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## Public infrastructures, public consumption and welfare in a new open economy macro model

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Giovanni Ganelli – Juha Tervala

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and welfare in a new open  
economy macro model**




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## **Public infrastructures, public consumption and welfare in a new open economy macro model**

The views expressed in this paper are those of the authors and do not necessarily reflect the views of the Bank of Finland.

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# Public infrastructures, public consumption and welfare in a new open economy macro model

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## Abstract

This paper focuses on the trade-off faced by governments in deciding the allocation of public expenditures between productivity-enhancing public infrastructures and utility-enhancing public consumption in a two-country model. The results show that a permanent increase in the domestic stock of public capital financed by a reduction in public consumption raises domestic welfare if the productivity of public capital is high and the weight of public consumption in private utility is low compared with private consumption. The effect on foreign welfare is negative in the short run, but positive in the long run. This implies that, if foreign authorities care not only about the present discounted value of welfare but also about welfare dynamics, a permanent domestic reallocation of public spending might result in a virtuous global technological cycle.

Keywords: public spending composition, welfare, imperfect competition, nominal rigidities

JEL classification numbers: E62, F41, H42, H54

# Julkinen infrastruktuuri, julkinen kulutus ja hyvinvointi avotalouden makromallissa

Suomen Pankin keskustelualoitteita 8/2009

Giovanni Ganelli – Juha Tervala  
Rahapolitiikka- ja tutkimusosasto

## Tiivistelmä

Tässä tutkimuksessa analysoidaan kahden maan mallia käyttäen, miten valtioiden tulisi allokoida julkiset menot julkisen infrastruktuurin ja hyötyä tuottavien julkisten kulutusmenojen kesken. Tutkimuksessa osoitetaan, että pysyvä, julkisten kulutusmenojen vähentämisellä rahoitettava lisäys julkisessa infrastruktuurissa voi lisätä hyvinvointia. Hyvinvointi lisääntyy, jos julkisen infrastruktuurin tuottavuus on suuri ja julkisen kulutuksen hyöty on pieni suhteessa yksityiseen kulutukseen. Kotimaan julkisten menojen rakenteen muutoksen vaikutus ulkomaan hyvinvointiin on negatiivinen lyhyellä ajalla, mutta positiivinen pitkällä ajalla. Tämä merkitsee, että jos ulkomaan ei välitä ainoastaan hyvinvoinnin diskontatusta nykyarvosta, vaan myös hyvinvoinnin sopeutumisesta, pysyvä muutos kotimaan julkisten menojen rakenteessa voi aiheuttaa positiivisen teknologisen kierteen.

Avainsanat: julkisten menojen rakenne, hyvinvointi, epätäydellinen kilpailu, nimellisjäykkyydet

JEL-luokittelu: E62, F41, H42, H54

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# 1 Introduction

Governments face several trade-offs in the process of planning and executing fiscal policy. For example, a decision on the appropriate fiscal stance needs to take in to account both the short-run impact on the economy and the long-run sustainability of public finances. Furthermore, decisions on the methods of financing the deficit (or on the use of the surplus) and on the composition of public expenditures also need to be made.

With regard to the latter issue, governments are involved in the provision of public infrastructures which can increase the productivity of private firms.<sup>1</sup> Examples include roads, bridges, airports, and all ‘... *those public works, which, though they may be in the highest degree advantageous to a great society, are, however, of such a nature that the profit could never repay the expense to any individual or small number of individuals, and which it therefore cannot be expected that any individual or small number of individuals should erect or maintain.*’ (Adam Smith 1776). At the same time, governments spend large part of their budgets on goods and services that can also be privately provided and, while they do not directly impact the productivity of the private sector, are likely to affect consumers’ utility in a way similar to private consumption. Examples of such utility-enhancing spending for public consumption include (but are obviously not limited to) insurance programs, defense, clean streets, and public parks.

This trade-off between productivity-enhancing public investment and utility-enhancing public consumption is often at the forefront of the public debate and policy discussions. Despite being a major policy issue, this trade-off has however received less attention than it deserves in the academic literature.

Several authors, particularly since the work of Aschauer (1989) have investigated, both theoretically and empirically, the consequences of productive public spending. This literature includes Baxter and King (1993), Gramlich (1994), Glomm and Ravikumar (1997), Rioja (1999, 2003), Feltenstein and Morris (1990), Kalaitzidakis and Kalyvitis (2004), Coto-Martinez (2006), Duggal, Saltzman and Klein (2007) and Linnemann and Schabert (2006). Very few papers in this literature, however, explicitly focus on the trade-off between productive infrastructure spending and the welfare effects of public consumption. Prominent exceptions are Barro (1990), who incorporates tax-financed government services that affect production and utility into an endogenous growth model, and Turnovsky and Fisher (1995), who carry out a similar analysis using a neoclassical intertemporal framework.

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<sup>1</sup> Throughout the paper, we will use interchangeably the expressions infrastructure expenditure and capital expenditure. Public infrastructures and public capital will also be used as synonymous.

In this paper we analyze the trade-off related to government spending composition in the context of a New Keynesian two-country model with imperfect competition and nominal rigidities. Our model belongs to the so-called New Open Economy Macroeconomics (NOEM) framework, which many currently regard as the workhorse model for the analysis of macroeconomic issues in open economies.<sup>2</sup> Compared to the existing literature, one key innovation of our paper is that of analyzing productive public infrastructure spending in this new modeling paradigm. While some of the papers that we reviewed contain ingredients of the New Keynesian open economy paradigm, we are not aware of any paper that analyses the implications of public capital in a model that features at the same time imperfect competition, nominal rigidities and a two-country world.

As we already stressed above, the only papers of which we are aware that explicitly focus on the trade-off between productive government spending and utility from public consumption (Barro 1990; Turnovsky and Fisher 1995) do not belong to the New Keynesian strand of literature and do not consider market imperfections such as monopolistic competition and price rigidities. The analysis of how the trade-off is affected by such imperfections is a novel contribution of our paper. In particular, in Section 4 we compare our welfare results to those of the previous literature. We find that, contrary to Turnovsky and Fisher (1995), since initial output and consumption are sub-optimally low in our model (due to monopolistic competition) a shift toward productive government spending is welfare improving even in the short run for plausible parameter values. In addition, the open economy dimension is also important in differentiating our welfare results from those derived by Turnovsky and Fisher (1995). In our open economy framework, unlike in Turnovsky and Fisher (1995), domestic residents can also increase short-run consumption, and therefore welfare, by running a current account deficit.

The above discussion implies that our welfare results are more in line with the endogenous growth model presented by Barro (1990) – in which an increase in the share of productive capital in total government spending is welfare-enhancing at all horizons – than with the neoclassical framework used by Turnovsky and Fisher (1995).

