-content of exports), while it dampens domestic demand. The net result is a strong increase in output, driven mainly by the tradable sector. The responses for Slovenia are much more muted, as the positive effects from increased world demand are indirect, working mainly through rest of the EA.

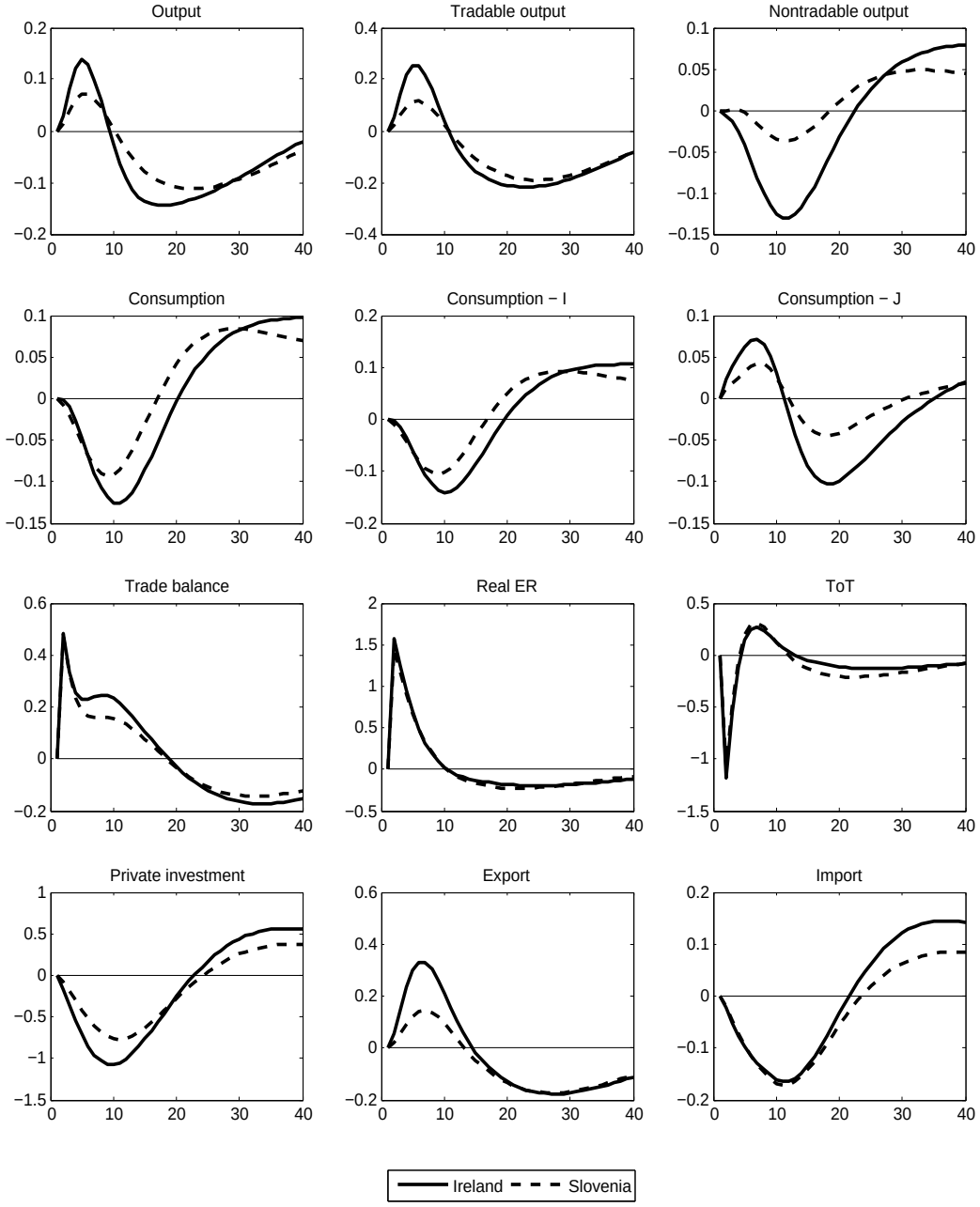
FIGURE 18. World demand shock



Notes: Impulse responses to a positive shock to consumption preferences in the U.S. and the Rest of the World. All variables are in percentage deviations from the steady state, except trade balance, which is defined as the ratio of trade balance to GDP and its impulse response is expressed in percentage-point deviations.

