Fiscal Shocks in a Small Open Economy

Francesco Furlanetto
DEEP, University of Lausanne

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Abstract

This paper extends the model of Gali and Monacelli (2005) to study the impact of a government spending shock in a small open economy with staggered prices and monopolistic competition. The model is consistent with the available empirical evidence (Perotti (2004)) and confirms the main results of the Mundell-Flemming-Dornbush (MFD) tradition: 1) the effect of a fiscal shock on output is low and decreasing in the degree of openness 2) the model predicts a real appreciation of the exchange rate (in contrast to other New Open Economy Models (NOEM)) 3) the impact of a fiscal shock is higher under fixed exchange rates. However, we identify a "consumption multiplier puzzle": the model cannot reproduce a consumption multiplier that is positive and decreasing in the degree of openness as it is observed in the data. The results of the baseline model are robust to several extensions allowing for incomplete pass-through, useful government spending and productive government spending.

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1 Introduction

This paper compares the available empirical evidence with the implications of a government spending shock in a small open economy New Keynesian model (Gali and Monacelli (2005)) that we extend to include a public sector.

This approach is motivated by the need of evaluating models not only on their ability to replicate the empirical moments but also on their ability to replicate reasonable responses to different exogenous shocks. Many papers have adopted this motivation to study the effects of monetary and productivity shocks in dynamic stochastic general equilibrium models (DSGE) (Gali (1999 and 2003)) among others). The same work has not been done for fiscal

shocks because of the lack of a reliable empirical evidence. The recent availability of some econometric evidence and the extension to the open economy of New Keynesian models allow us to do this exercise also for fiscal shocks in open economies. We think that the New Keynesian framework is the most suitable to satisfy our goal because it integrates some realistic features (such as sticky prices, endogenous monetary policy and departures from PPP) in the workhorse model in open economy macroeconomics developed by Obstfeld and Rogoff (1995 and 1996).

The empirical literature on the effects of fiscal policy[1]has grown only in the recent years and is based on Vector Autoregressions (VAR), an econometric tool that previously has been widely used in the empirical research on monetary policy. However, the papers cited above deal almost exclusively with the United States with no attention to open economy variables[2]. Some recent papers (Perotti (2004), Corsetti and Müller (2005) and Giuliodori and Beetsma (2004)) bridged the gap and started to investigate in depth the implications of a fiscal shock in small open economies and some stylized facts are now available. We can summarize this evidence as follows:

1) The output multiplier is low and declining in the degree of openness.

2) The consumption multiplier is also declining in the degree of openness (it is positive in the United States and it is negative but not significant in more open economies).

3) The interest rate response is positive.

4) The trade balance responds in a negative way.

The recent theoretical literature on open economy macroeconomics (NOEM) is based on the Redux model of Obstfeld and Rogoff (1995). This model has been studied in depth and is considered as the successor of the Mundell-Flemming-Dornbush (MFD) model for policy analysis. However, many papers have investigated in detail monetary policy issues in this framework but, as noted by Ganelli and Lane (2002) in their survey, only a limited number of contributions deals with fiscal policy[3]. We consider that this framework is not suitable for a comparison with stylized facts essentially for

[1]Fatas and Mihov (2002), Gali, Valles and Lopez-Salido (2005), Blanchard and Perotti (2002), Burnside, Eichenbaum and Fisher (2000), Mountford and Uhlig (2002), Muller (2006) among others.

[2]Two exceptions are Muller (2006) and Kim and Roubini (2003): they provide results for open economy variables in the American case. They found results that are very specific to the American case: in their VAR an increase in government spending causes a trade surplus and a depreciation of the exchange rate.

[3]An analysis of fiscal shocks is provided in Obstfeld and Rogoff (1996), Ganelli (2002), Ganelli (2003), Tille (2001), Bacchetta and Van Wincoop (2000), Corsetti and Pesenti (2001) among others.

two reasons: a general lack of dynamics in the model (due essentially to the assumptions of prices fixed one period in advance and Purchasing Power Parity (PPP)) and the assumption of exogenous monetary policy. And in fact the NOEM literature concentrates on normative issues, such as spillover effects on welfare, and almost ignores positive implications.

The model of Gali and Monacelli (2005) modifies the assumptions above and in our opinion is better suited for a comparison with the available empirical evidence.