The open-economy dimension also allows us – unlike Barro (1990) and Turnovsky and Fisher (1995) – to study the impact of a shift in domestic government spending composition on the current account, the exchange rate, and

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<sup>2</sup> The NOEM literature originated with the seminal paper of Obstfeld and Rogoff (1995, 1996). Subsequent important contributions include, but are not limited to, Betts and Devereux (2000, 2001), Corsetti and Pesenti (2001), Devereux and Engel (2002), Obstfeld and Rogoff (2000, 2002), Hau (2000), Tille (2001), Benigno and Benigno (2003), Bergin (2003), Kollman (2002), Sutherland (1996, 2005), Pierdzioch (2004), and Ghironi (2006). Surveys of this literature are provided by Lane (2001), Sarno (2001), and Corsetti (2007). Coutinho (2005) focuses on the fiscal NOEM literature.

on foreign variables. This analysis of how public infrastructures in one country affect another country is important from both the theoretical and empirical point of view. Clarida and Findlay (1994), for example, in a theoretical study of European integration, stress how countries engage in strategic behavior by taking into account, in their decision on public infrastructure investment, the level of public capital in neighboring countries. Empirically, important spillover effects are found to be generated by public highway spending between USA states (Pereira and Andraz, 2004) and by total public capital spending between the USA and Canada (Owyong and Thangavelu, 2001).

More in general, we see our paper as furthering the theoretical analysis of fiscal policy. This is important because while policy makers in several countries are showing a renewed interest in the fiscal instrument and an increasing number of academic and policy studies are focusing on fiscal issues, the analysis of the macroeconomic and welfare impact of fiscal policy still receives limited attention compared with that of monetary policy. In addition, as stressed by Alesina and Perotti (1995), the academic debate on fiscal policy tends to neglect composition issues. Fiscal policy is therefore usually modeled with reference to a general aggregate, often identified exclusively in terms of government consumption of goods and services.<sup>3</sup> This implies that additional work taking into account the complexity of fiscal policy and the multi-dimensionality of governments' fiscal activities can be particularly useful. The spirit of this paper is that of contributing to foster the debate in this area.

Our analysis shows that a permanent increase in domestic public infrastructure financed by a reduction in public consumption is welfare enhancing for domestic residents, provided that the productivity of public capital is not too low and the weight of public consumption (compared to private consumption) in private utility not too high. However, since a negative net welfare impact cannot be ruled out, one policy implication is that governments should take into account household preferences with respect to public provision of goods and services in deciding the composition of public spending.

The implementation of such a policy, moreover, has important international implications. In particular, the impact on foreign utility is negative in the short run, because foreign residents have to meet an increased global demand within a relatively underdeveloped (compared to domestic) public infrastructure system, while they only reap the benefits of the increased global demand in the long run. Foreign long-run welfare gains, however, more than offset the short-term losses. One implication of this analysis is that, if foreign authorities care not only about the present discounted value of foreign utility, but also about welfare dynamics, the domestic policy change can generate incentives for reallocation of public

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<sup>3</sup> Noteworthy exceptions, besides the papers already mentioned above, are Roche (1996), Finn (1998), Lane and Perotti (2003), and van der Ploeg (2006).

spending abroad. In this case, as the foreign country tries to avoid short-run welfare losses, it has an incentive to also increase the level of its productive public capital. A domestic policy shift can therefore result in a virtuous global technological cycle.

If the domestic shift in public spending composition is temporary, overall domestic welfare is reduced for low levels of the productivity of public capital, but is increased for high levels. This implies that governments which value the welfare of their citizens should carefully evaluate the impact of planned infrastructure projects on the productivity of the private sector before changing the public spending mix, especially in cases in which the projected increase in productive capital stock is likely to be temporary (due, for example, to uncertainty about securing the necessary fiscal resources to maintain it in the medium and long run).

The rest of the paper is organized as follows. Section 2 introduces the model. Section 3 discusses the parameterization. Sections 4 and 5 present and discuss the results for the case of a permanent and of a temporary shift in public spending composition, respectively. Section 6 concludes.

## 2 The model

The model is a standard NOEM model, similar to those developed by Obstfeld and Rogoff (1995) and Betts and Devereux (2000). Our main modelling innovations, which are crucial for the issues we want to investigate, are the introduction of productive public capital and of utility-enhancing public consumption. We also assume that nominal rigidities take the form of staggered price setting as in Calvo (1983), rather than one-period fixed prices.<sup>4</sup>

The model contains two countries. Firms and households are indexed by  $z \in [0,1]$ . A fraction  $n$  of households and firms are located in the domestic country, while  $1-n$  are located in the foreign country. In the description of the model that follows, unless equations for the foreign country are explicitly discussed they can be assumed to be symmetric to the equations for the domestic country.

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<sup>4</sup> We restrict our attention to the case of Producer Currency Pricing (PCP), in order to focus on the international impact of government spending composition, rather than on deviations from the Purchasing Power Parity.

## 2.1 Households

Domestic households gain utility from private and public consumption and real balances. They also experience disutility from supplying labor. The domestic utility function is therefore given by

$$U_t = \sum_{s=t}^{\infty} \beta^{s-t} \left[ \log C_s + \frac{\chi}{1-\varepsilon} \left( \frac{M_s}{P_s} \right)^{1-\varepsilon} - \frac{l_s(z)^2}{2} + \phi \log G_s^C \right] \quad (2.1)$$

where  $0 < \beta < 1$  is the discount factor,  $C$  is a composite good representing private consumption and  $P_s$  is the price index associated with it.  $G_s^C$  represents public consumption.  $M_s$  denotes nominal money balances and  $l_s(z)$  the household's supply of labor;  $\varepsilon > 0$  is the inverse of the consumption elasticity of money demand, and  $\chi$  and  $\phi$  are positive parameters.

The composite private consumption good is defined in the following equation as an aggregate across the individual goods produced by firms

$$C_t = \left[ \int_0^1 c_t(z)^{\frac{\theta-1}{\theta}} dz \right]^{\frac{\theta}{\theta-1}} \quad (2.2)$$

where  $\theta$  is the elasticity of substitution between any pair of individual goods. The associated price index is

$$P_t = \left[ \int_0^n p_t(z)^{1-\theta} dz + \int_n^1 (E_t p_t^*(z))^{1-\theta} dz \right]^{\frac{1}{1-\theta}} \quad (2.3)$$

where  $p_t(z)$  is the price of good  $z$  expressed in domestic currency,  $p_t^*(z)$  is the foreign currency price of foreign good  $z$  and  $E$  is the exchange rate, defined as the price of the foreign currency in terms of the domestic currency.