Figure 19 shows the responses to a shock that increases the external risk premium for the EA blocs by one percentage point ex-ante. Depreciation of the real exchange rate benefits exports and reduces imports in both countries. However, the effects are much more pronounced in Ireland, again due to its extensive trade linkages with non-EA regions. The boost in exports dominates over the reduction in domestic demand, and so output in Ireland increases. In Slovenia, the negative effects of an external risk premium shock on domestic demand prevail over the increase in net exports, with output therefore decreasing.

FIGURE 19. External risk premium shock



Notes: Impulse responses to an increase in external risk premium of the EA. All variables are in percentage deviations from the steady state, except trade balance, which is defined as the ratio of trade balance to GDP and its impulse response is expressed in percentage-point deviations.

D Sensitivity Analysis

Due to modelling uncertainty, it is essential that policy evaluations be robust to alternative assumptions (Cogan et al., 2010). Christiano et al. (2009) note that the value of the government spending multiplier is sensitive to the model's parameter values. Therefore, sensitivity analysis is conducted whereby alternative values for uncertain parameters are employed.

Complementarity between private and government consumption. As noted earlier, the degree of complementarity between private and government consumption plays an important role in the determination of responses to the government consumption expenditure shock, as it determines the degree of co-movement between private and government consumption. Here we illustrate the difference in responses to the government consumption expenditure shock between the benchmark calibration, where $\mu_{CCES} = 0.20$, and an alternative, where we increase substitutability between private and government consumption by setting $\mu_{CCES} = 0.70$.

Figures 20 and 21 show the results of this experiment. The most obvious difference is that private consumption decreases sharply on impact when substitutability between private and government consumption is high. Such a result is expected, as households desire to smooth (and form habits) a consumption good bundle which is a composite of private consumption and government consumption. If private and government consumption are highly substituTable, households prefer to alter the composition of the bundle by reducing private consumption at the time when government consumption increases. When this is the case, households' reduction in private consumption offsets part of the government stimulus.

The result is that the response of output to government consumption expenditure shock is more attenuated when the degree of substitution between private and government consumption expenditure is higher, even though the shock and the path of government consumption expenditure are identical. For instance, the short-run output multiplier has more than halved from 1.116 percent at the peak when $\mu_{CCES} = 0.20$ to 0.49 percent when $\mu_{CCES} = 0.70$. The key mechanism behind this result is that a low complementarity of government and private consumption restores the standard crowding-out between private and government consumption. The high elasticity of substitution between private and government expenditure undoes a large portion of government consumption spending already in the aggregator, as it now becomes optimal for households to decrease private consumption to offset the strong increase in government consumption. The impact of a government consumption expenditure increase on the CES-aggregated consumption, which is the aggregate that enters the first order

conditions of the household and governs their investment-saving and labour-leisure decisions, is therefore much smaller. Because of this, the stimulus from government consumption to domestic demand is much weaker and output increases by less.

Such a result also has important policy implications. The effects of government consumption expenditure increases on macroeconomic variables will be stronger when complementarity between private and government consumption is high. If this is not the case, then other forms of government spending may be more desirable. Moreover, if the substitutability between private and government consumption is high, expenditure switching away from government consumption and towards government investment may become a very desirable alternative.