The assumption of prices fixed one period in advance is a simple device to induce monetary non-neutralities in the short run and to allow an analytical solution in the Redux model. However, this assumption limits the analysis either to temporary shocks, that last for only one period, or to permanent shocks that imply a jump to a new steady state from the second period on. This is in contrast with our goal of comparing empirical evidence and model's implications because government spending shocks exhibit a considerable amount of persistence without, however, being permanent. Introducing price rigidities in the form popularized by Calvo (1983), as is done by Gali and Monacelli (2005), allows us to study the effects of a persistent shock in a framework that is consistent with the impulse response functions derived in the VAR evidence.[4]

The assumption of PPP also limits considerably the dynamic effects in the Obstfeld-Rogoff model: in their framework PPP implies that the real exchange rate is constant and that the real interest rate is constant and equal across countries; moreover UIP does not hold and only permanent fiscal shocks have an effect on the interest rate. The assumption of PPP has already been relaxed in other NOEM papers[5]. However, as far as we know, this has been done in the context of a two-country model In this paper we perform a small open economy analysis and we introduce deviations from PPP in the form of home bias in consumption. This implies that consumers in our small open economy have a preference for domestically produced goods. This behavior is almost a natural choice in a small open economy framework: otherwise, in case of identical preferences across countries, given that the share of the domestic good in the foreign countries consumption basket is irrelevant, the domestic country should consume only foreign goods and export all the production of the domestic good. Deviations from PPP, together with Uncovered Interest Parity (UIP), allow rich dynamics in the

[4]In our version of the Gali and Monacelli model we preserve the benefit of an analytical solution if a domestic inflation targeting (DIT) regime is in place.

[5]Pitterle and Steffen (2004), Bacchetta and Van Wincoop (2000) among others.

real and nominal exchange rate response to shock.

The assumption of exogenous monetary policy prevents interesting interactions between monetary and fiscal policy and is not consistent with the recent literature on optimal monetary policy in small-scale monetary models of the business cycle. This literature, surveyed in Woodford (2003), shows that the optimal monetary policy is given by an interest rate rule implying an endogenous reaction by the monetary authority to the shocks hitting the economy. The optimal rule can be complex but a simple rule, like the one proposed by Taylor, provides a good approximation in terms of welfare of the representative agent. However, the approximation can be very bad using other rules like a constant money growth or an interest rate peg. And this is the case also in our model where the optimal monetary policy is given by a domestic inflation targeting (DIT) regime[6]: a Taylor rule does a good job in approximating the DIT policy whereas an interest rate peg (a fixed exchange rate regime) or a constant money growth rate are largely suboptimal. All the papers cited above, in the Obstfeld-Rogoff framework, assume exogenous monetary policy; in this paper we show that the assumption of endogenous monetary policy reaction implies a very different response of the economy to a government spending shock[7].

In this paper we argue that the model of Gali and Monacelli provides results more in line with the empirical evidence and allows a richer analysis of fiscal shocks consequences essentially because the three assumptions cited above are relaxed.

We highlight four main results from our analysis:

1) The impact of a fiscal shock on output is very limited and decreasing in the degree of openness. The output multiplier is largely below one and is higher under fixed exchange rates (as in the MFD model).

2) Monetary policy endogenously reacts to a fiscal shock and this reaction produces an increase in the nominal interest rate (as in the MFD model).

3) The increase in the nominal interest rate is accompanied by an appreciation of the nominal and real exchange rate through UIP (as in the MFD

[6]In fact this is true only for a specific parametric configuration (see Benigno and Benigno (2003)).

[7]In the NOEM framework the effects of a fiscal shock are tightly linked to the form of the money demand function. Results differ if money is introduced in the utility function (MIU, as in the articles of Obstfeld-Rogoff (1995), Ganelli (2002) among others) or through a cash in advance constraint (CIA) as in Pitterle and Steffen (2004)). In the first case a fiscal shock implies a depreciation of the domestic currency, in the second an appreciation. In our framework with an endogenous interest rate rule the model predicts unambiguosly an appreciation and there is no need to model the money demand function (cashless-limit à la Woodford).

model). This implies a decline in net exports.

4) The appreciation implies that the negative effect on consumption is lower in an open economy than in a closed economy.

Results one to three are consistent with the empirical evidence provided in section 2 and are more in line with the Mundell-Flemming-Dornbush tradition and in contrast with other NOEM models listed above. The fourth result is not in line with the empirical evidence and represents a puzzle that will be discussed in the remaining sections.

We underline the fact that even if the structure of the model is quite rich, we made many simplifying assumptions: there is no investment, taxation is lump-sum, consumers behaves in a fully Ricardian way and thus there is no role for government debt policies.