The budget constraint of the domestic representative household is given by

$$M_t + \delta_t D_t = D_{t-1} + M_{t-1} + w_t l_t(z) - P_t C_t + \pi_t - P_t \tau_t \quad (2.4)$$

where  $D$  denotes the household's holding of domestic currency denominated nominal bonds, which account for international shifts in wealth,  $\delta$  is the price of a bond (the inverse of one plus the nominal interest rate),  $w_t$  is the nominal wage paid to the household in a competitive labor market,  $\pi$  is the household's share of profits received by firms and  $\tau$  denotes real lump-sum taxes paid to the

government. Given that bonds are denominated in domestic currency, the budget constraint of the foreign representative household is

$$M_t^* + \delta_t \frac{D_t^*}{E_t} = \frac{D_{t-1}^*}{E_t} + M_{t-1}^* + w_t^* l_t^*(z) - P_t^* C_t^* + \pi_t^* - P_t^* \tau_t^* \quad (2.5)$$

where foreign variables are denoted by asterisks.

The first order conditions are given by

$$\delta_t P_{t+1} C_{t+1} = \beta P_t C_t \quad (2.6)$$

$$\delta_t P_{t+1}^* C_{t+1}^* E_{t+1} = \beta P_t^* C_t^* E_t \quad (2.7)$$

$$l_t = \frac{w_t}{C_t P_t} \quad (2.8)$$

$$l_t^* = \frac{w_t^*}{C_t^* P_t^*} \quad (2.9)$$

$$\frac{M_t}{P_t} = \left( \frac{\chi C_t}{1 - \delta_t} \right)^{\frac{1}{\varepsilon}} \quad (2.10)$$

$$\frac{M_t^*}{P_t^*} = \left( \frac{\chi C_t^*}{1 - \frac{\delta_t E_{t+1}}{E_t}} \right)^{\frac{1}{\varepsilon}} \quad (2.11)$$

Equations (2.6) and (2.7) are the Euler equations for optimal domestic and foreign consumption, respectively. Equations (2.8) and (2.9) are the domestic and foreign optimal labor supply equations, which equate the disutility of supplying an extra unit of labor with the marginal utility of the extra private consumption that can be bought due to the marginal increase in labor supply. Finally, equations (2.10) and (2.11) show that households' optimal money demand is an increasing function of private consumption and a decreasing function of the interest rate.

## 2.2 The government

The consolidated budget constraint of the monetary and fiscal authorities, expressed in per-capita terms, is given by

$$G_t = \tau_t + \frac{M_t - M_{t-1}}{P_t} \quad (2.12)$$

where total government spending  $G_t$  is distributed between public consumption  $G_t^C$  and public capital  $G_t^I$ , according to the formula  $G_t = G_t^C + G_t^I$ . In the experiments that we carry out in this paper, only the composition of (domestic) government spending changes. Total government spending, taxes and the money supply (as well as foreign composition of government spending) are kept constant throughout our exercises.

Government consumption takes the same form as the private sector's consumption index and it is thus given by

$$G_t^C = \left[ \int_0^1 g_t^C(z)^{\frac{\theta-1}{\theta}} dz \right]^{\frac{\theta}{\theta-1}} \quad (2.13)$$

An analogous index governs public capital spending. Government spending on public capital and consumption are assumed to follow a first-order autoregressive process described by the following equations

$$\hat{G}_t^I = \rho \hat{G}_{t-1}^I + \sigma_t^I \quad (2.14)$$

$$\hat{G}_t^C = \rho \hat{G}_{t-1}^C + \sigma_t^C \quad (2.15)$$

where  $\rho$  governs the persistence of a fiscal shock,  $\sigma^I$  and  $\sigma^C$  are unpredictable shifts in the components of government spending and the hat notation represents percentage deviations from the initial steady state.



## 2.3 Private firms

### Technology

Each firm produces a differentiated good. The production function of a representative domestic firm  $z$  is

$$y_t(z) = l_t(z)(K_t^G)^\alpha \quad (2.16)$$

where  $y_t(z)$  is the output of firm  $z$ ,  $l_t(z)$  is the labor input used by firm  $z$ ,  $\alpha > 0$  measures the productivity of public capital and  $K^G$  is the stock of public capital provided by government spending, which evolves according to

$$K_{t+1}^G = (1 - \lambda)K_t^G + G_t^I \quad (2.17)$$

where  $\lambda$  is the depreciation rate.

One obvious shortcoming of our model is the absence of private capital. This is a limitation shared with large part of the NOEM literature, which usually assumes that labor is the only factor of production. The papers – discussed in the Introduction – which focus on the impact of productive public spending in a closed economy usually assume that private capital also enters the production function. Since our framework complicates the modeling strategy by introducing the open economy dimension, we abstract from private capital so as to avoid overly complicating the model.

If public and private capital are complements in production – as it is likely to be the case for most categories of productive public investment (for example, roads and airports) – increasing the stock of public capital would also increase the marginal productivity of private capital. In this case the introduction of private capital in our model would produce results qualitatively similar to the ones we derive here. From the quantitative point of view, the impact of raising the share of productive public spending would be magnified. We therefore believe that excluding private capital does not – in our model – fundamentally alter the implications of shifting public spending towards the kind of large infrastructure projects that we have in mind in motivating this paper.

### Profits

Domestic firms minimize their costs  $w_t l_t(z)$  subject to (2.16). The nominal marginal cost is given by

$$MC_t(z) = \frac{W_t}{(K_t^G)^\alpha} \quad (2.18)$$

The profits of domestic firms are given by

$$\pi_t(z) = p_t(z)y_t(z) - w_t l_t(z) \quad (2.19)$$

Equations (2.19) and (2.12) can be substituted into the households' budget constraint equation (2.4) to derive the consolidated budget constraint of the domestic economy

$$\delta_t D_t = D_{t-1} + p_t(z)y_t(z) - P_t C_t - P_t G_t \quad (2.20)$$

Making use of the global asset-market-clearing condition  $nD_t + (1-n)D_t^* = 0$ , the consolidated budget constraint of the foreign economy can be derived in an analogous way as

$$-\frac{n}{1-n} \delta_t \frac{D_t}{E_t} = -\frac{n}{1-n} \frac{D_{t-1}}{E_t} + p_t^*(z)y_t^*(z) - P_t^* C_t^* - P_t^* G_t^* \quad (2.21)$$

The fact that the law of one price holds in each country and domestic and foreign households consume identical consumption baskets implies the following demand curve for each differentiated good  $z$

$$y_t(z) = \left( \frac{p_t(z)}{P_t} \right)^{-\theta} (C_t^W + G_t^W) \quad (2.22)$$

where  $C_t^W$  is world private consumption demand, given by

$$C_t^W = nC_t + (1-n)C_t^* \quad (2.23)$$

and world total government spending  $C_t^W$  is defined in an analogous way.