FIGURE 20. Effect of elasticity of substitution (I)

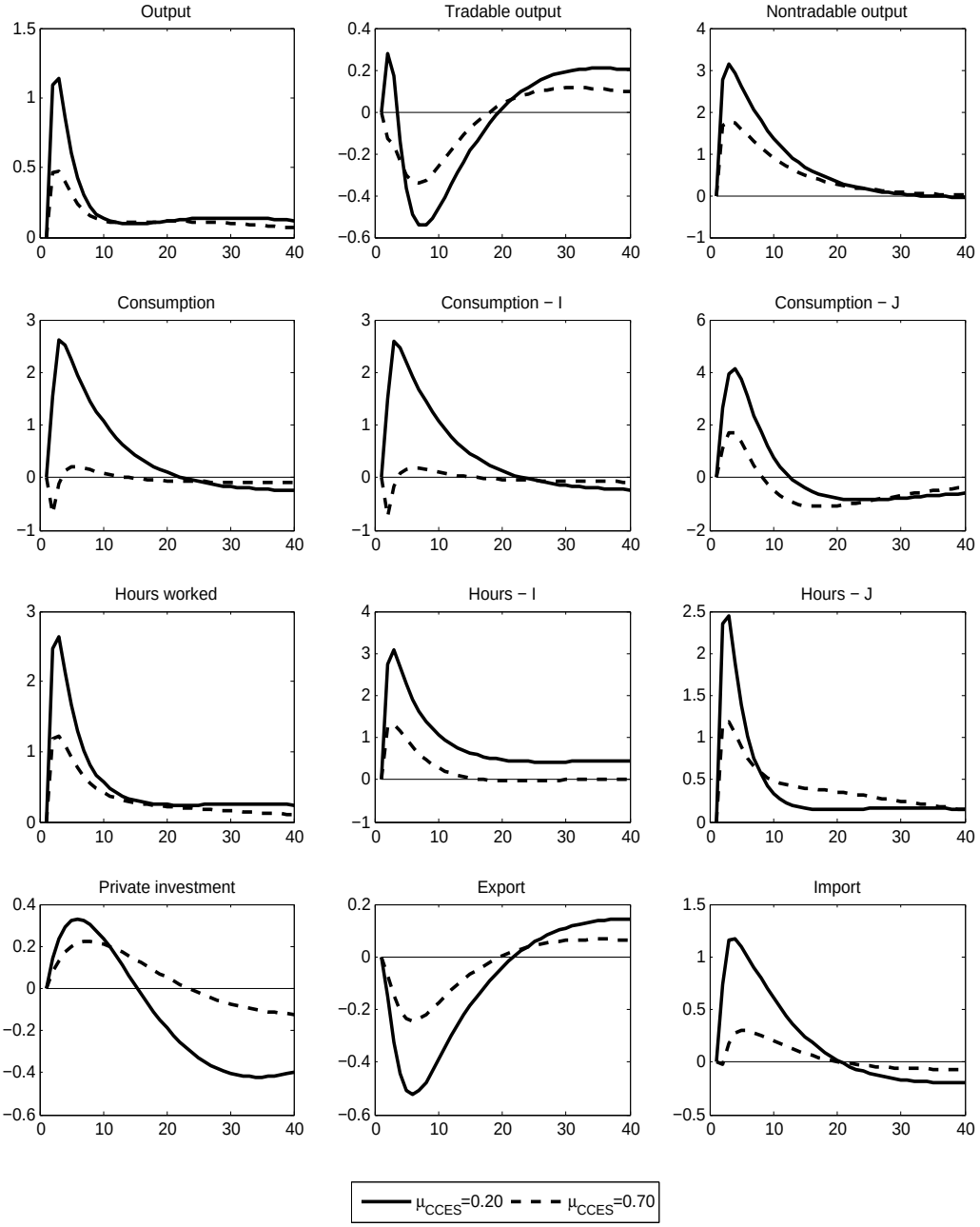
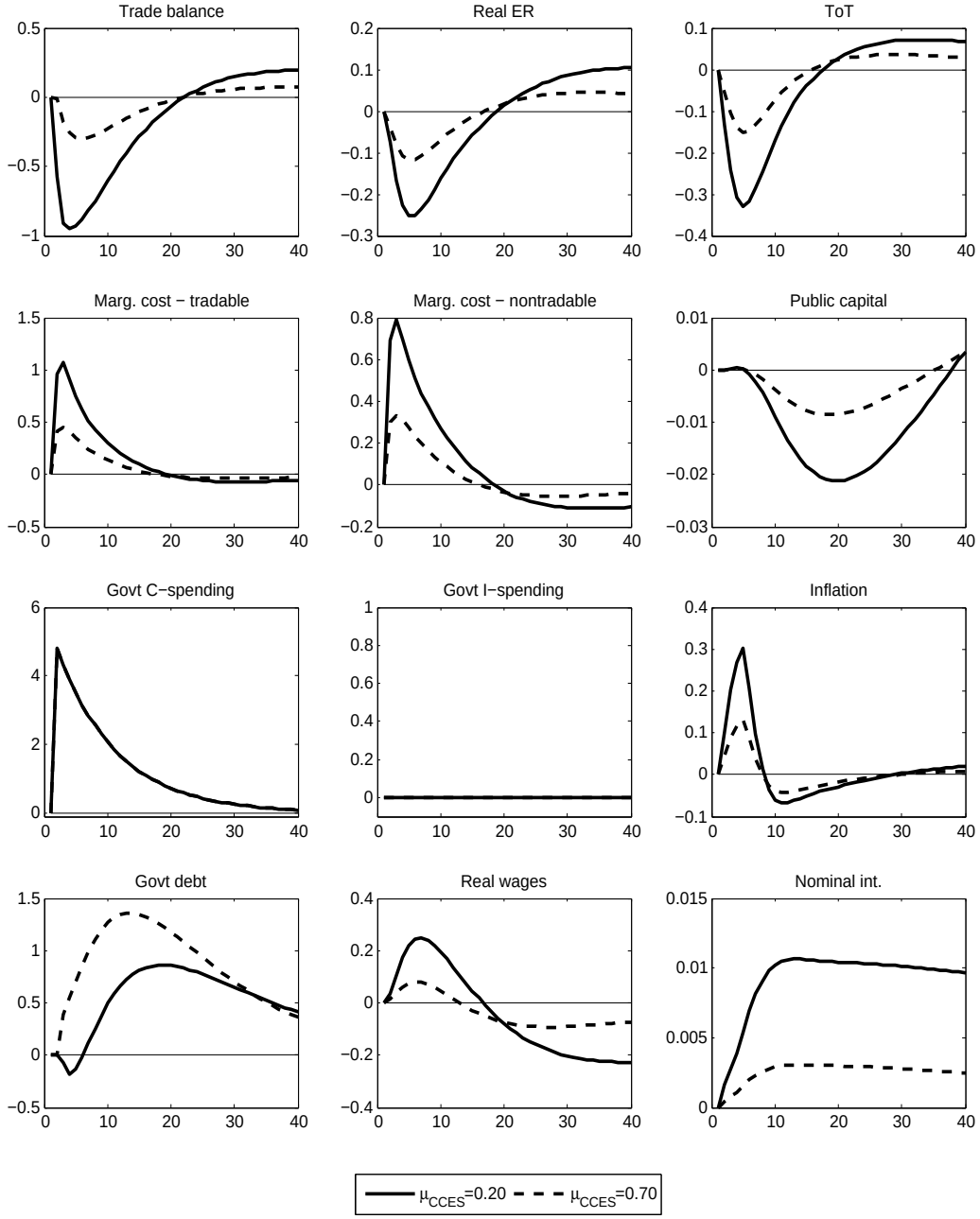