The rest of the paper is organized as follows: in section 2 we provide a review of the related literature and we resume the available stylized facts, in section 3 we present the model, in section 4 we look at equilibrium dynamics, in section 5 we describe the positive implications of a fiscal shock. In section 6 we extend the model allowing for complementarity (or substitutability) between private consumption and public spending in the utility function, for productive government spending and for incomplete pass-through: these extensions improve the model along some dimensions but the general message of the baseline model is not affected. Finally, section 7 concludes.

2 Literature and stylized facts

Before reviewing briefly the literature on the field, two considerations have to be made: the first is that all the papers cited lay out a two country model analysis. In our paper, instead, we consider a small open economy that trades with the rest of the world (formed by an infinity of small open economies) without affecting world-wide variables. The second is that what we call fiscal shock in this paper is an increase in government spending. In the model it does not matter if this increase if financed through an increase in taxation or through an increase in public deficit. In both cases agents cut current consumption because they correctly anticipate the increase in the discounted value of future taxes. In other words agents integrate in their optimization choice that the government budget constraint has to be satisfied and Ricardian equivalence holds. This is standard in the NOEM literature and few attempts have been made to overcome this strong assumptions[8].

[8]See Gali, Lopez-Salido and Valles (2005) for a closed economy analysis and Ganelli (2005) for an open economy model with a role por government debt policies.

The Mundell-Flemming-Dornbush (MFD) model has been the reference in the field for many years. It provides at least two important conclusions on this topic: a fiscal shock has a positive effect on output and consumption (but this effect is larger under fixed exchange rates) and implies an appreciation of the domestic currency

The Redux model of Obstfeld and Rogoff (1995) is explicitly micro-founded and thus is well suited to conduct welfare analysis. The key frictions are monopolistic competition, prices fixed one period in advance and incomplete markets (only one-period bonds are available). There is no home-bias in government spending and thus the public authority consumes the same consumption bundle (including foreign goods) as the domestic representative agent. This implies that the tax-bill of a fiscal expansion is paid by domestic agents, while the increase in demand is shared with foreign countries and thus domestic consumption is reduced as in any neoclassical model of fiscal policy (Baxter and King (1993)). The decline in consumption implies a depreciation of the nominal exchange rate through consumption based money demand equation[9].

Ganelli extends the Redux model along two dimensions. In a first paper (2002) he allows for home bias in government spending. This assumption implies the "quasi-neutrality" of fiscal shocks: the costs (the increase in taxes) and the benefits (the increase in demand) of the fiscal shocks are not shared with foreign countries and exactly compensate each other. Thus, there is no effect on domestic consumption, on the exchange rate (the money demand equation is unchanged) and on the net foreign asset position. This implies also that output increases one to one with government spending (given that consumption and trade balance are unchanged and there is no investment in the model). In a second paper Ganelli (2003) introduces public spending in the utility function as a substitute for private consumption. The main effect is that an increase in public spending implies a larger decrease in consumption and a smaller depreciation of the exchange rate.[10]

[9]The money demand equation has the following form:

$$\frac{M_t}{P_t} = L\left(C_t, R_t\right) \tag{1}$$

On the right hand side consumption declines because of the wealth effect and the nominal interest rate is fixed because of the assumptions of prices fixed one period in advance and PPP (that implies constant real interest rate). Given that money is exogenous and domestic prices are fixed, the only way to insure the equilibrium on the money market is a depreciation of the exchange rate.

[10]Consumption decreases more with respect to the Redux model because an increase in public spending lowers marginal utility of consumption and thus agents want to consume

Corsetti and Pesenti (2001) build a model that can be solved analytically without resorting to linearization. The main features of the model are home bias in government spending, Cobb-Douglas preferences with unitary cross-country elasticity of substitution, PPP holds. Given the preferences chosen by the authors, even if markets are incomplete, the current account channel is shut off and thus the model exhibits the same kind of risk sharing implied by complete markets. In the short run quasi-neutrality holds exactly as in the Ganelli model.