## Price setting

In the absence of nominal rigidities, each home firm would maximize its profits using  $p(z)$  as the choice variable. This would imply

$$p_t(z) = \frac{\theta}{\theta-1} MC_t(z) \quad (2.24)$$

Following Calvo (1983), we introduce nominal rigidities by assuming that each firm resets its prices with a probability  $1-\gamma$  in each period, independently of other firms and independently of the time elapsed since the last adjustment. Each firm has to take into account, when setting its profit-maximizing price, that in every subsequent period there is a probability  $0 < \gamma < 1$  that it will not be able to revise its price setting decision. When setting a new price in period  $t$ , each firm seeks to maximize the present value of profits weighting future profits by the probability that the price will still be effective in that period. Thus the representative home firm seeks to maximize

$$\max_{p_t(z)} V_t(z) = \sum_{s=t}^{\infty} \gamma^{s-t} \zeta_{t,s} \pi_s(z) \quad (2.25)$$

where  $\zeta_{t,s}$  is the domestic discount factor between period  $t$  and period  $s$ , defined as  $\zeta_{t,s} = \prod_{j=s}^t (1+i_j)^{-1}$  where  $i$  denotes the nominal interest rate. The result is that the pricing rule for home good  $z$  is given by

$$p_t(z) = \left( \frac{\theta}{\theta-1} \right) \frac{\sum_{s=t}^{\infty} \gamma^{s-t} \zeta_{t,s} (C_s^W + G_s^W) \left( \frac{1}{P_s} \right)^{-\theta} MC_s(z)}{\sum_{s=t}^{\infty} \gamma^{s-t} \zeta_{t,s} (C_s^W + G_s^W) \left( \frac{1}{P_s} \right)^{-\theta}} \quad (2.26)$$

All firms in a country are symmetric and every firm that changes its price in any given period chooses the same price and output consistently with (2.26). The structure of price setting implies that each period a fraction of  $1-\gamma$  of firms sets a new price and the remaining fraction keeps their price unchanged.

## 2.4 The initial steady state

The model is log-linearized around a symmetric steady state where all exogenous variables are constant. In addition, initial net foreign assets and government capital spending are both zero.

In existing NOEM models total government spending is usually assumed to be zero at the initial steady state. We depart from this practice by assuming that government consumption is positive and equal in both countries at the initial steady state. This allows us to carry out policy exercises in which a reduction in public consumption is used to finance an increase in public capital. We also assume that the initial level of private consumption is equal in both countries.

Our assumptions imply that the optimal labor supply (2.8), the pricing rule (2.24), the production function (2.16)<sup>5</sup> and their foreign equivalent equations can be combined to yield the following relationships between steady-state output, labor supply, and consumption

$$y_0 = l_0 = \left( \frac{\theta - 1}{\theta C_0} \right) \quad (2.27)$$

$$y_0^* = l_0^* = \left( \frac{\theta - 1}{\theta C_0^*} \right) \quad (2.28)$$

where 0 subscripts denote the initial steady state.<sup>6</sup>

## 3 Parameterization

We simulate our model for a benchmark parameterization and we check the sensitivity of our results by also considering alternative values for the productivity of public capital and the weight of public consumption in private utility.

In the benchmark parameterization, the elasticity of substitution between differentiated goods  $\theta$  is set equal to 6, implying a 20 per cent mark-up of prices over marginal costs in the steady state. The subjective discount factor  $\beta$  is set at  $1/1.05$ , which implies a 5 per cent annual real interest rate. The price stickiness parameter  $\gamma$  is assumed to be equal to 0.5, implying an average delay between

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<sup>5</sup> Assume that the production function in the initial steady state is  $y_i(z) = l_i(z)$ .

<sup>6</sup> The derivation of equations (2.27)–(2.28) and (4.1)–(4.2) is also based on the fact that initial output is equal to the sum of initial private and public consumption in each country. This is a consequence of the assumption of zero initial net foreign assets holdings.

price adjustments of two years.<sup>7</sup> As it can be seen by looking at equation (2.10) and its foreign equivalent, the parameter  $\varepsilon$  determines both the consumption and interest elasticity of money demand. We set  $\varepsilon$  equal to 9, which implies a consumption elasticity of money demand of  $1/9$  and an interest rate elasticity of money demand of  $-1/9$ .<sup>8</sup> The two countries are assumed to be of equal size, ie  $n = 0.5$ . The ratio of initial total government spending (ie initial public consumption to output) is set to 0.2.

In the benchmark simulations presented below, we assume that the utility provided by public consumption is low compared to that provided by private consumption. We therefore set  $\phi = 0.4$ . We also need to specify values for the productivity and depreciation rate of public capital parameters,  $\alpha$  and  $\lambda$ . The latter is assumed to be 0.10 (as in Baxter and King, 1993, and Rioja, 2003). The existing literature is far from conclusive on what a plausible value for  $\alpha$  could be. Glomm and Ravikumar (1997) surveys paper which have attempted to estimate the productivity of public capital. Results vary from a statistically insignificant  $\alpha$  (Hulten and Schwab, 1991) to 0.39 (Aschauer, 1989). Although Aschauer's upper bound is widely cited, most studies criticize it as too high and find estimates which are positive but much smaller. We therefore consider two values of  $\alpha$  in our experiments,  $\alpha = 0.05$  (as in Baxter and King, 1993) and  $\alpha = 0.1$  (as in Rioja, 2003).

In what follows we consider the domestic and international impact of both permanent and temporary shocks to government spending composition in the domestic country. In the case of permanent shocks the persistency parameter  $\rho$  is set to 1 in equations (2.14) and (2.15). In the case of temporary shocks, we set this parameter to 0.8. We simulate the model using the algorithm developed by Klein (2000) and McCallum (2001).

## 4 A permanent shift in government spending composition

In this section we consider a permanent one percentage increase in home government infrastructure investment relative to initial output and a simultaneous one percentage decrease in home government consumption relative to initial output. Total government spending is therefore constant both at home and in the foreign country. The composition of foreign public spending is unchanged compared to the initial steady state. We evaluate the impact of such a policy on

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<sup>7</sup> Carlton (1986) suggests that that in various industries is not unusual for prices to remain unchanged for several years.

<sup>8</sup> Our parameterization is mostly consistent with Sutherland (1996).

the main domestic and foreign macroeconomic variables as well as on domestic and foreign welfare.