FIGURE 21. Effect of elasticity of substitution (II)



Productivity of public capital. The productivity of public capital, α_G, is one of the key parameters that determines the strength of the effect of government investment expenditure, as well as the co-movement between variables. As we have seen in the main text, this channel is very strong in SOEs in the medium run, as productive public capital is very persistent. There is no straightforward way to determine the value of this parameter. In the benchmark calibration, we set $\alpha_G = 0.05$. We follow Leeper et al. (2010) and investigate the effect of setting α_G to 0.10, i.e. when public capital is more productive.[30]

Figures 22 and 23 show that there are important effects of higher public capital productivity. First, there is little difference in the very short run between the case with more productive public capital and our benchmark calibration, while differences in the medium run are substantial. The reason is that it takes time to increase the public capital stock, so that differences in its productivity do not play a role over very short horizons. Second, consumption increases if public capital is more productive. This is due to a stronger wealth effect for Ricardian households, who increase their consumption sooner and more substantially if public capital is more productive. Third, the effect of more productive public capital on hours worked is small. The rise in hours worked is caused by the higher demand for labour to meet the increase in aggregate demand due to the higher demand for government investment goods. The increase in production has to be driven primarily by labour inputs, as public capital has not increased yet. In the medium run, when public capital begins to increase, the wealth and substitution effects almost cancel out. Ricardian households prefer to work less because they are wealthier, but at the same time they are more productive because of the build-up of now more productive public capital. Finally, the increase in consumption contributes to the initial output increase, as well as to the deterioration of the trade balance in the short run (on top of the import content of government consumption spending). In the medium run, however, private investment starts to increase due to higher productivity induced by more productive public capital. This is the main driving force of positive output growth in the medium run, along with decreased marginal costs, depreciation of the real exchange rate and improvement of the trade balance.

The key insight of more productive public capital is with respect to the co-movement of key economic variables. If the productivity of public capital is low, we have negative co-movement between government investment expenditure and consumption (and between private consumption and output). Higher productivity of public capital leads to positive co-movement of government investment spending, output, private consumption and investment.

[30] See Leeper et al. (2010) for a review of the alternative values taken for this parameter in the literature.

FIGURE 22. Effect of public capital productivity (I)