The two closest papers to this work are Pitterle and Steffen (2004) and Müller (2006). Pitterle and Steffen (2004) conduct a careful analysis on the implications of a fiscal shock in an extension of the Redux model with home bias in consumption and incomplete pass-through. They introduce money in the model through a cash in advance constraint where money is needed to buy consumption goods and to pay taxes: in that way the money demand depends also on taxes and thus a fiscal shock implies an appreciation of the exchange rate (instead of a depreciation as in Obstefeld-Rogoff). The implied appreciation increases with respect to the degree of home bias in consumption and to the fraction of pricing to market firms. Our work differs because we relax the assumption of prices fixed one period in advance, we introduce endogenous monetary policy and we impose the small open economy assumption. The model of Müller (2006) is very similar to the one presented here but is a two country analysis and the focus of the paper is the impact of a fiscal shock on the trade balance in the United States. Müller (2006) shows that the response of the trade balance can be positive or negative depending on the magnitude of the cross country elasticity of substitution and on the intertemporal elasticity of substitution; he shows also that the assumption of complete markets does not affect the model implications.

The empirical literature on fiscal policy is very recent and is based on VAR techniques. While VAR models have been used extensively in the literature to look at the effects of monetary shocks, it is only in the last few years that the same methodology has been applied also to fiscal shocks. Almost all the papers dealing with this topic are about the US economy, thus not being very useful for the open economy analysis (Gali, Lopez-Salido and Valles (2005), Blanchard and Perotti (2002) among others).

However a recent study by Perotti (2004) looks at the impact of fiscal shocks in five OECD countries (USA, UK, Australia, Germany and Canada)

less and hold more real balances. The depreciation is lower because now money demand is function also of public spending.

and some of them are very open economies[11].

The main results for the period 1980-1998 are the following.

Small effect on output. The effect of fiscal shocks on GDP are positive and significant in USA, Australia and Germany but only on impact (for two quarters) and are negative and not significant in UK and Canada. At a longer horizon (12 quarters) the effect is positive and significant only in Australia (but very small), not significant in the US and negative and significant in Germany, UK and Canada. It seems also that fiscal policy is much less effective over 1980-2001 than over 1960-1980. The output-level multiplier is estimated around 0.7 in the USA, 0.5 in Germany and 0.1 in the other three countries[12]. These results show that the biggest output multiplier is by far in the most closed economy (Unites States) and the effects are more persistent in the second most closed country (Australia). The two more open economies (UK and Canada) exhibit lower multipliers that become even significantly negative at a three years horizon.

Mixed evidence on consumption. The effect on consumption on impact is positive and significant only in USA and Australia (the two closest economies); it is negative but not significant in the other three countries. At longer horizon (12 quarters) the effect is positive and significant only in the USA, it is negative and significant in Germany and Canada and is not significant in UK and Australia[13]. Thus Perotti confirms the evidence of Gali, Lopez Salido and Valles (200%) for the United States and Australia but this evidence is in contrast with the other countries. One tentative explanation, among others, of this cross-country heterogeneity can be the different degree of openness across countries

Positive response of interest rate. The effect on the interest rate is positive and significant in USA, Germany, Canada and Australia (but for the USA it is significant only on impact); in the UK it becomes significant only three quarters after the shock. All these results show a significant increase in the response of the interest rate with respect to the period 1960-1980: a more reactive monetary policy is a possible answer to this empirical evidence.

[11]Following Corsetti and Müller (2005) we define openness as the ratio of imports to GDP (net of government spending): This ratio is equal to 0.14 for the US, 0.24 for Australia, 0.35 for UK and 0.4 for Canada. We do not empathize the results for Germany because because the sample data ends in 1989 and thus the estimates are based only on ten years data.

[12]The low impact of fiscal shocks on GDP is documented also in De Arcangelis and Lamartina (2003) and Giuliodori and Beetsma (2004).

[13]The consumption level multiplier is on impact around 0.4 in the USA, 0.1 in Australia and between -0.1 and -0.2 in UK, Germany and Canada.

Low and mixed response of CPI inflation. Under plausible values for the elasticity of government spending to the price level, the effect of a fiscal shock on CPI inflation is not significant in three countries (USA, Germany and Canada), is positive and significant in Australia and negative and significant in the UK. This evidence is compatible with an appreciation of the exchange rate lowering the price of foreign goods (at least if the degree of pass through is not nil) and also with the assumption of sticky prices.

Open economy variables. Recent empirical evidence on the impact of fiscal shocks that considers open economy variables is scarce. However Giuliodori and Beetsma (2004) provide an attempt in this direction. They use a VAR to look at the impact of a public spending shock in Germany, France and Italy. The results for the three countries are quite different but nevertheless some patterns emerge: the effect on the real effective exchange rate is not significant whereas the effect on imports is positive and significant, especially using bilateral data. Unfortunately the authors do not provide the results for nominal and real bilateral exchange rate.