The results for this case are presented in Figure 4.1. The vertical axes show percentage deviations from the initial steady state. For variables whose initial steady state value is zero, the percentage deviations are expressed in relation to initial output.

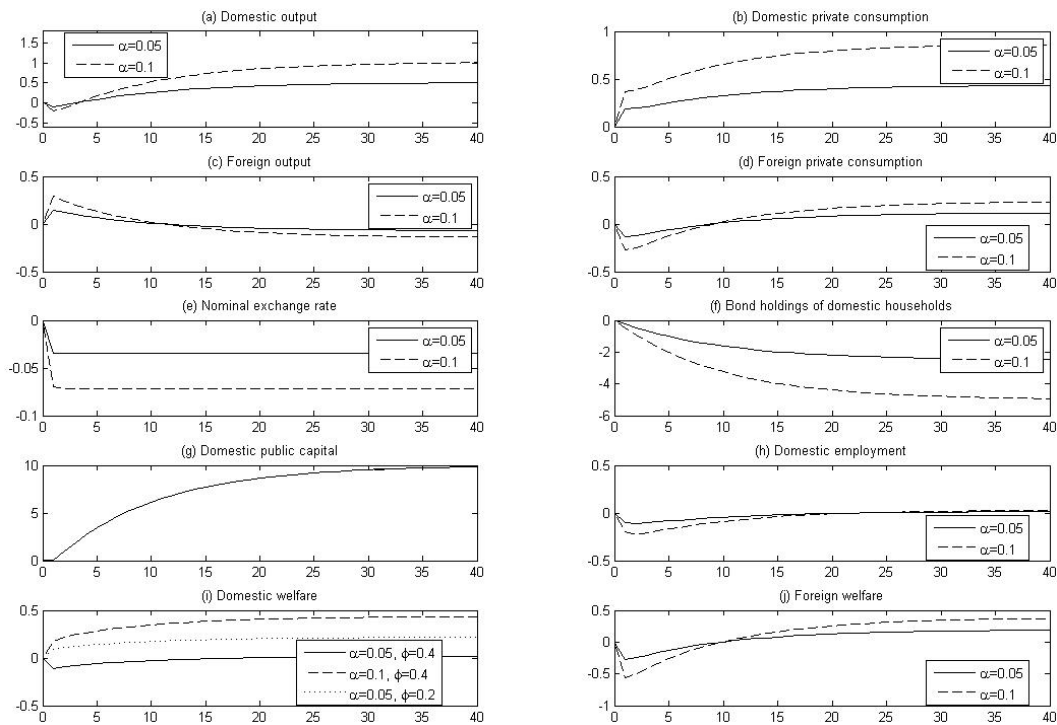
## 4.1 The impact on the domestic economy

Figure 4.1 shows that a shift in the composition of public spending towards public capital generates a boom in the domestic economy, by increasing domestic output. This is consistent with the findings of other papers which have investigated the impact of an increase in public capital in closed economies (for example, Baxter and King, 1993). The basic intuition for this result is that an increase in public capital leads to an expansion of production possibilities, thus implying an increase in domestic output.

Since the accumulation of public capital is gradual, the increase in domestic output is equally gradual, with an almost insignificant impact in the short run. However, since domestic households anticipate the medium and long-run increase in output, they increase private consumption immediately in order to smooth consumption intertemporally. This implies that the domestic economy must run a current account deficit in the short run to be able to consume more than it is producing in anticipation of future productivity gains. Consequently, in order to service the accumulated external debt domestic output has to increase more than consumption in the long run.

Figure 4.1

### The effects of a permanent shift in government spending composition



A *prima facie* interpretation of these results could lead to the conclusion that a domestic shift in the composition of public spending towards public infrastructure worsens the sustainability of the domestic economy by increasing its external debt. However, if we take the view that public capital increases a country's net worth (see, for example, Milesi-Ferretti and Moriyama, 2006), then the accumulation of external debt does not necessarily imply a worsening of total domestic net worth, since it is more than offset by the permanent increase in public capital.

Figure 4.1 also highlights the role of  $\alpha$ . A higher  $\alpha$  increases the productivity of public capital more, thus implying a further expansion of production possibilities, which results in higher domestic output. An increase in  $\alpha$  also increases the domestic marginal productivity of labor; this allows domestic firms to produce more output for a given labor input. Equations (2.18) and (2.24) imply that an increase in  $\alpha$  would reduce prices if these were perfectly flexible. However, due to the presence of nominal rigidities, prices cannot be reduced to fully match the increase in productivity. The fact that output increases while prices are only partially adjusted results in higher domestic profits in the short run. Since domestic firms are owned by domestic households, higher profits are re-distributed to them, partly translating into higher consumption for a higher level of  $\alpha$ .

Figure 4.1(h) also shows that a shift in the composition of spending has a non-monotonic impact on home employment, since it tends to reduce it in the short run, but raise it in the medium and long run. In addition, an increase in  $\alpha$  has a similar non-monotonic impact. This can be seen by comparing the results for  $\alpha = 0.05$  and  $\alpha = 0.1$  in Figure 4.1(h). A higher  $\alpha$  generates lower domestic employment in the short-run (the first ten periods after the shock) but higher domestic employment afterwards.

The results described above reflect various effects at work following an increase in the level and productivity of public capital. One obvious implication of higher and/or more productive public capital is that the same level of output can be produced with less labor effort. This ‘pure public capital productivity’ effect explains why domestic employment initially falls when the level of public capital is increased, and why it falls more if the productivity of public capital is higher.

However, higher and more productive public capital also implies that, on average, the prices of domestic goods are lower. This raises the real wage, thus generating incentives for higher domestic labor supply. In addition to this increase in the real wage, the domestic accumulation of current account deficit reduces domestic households’ net wealth, thus pushing them to increase their labor supply (ie to decrease their consumption of leisure). In the medium and long run, the wealth effect stemming from the current account deficit, together with the impact of the higher real wage, more than offset the pure public capital productivity effect. The interaction of these various effects thus explains the non-monotonic impact of both a shift towards public capital and of a higher  $\alpha$  on domestic labor supply. Intuitively, these results imply that the short-run impact of productive capital in the economy might result in a job-less expansion, due to the generalized increase in productivity, while in the medium and long run the benefits of expanding the production possibilities of the economy will manifest themselves not only on economic activity but also on employment.

## 4.2 The open economy impact

As we stressed in the Introduction, one advantage of the open economy set-up is that it enables us to assess the impact of shifts in public spending composition on the exchange rate and on foreign variables.