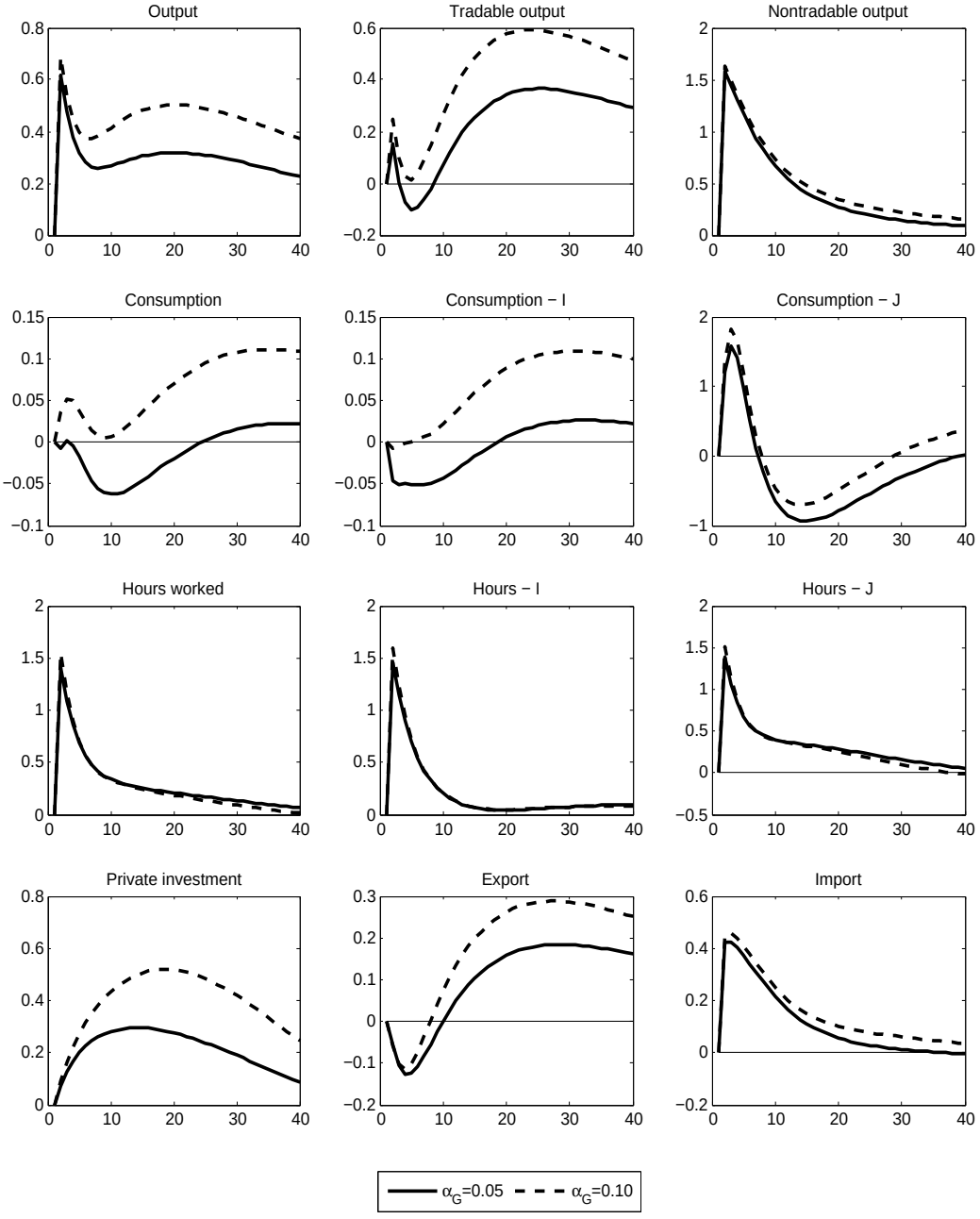
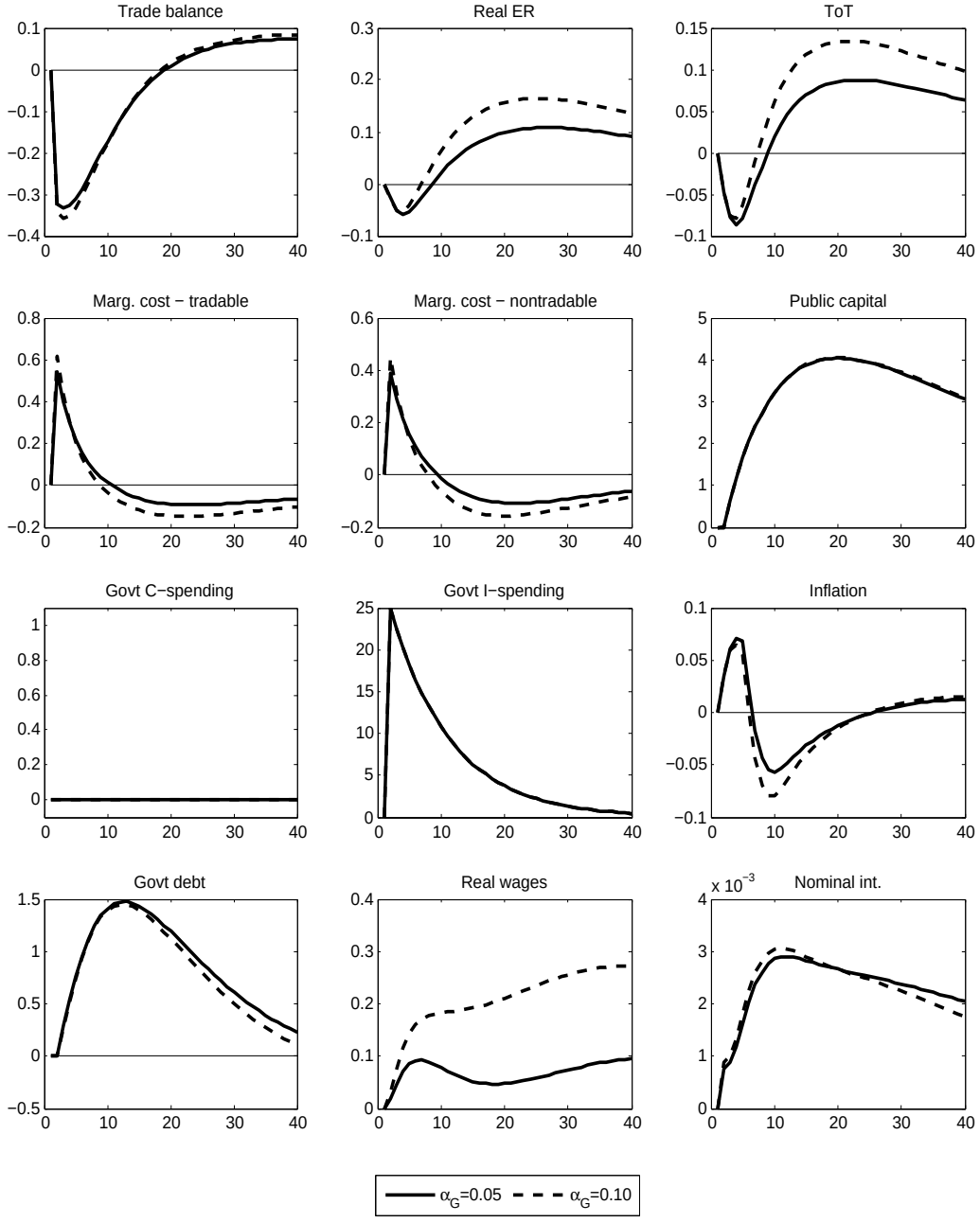