Figure 4.1(e) shows that an increase in productive capital in the domestic economy implies an appreciation of the domestic exchange rate (a fall of the price of the foreign currency expressed in terms of the domestic currency). The main mechanism at work is a ‘money demand’ effect arising through higher domestic consumption: as discussed in Section 4.1, domestic consumption increases, both in absolute terms and relative to foreign one, when the domestic government



shifts its spending composition towards productive capital. Since money demand is a positive function of consumption (see equations (2.10) and (2.11)), an increase in domestic consumption relative to foreign one increases domestic money demand compared to foreign one. An appreciation of the domestic currency is therefore required to reestablish equilibrium in the money market. The fact that domestic consumption increases more when  $\alpha$  is higher implies that the money demand effect is stronger in that case. This explains why the domestic currency appreciates even more when public capital is more productive.

Figure 4.1(c) also shows that foreign output increases in the short run and slightly declines in the long run following a shift in domestic public spending composition, while foreign private consumption displays an opposite response. The short-run increase in foreign output can be explained by both an ‘expenditure switching’ and an ‘expenditure boosting’ effect. The expenditure switching effect is due to the fact that an appreciation of the domestic currency makes foreign goods cheaper. This shifts some of the higher world demand away from domestic and towards foreign goods. However, since the effect on the exchange rate is small in our model, so is the expenditure switching effect.

What accounts for the bulk of the short-run increase in foreign output is therefore the expenditure boosting effect, due to higher aggregate demand in the world economy in the wake of an increase in production possibilities in the domestic economy. As we have seen, an immediate implication of the latter is a consumption boom in the domestic economy. Since household preferences do not display home bias, part of the higher domestic demand falls on foreign goods, thus explaining why foreign output increases on impact.

Since the stock of foreign public capital has not changed, foreign households have to meet the increased demand for their goods with the same pre-shock technology, ie the foreign equivalent of equation (2.16) with an unchanged level of public capital. This implies that foreign labor supply will need to increase. As the (foreign equivalent of) utility function (1) shows, the marginal disutility of supplying labor increases for higher levels of labor supply, while the marginal utility of private consumption is higher for lower consumption levels. This means that lower levels of private consumption (ie higher levels of marginal utility of consumption) need to correspond to higher levels of labor supply (ie to higher levels of marginal disutility of supplying labor). In this way, foreign agents seek to compensate the higher marginal disutility of providing an additional amount of labor with the marginal utility of the amount of private consumption that the increase in labor supply can buy.

In the long run, however, the accumulation of external assets by foreign households – the other side of the coin of the current account deficit run by the domestic country – implies an increase in both private consumption and leisure of foreign residents. In addition, a ‘terms-of-trade’ effect is at work in the long run. A rise in supply of domestic goods worsens the domestic terms of trade (ie the

price of domestic goods relative to foreign falls). This implies that foreign consumption is higher in the long run. Both the accumulation of external assets and the worsening in the domestic terms of trade have a positive effect on long-run foreign private consumption.

### 4.3 Welfare impact

In this section we focus on the welfare impact of a shift in the domestic composition of government spending. As we stressed in the Introduction, the trade-off between utility-enhancing public consumption and productivity-enhancing public capital is often a crucial aspect of the public debate and of policy discussions. In spite of this, we are not aware of any paper which explicitly focuses on this trade-off in the NOEM framework. The basic intuition behind this trade-off is that cutting spending for public consumption directly reduces households utility. However, if the cut in current spending is used to raise public capital, this shift can also have a positive indirect effect on households utility, namely through the impact of improved public infrastructure on other variables which affect private utility.

In our welfare analysis it is useful to look at a measure of accumulated welfare over the long-term planning horizon of the representative agent. In ‘first generation’ NOEM models such as the seminal Redux model (Obstfeld and Rogoff, 1995) prices are fixed for one period and economies reach the steady state in the following period. In such a framework, the welfare effect of a shock is the sum of the short-run change in utility and the discounted present value of the change in steady-state utility. Since we have staggered price setting, we calculate the present discounted value (PDV) of the change in utility, using a large number of periods to numerically approximate the long-term impact.

Formally, the change in domestic utility in period  $t$  is given by

$$dU_t = \hat{C}_t - l_0^2 \hat{l}_t + \phi \hat{G}_t^C \quad (4.1)$$

while an analogous expression holds for foreign utility.<sup>9</sup> The PDV value of the change in utility is therefore calculated as

$$dU_{DPV} = \sum_{s=t}^{\infty} \beta^{s-t} dU_s \quad (4.2)$$

with an equivalent expression holding for the foreign country.

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<sup>9</sup> As customary in this literature, we neglect the utility derived from real balances.

Figure 4.1(i) illustrates the response of domestic instantaneous utility ( $dU_t$ ) to changes in government spending composition for various combinations of the productivity of public capital ( $\alpha$ ) and the weight of public consumption in private utility ( $\phi$ ). Figure 4.1(i) shows that a shift in composition toward public capital is more likely to be welfare enhancing in every period for domestic households the higher is  $\alpha$  and the lower  $\phi$ . The intuition behind these results is straightforward. Since a decrease in public consumption directly lowers welfare, the direct utility loss of a shift in the composition of spending is lower if households attach a low weight to public consumption in their utility function. In addition, the loss due to lower public consumption can be compensated by the fact that higher public infrastructure allow households to consume more privately at every horizon. Furthermore, this effect is stronger for higher values of  $\alpha$  (Figure 4.1(b)). This effect is reinforced also because higher consumption can be achieved domestically without having to increase labor proportionally to the increase in consumption. On the contrary, labor effort can even be reduced in the short term (Figure 4.1(h)).

The welfare results presented in Figure 4.1(i) can be compared with those of previous papers. Turnovsky and Fisher (1995) look separately at public consumption and public investment expansions, rather than at a shift in composition for a given level of total government spending. They stress how in their model a permanent expansion in public investment requires agents to sacrifice more welfare initially (compared to a permanent expansion in public consumption) in exchange for increased steady-state welfare.<sup>10</sup> This implies that, in their model, an exercise like the one we consider would unambiguously reduce welfare on impact. This is due to the fact that an increase in public investment generates a higher level of transitional investment compared to an increase in public consumption. In Turnovsky and Fisher's neoclassical framework this can only be achieved by temporarily reducing the level of private consumption, thus short-run utility.

In our model, this trade-off between short term welfare losses and long-run welfare gains of a shift toward higher public investment can be eliminated for reasonable parameter values (when the weight of public consumption in private utility is not too high). This is a result of two fundamental differences between our modeling framework and the one used by Turnovsky and Fisher (1995). First, due to the to the presence of imperfect competition, the initial output and consumption steady state is sub-optimally low in our model. As a consequence, unlike in Turnovsky and Fisher (1995), in our framework the expansion of public capital need not happen at the expense of short-run resources available to the private sector. Second, the open economy dimension also implies that, in our model, domestic households can increase short-run consumption, and therefore welfare, by running a current account deficit. This effect is absent by definition in

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<sup>10</sup> See Turnovsky and Fisher (1995, p. 769).

Turnovsky and Fisher (1995): due to the closed-economy setting, in their framework domestic agents are not able to increase consumption in the short run by accumulating external debt.

The discussion above implies that, from the point of view of the short-run welfare effects, our new Keynesian framework is closer to the endogenous growth model presented by Barro (1990) than to Turnovsky and Fisher (1995). In Barro (1990) an increase in the share of productive government spending over total spending unambiguously raises the rate of growth of output and private savings at all horizons, with a positive impact on utility.

Table 4.1 **PDV of change in utility in the case of a permanent shift in government spending composition**

Parameterization	$dU_{DPV}$	$dU_{DPV}^*$
$\alpha = 0.05; \phi = 0.2$	3.7	0.65
$\alpha = 0.05; \phi = 0.4$	-0.45	0.65
$\alpha = 0.10; \phi = 0.4$	7.5	1.2

So far, the discussion has focused on short-run utility. Table 4.1 shows the PDV of welfare for the same parameterizations considered in Figure 4.1.<sup>11</sup> Overall, the results presented in Table 4.1 suggest that a shift toward public infrastructure is welfare enhancing domestically if the weight of public consumption (compared to private consumption) in private utility is low and/or the productivity of public capital is high. However, since a negative welfare impact cannot be ruled out when the weight of public consumption in private utility is relatively high (see the case  $\alpha = 0.05$  and  $\phi = 0.4$ ) the results also imply that governments should take into account households' preferences with respect to public provision of services in order to evaluate shifts in the composition of public spending. Similarly, given the importance of changes in  $\alpha$  for the welfare results, the impact of planned infrastructure projects on the productivity of the private sector should be evaluated as carefully as possible before changing the public spending mix.

Figure 4.1(j) presents the impact on foreign utility of a domestic shift in public spending composition. The international consequence of the shift in public spending decided by the home country is a reduction of foreign instantaneous utility in the short run. This negative international welfare spillover is reversed in the medium and long run, due to the changes in the paths of foreign private consumption and employment discussed in section 4.2. Table 4.1 illustrates that the overall effect on the PDV of foreign utility is positive because the positive

<sup>11</sup> For instance, if  $\alpha = 0.05$  and  $\phi = 0.2$ , a permanent shift in government spending increases the PDV of domestic utility by 3.7 per cent and the PDV of foreign utility by 0.65 per cent. The numerical values presented in Tables 4.1 and 5.1 are calculated using 200 periods.

medium and long run effects of the domestic policy shift more than offset the negative short-run impact. The main intuitive explanation for the increase in overall foreign welfare is related to the terms of trade effect: an increase in the supply of domestic goods induces an improvement in the terms of trade of the foreign country, resulting in a higher level of foreign consumption.

Figure 4.1(j) also shows that the negative short-run impact on foreign utility is stronger for higher values of  $\alpha$ . This has interesting implications for international policy coordination. In the short run, the more efficient is the reallocation of public spending decided by the domestic authorities (the higher  $\alpha$ ), the more the domestic policy change harms foreign residents. The intuitive explanation for this result is that having more efficient infrastructure generates a competitive advantage for the domestic economy compared to the foreign. The domestic expansion of productive possibilities also generates some positive international demand spillovers which partially benefit foreign residents. However, foreign residents have to meet the increased global demand within a relatively underdeveloped (compared to domestic) public infrastructure system. Figure 4.1(j) shows that the positive spillover impact of the domestic policy shift does not offset the domestic competitive advantage quickly enough to prevent foreign welfare from falling in the short run.

One implication of this analysis is that the domestic policy change and the associate short run welfare loss of the foreign country can generate incentives for reallocation of public spending also in the foreign country. Although the impact on the PDV of foreign utility is positive for reasonable parameter values (Table 4.1), if foreign authorities are worried about welfare dynamics (not only about the PDV of utility) they will still try to offset the negative short run effect of the domestic policy. In order to do so, they will have an incentive to also increase the level of foreign productive public capital in response to the domestic policy. In such circumstances, a domestic policy shift can therefore trigger a virtuous global technological cycle.

## 5 A temporary shift in government spending composition

In this section we assess the impact of a temporary shift in domestic government spending composition. In this policy experiment the persistency parameter  $\rho$  is set to 0.8 in equations (2.14) and (2.15). Figure 5.1 and Table 5.1 illustrate the results in this case.<sup>12</sup>

Table 5.1 **PDV of change in utility in the case of a temporary shift in government spending composition**

Parameterization	$dU_{DPV}$	$dU_{DPV}^*$
$\alpha = 0.05; \phi = 0.4$	-0.089	0.13
$\alpha = 0.10; \phi = 0.4$	1.5	0.27

As Figure 5.1(g) shows, depreciation of public capital implies that the stock of public infrastructure accumulated while public investment was temporarily higher is almost completely depleted about 40 periods after the shock. This dynamics implies that the increase in productivity of domestic firms is also only temporary. The temporary increase in productivity brings about a temporary rise in domestic output, which is, for obvious reasons, more pronounced for higher values of  $\alpha$  (Figure 5.1(a)). Domestic households also temporarily increase consumption following the temporary increase in productivity (Figure 5.1(b)). For consumption smoothing reasons analogous to those discussed in section 4.1, domestic households save part of the temporary higher income by running a current account surplus in the medium run. Figure 5.1(f) shows that domestic residents accumulate a permanently higher amount of bonds. One of the implications of a temporary increase in the stock of public infrastructure is therefore a permanent improvement in the net worth position of the domestic economy. Due to higher interest income, domestic private consumption is higher in the new steady state.

The short-run response of foreign output and consumption is similar to the one displayed in the case of permanent shifts in government spending composition, and can be explained with arguments analogous to the ones discussed in section 4.2. However, since the total expenditure boosting effect stemming from an increase in domestic productivity is smaller over the time horizon considered, the reaction of foreign variables is also quantitatively more limited in the case of temporary shifts.

<sup>12</sup> Figures 5.1 shows that, although the solution of the model is stable, it takes more than 40 periods to reach the new steady state.

The accumulation of a current account deficit implies that foreign residents reduce both their private consumption and their leisure (increase output) in the long run, due to reduced wealth. However, they intertemporally smooth this behavior, thus temporarily increasing their leisure and consumption in the medium term (Figure 5.1(c,d)). In addition, the more pronounced medium-run fall in foreign output in the case of a higher  $\alpha$  also reflects some market gains of domestic firms at the expense of foreign firms, since the nominal appreciation of the domestic currency (Figure 5.1(e)) is more than offset by the fact that domestic prices are likely to fall more than foreign prices in the medium run when  $\alpha$  is higher. This in turn is because a higher level of  $\alpha$  reduces domestic (but not foreign) marginal costs and therefore domestic (but not foreign) prices.