FIGURE 23. Effect of public capital productivity (II)



Import content of government investment. The analysis above seems to indicate that, at least on impact, output multipliers of government investment expenditure tend to be smaller than those of government consumption expenditure. It turns out that this depends almost entirely on the import content of each type of government expenditure. In the analysis above, we assumed that roughly 5 percent of government consumption expenditure is imported directly, while the import content of government investment expenditure was 25 percent. Here, we show how changing the size of imports in government investment affects the analysis.

Figures 24 and 25 show the effect of a government investment expenditure increase for two different import content magnitudes of government investment expenditure. A reduction of the import content of government investment expenditure from 0.01 to 0.005 percent of GDP has mainly short-run effects. The most obvious effect is on trade balance, which deteriorates by much less on impact, because less government investment goods are imported. At the same time, as investment goods contain a high proportion of tradable goods, tradable output increases by more and total output increases more strongly. Relative to the baseline, hours worked increase by more and there is a stronger initial increase in marginal costs and (after a slight delay) on inflation, which results in stronger initial real effective exchange rate appreciation. The reason is that in our calibration (the experiment was conducted for Slovenia), prices in the tradable sector are less rigid than in the nontradable sector, which explains the stronger price increase when tradable sector output expands.

What is interesting is that in the medium run, effects on output and most other real variables do not depend on the import content of government expenditure. The reason is that the medium-run benefits of a public capital increase depend only on the stock of public capital and not on the origin of this capital (whether it was imported or produced at home). The import content of government investment expenditure matters only in the short run.

FIGURE 24. Effect of import content of government investment (I)

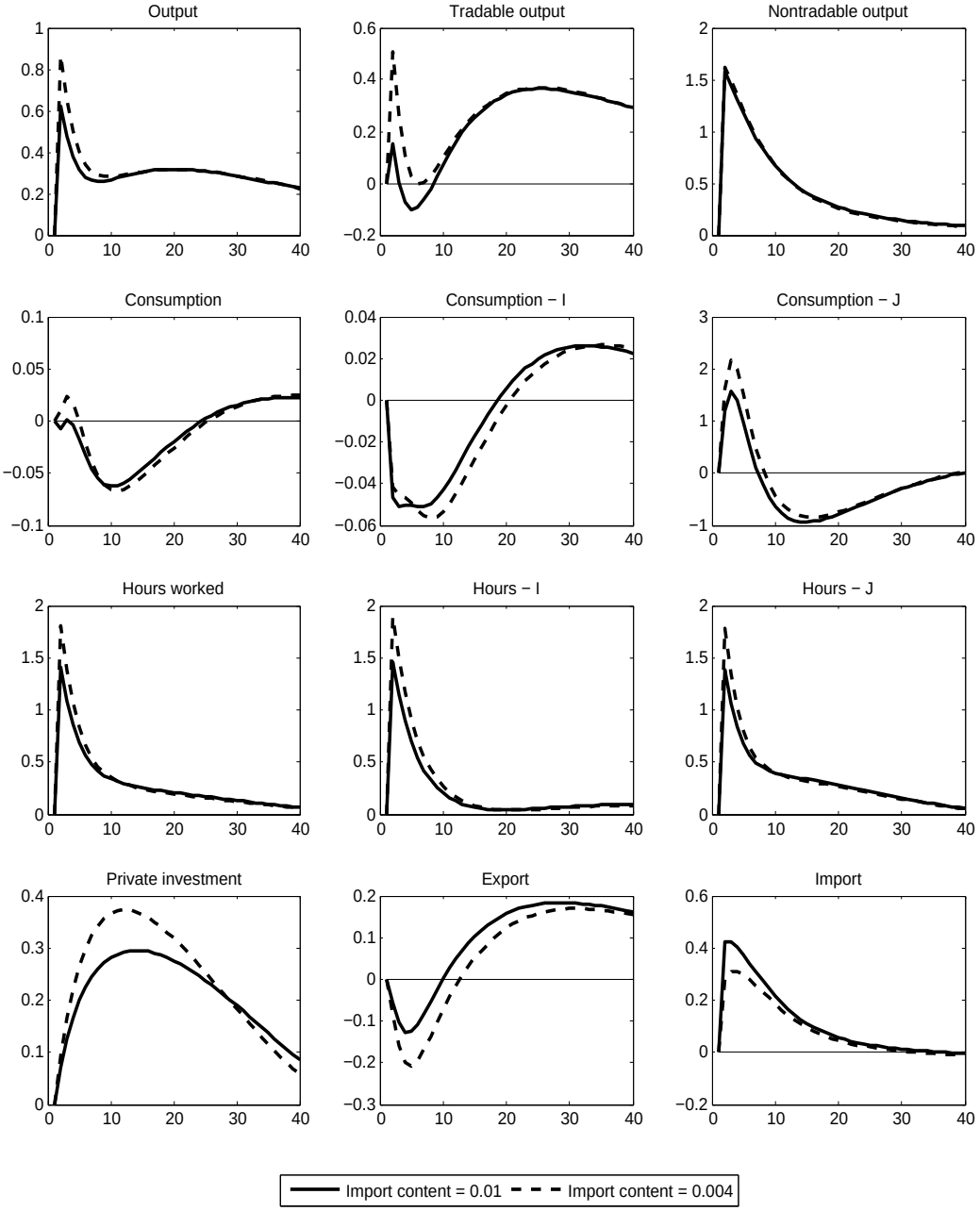


FIGURE 25. Effect of import content of government investment (II)