Figure 5.1 **The effects of a temporary shift in government spending composition**

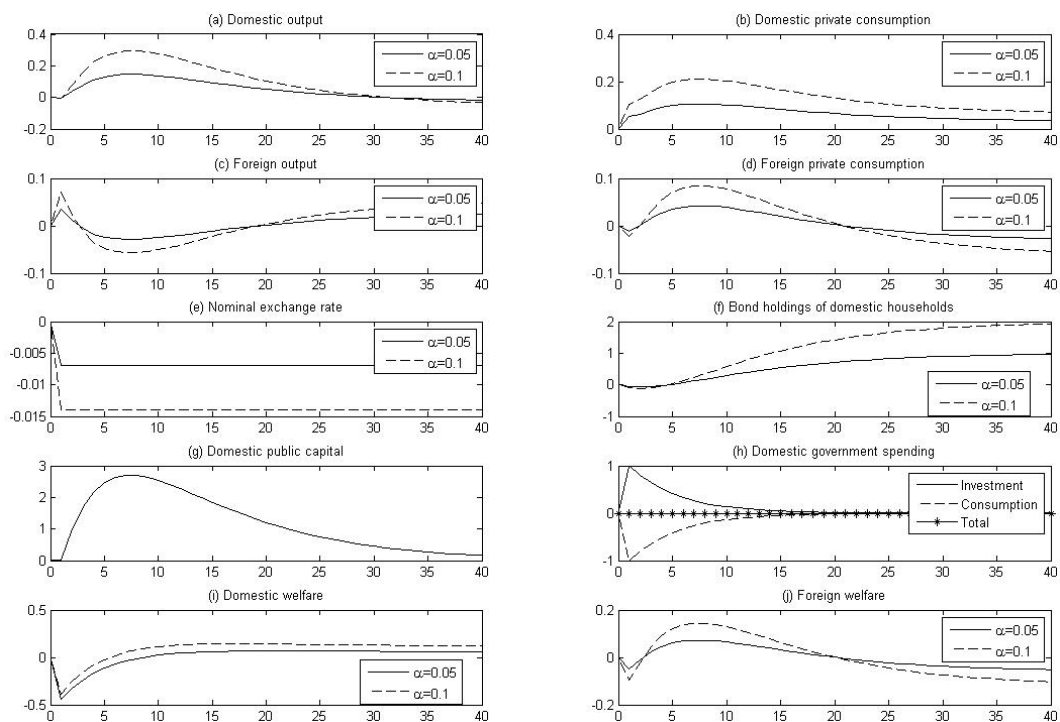


Figure 5.1(i) shows that, contrary to the case of a permanent shift, a temporary domestic policy shift can reduce domestic welfare in the short run even when  $\alpha$  is high (ie  $\alpha = 0.1$ ). This can intuitively be explained by the fact that the expansion of production possibilities is much more limited when the shift is only temporary. Domestic households therefore cannot expand private consumption as much as in the permanent case. The impact of the reduction of public consumption hence dominates domestic utility in the short run. In the long run,  $G_t^C$  returns to the initial level, thus neutralizing the negative welfare impact of the temporary

reduction in public consumption. However, domestic welfare increases in the long run (rather than just returning to the pre-shock level) because the higher wealth accumulated by domestic residents through running a current account surplus allows them to reduce their supply of labor while at the same time increasing private consumption. Table 5.1 shows that the PDV of domestic welfare is positive for a high level of  $\alpha$  ( $\alpha = 0.10$ ). In this case, the long run improvement in utility more than offsets the short run reduction in terms of PDV. On the other hand, if  $\alpha$  is low ( $\alpha = 0.05$ ), the PDV of domestic utility is negative.

In terms of foreign welfare, Figure 5.1(j) shows that the impact on utility is driven by foreign consumption and output movements, and is negative in the short and the long run but briefly positive in the medium run. The short-term welfare loss of foreign agents is more limited compared to domestic residents, because foreigners do not see their utility reduced by a cut in publicly provided consumption. This implies that, as shown in Table 5.1, the PDV of foreign utility is positive both for high and for low values of  $\alpha$ .

## 6 Conclusions

In this paper we focused, in the context of an open-economy model with imperfect competition and nominal rigidities, on the trade-offs faced by governments in deciding the allocation of public spending between productivity-enhancing public infrastructures and utility-enhancing public consumption.

Our analysis shows that shifts in the composition of public spending have important positive and welfare implications, both domestically and abroad. In particular, a temporary increase in the domestic stock of public capital financed by a reduction in public consumption reduces domestic welfare if the productivity of public capital is low. If the policy shift is permanent, domestic utility is increased if the productivity of government spending is not too low and the importance of public consumption (relative to private consumption) in private utility is not too high. However, since a negative welfare impact cannot be ruled out when the weight of public consumption in private utility is relatively high, one policy implication of our results is that governments should take into account households' preferences with respect to public provision of services in order to evaluate shifts in the composition of public spending. Similarly, given the importance of changes in  $\alpha$  for the welfare results, the impact of planned infrastructure projects on the productivity of the private sector should be evaluated as carefully as possible before changing the public spending mix. These concerns are valid in the cases of permanent as well as temporary shifts in the composition of public spending, since in both cases the PDV of domestic welfare can be negative for reasonable parameterizations.



With regards to the effect on foreign welfare, a domestic shift in government spending implies a reduction of short-term foreign utility, while the PDV of foreign welfare is positive, as the benefits of the global expansion in demand are reaped in the medium-long run by the foreign country. If foreign authorities are worried not only about the PDV of utility, but also about welfare dynamics, they will still try to offset the negative short-run welfare effect of the domestic policy. In this case, they will have an incentive to increase the level of foreign productive public capital. In such a situation a domestic policy shift can therefore trigger a virtuous global technological cycle.

Some of our results might obviously be sensitive to the specification of our model. In particular, we assume that public and private consumption enter private utility in a non-separable way. This means that the decrease in utility-enhancing public consumption necessary to finance the increase in productive public infrastructure does not affect the marginal utility of private consumption. Non-separability between private and public consumption could of course be an interesting case to consider in future research. How our results would be affected by the introduction of non-separability would depend on whether public and private consumption are substitute or complements. Another interesting extension of the model would be the introduction of asymmetry between the domestic and foreign countries. This could be achieved, for example, by introducing home bias in private and public consumption.

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