Lane and Perotti (1998) investigate the link between net exports and fiscal shocks in a panel of 16 OECD countries over 1960-1995. They show that an increase in wage government consumption (i.e. the main component of government spending) causes a deterioration in the trade balance, especially through a contraction in exports and under flexible exchange rates.

3 The model

3.1 Households

The setting of Gali and Monacelli (2005) includes a continuum of small open economies of measure one. Variables without superscripts refer to the domestic economy, variables with an i-superscript indicate foreign variables in country i with $i \in (0, 1)$, variables with a star indicate rest of the world variables, i.e. an aggregate of all foreign countries.

Given that the domestic economy is infinitely small, domestic shocks have no influence on world variables. Preferences, technologies and market structures are symmetric across countries.

In our small open economy the representative agent maximizes the following intertemporal utility function:[14]

[14]Money does not enter in the utility function that is written as a cashless limit utility à la Woodford.

$$E_0 \sum_{t=0}^{\infty} \beta^t \left(U\left(C_t, N_t\right) + V\left(G_t\right) \right) \tag{2}$$

where β is a discount factor, $V\left(G_t\right)$ is a function that represents the utility provided by public spending[15], N_t represents hours worked, C_t is a consumption index over domestic and foreign goods defined by:

$$C_t \equiv \left[(1-\alpha)^{\frac{1}{\eta}} \left(C_{H,t}\right)^{\frac{\eta-1}{\eta}} + \alpha^{\frac{1}{\eta}} \left(C_{F,t}\right)^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \tag{3}$$

where α measures the relative importance of foreign goods in the consumption basket and has two interesting interpretations: it can be seen as a natural measure of the openness of the economy (the higher is α the more open is the economy), or as a measure of the degree of home bias in consumption ($\alpha < 1$ indicates home bias because otherwise the percentage of domestic goods in the consumption basket should be infinitely small). η measures the substitutability between domestic and foreign goods and is allowed to be bigger than 1 (in Corsetti and Pesenti (2001) is fixed at one to obtain an analytical solution).

$C_{H,t}$ is a consumption index over domestic goods and is given by the following aggregator:

$$C_{H,t} \equiv \left(\int_0^1 C_{H,t}\left(j\right)^{\frac{\varepsilon-1}{\varepsilon}} dj \right)^{\frac{\varepsilon}{\varepsilon-1}} \tag{4}$$

where ε measures substitutability across varieties ($j \in [0,1]$) of the domestic good. This modeling choice allows to distinguish between within country substitutability and cross country substitutability. Tille (2001) reports evidence that within country substitutability is higher due to specialization patterns.

$C_{F,t}$ is a consumption basket of the foreign goods and aggregates consumption goods produced in each small open economy $C_{i,t}$ indexed by i ($i \in [0,1]$) that in turn aggregates across different varieties:

$$C_{F,t} \equiv \left(\int_0^1 {C_{i,t}}^{\frac{\eta-1}{\eta}} di \right)^{\frac{\eta}{\eta-1}} \tag{5}$$

[15]Utility is separable in private consumption and public spending and thus the variable G_t does not enter in the first order conditions for the representative agent. Even though this representation is equivalent to the "pure waste" case, we prefer to assign a role to government spending. In section 6 we will allow government spending to be a complement or a substitute of private consumption in the utility function.

$$C_{i,t} \equiv \left(\int_0^1 C_{i,t}(j)^{\frac{\varepsilon-1}{\varepsilon}} dj \right)^{\frac{\varepsilon}{\varepsilon-1}} \tag{6}$$

The per-period utility function U is separable in consumption and hours worked and is defined as:

$$U(C_t, N_t) \equiv \frac{C_t^{1-\sigma}}{1-\sigma} - \frac{N_t^{1+\varphi}}{1+\varphi} \tag{7}$$

where σ represents the inverse of the elasticity of intertemporal substitution and φ is the inverse of the elasticity of labor supply.

The representative agent maximizes (7) subject to the following budget constraint:

$$\int_0^1 P_{H,t}(j) C_{H,t}(j) dj + \int_0^1 \int_0^1 P_{i,t}(j) C_{i,t}(j) dj di + E_t Q_{t,t+1} D_{t,t+1} + T_t \leq D_t + W_t N_t \tag{8}$$

On the left-hand side we have consumption expenditure for domestic goods and consumption of imported goods. $D_{t,t+1}$ represents the nominal payoff in period t+1 of a portfolio of state contingent claims held during the preceding period (including shares in firms)[16], $Q_{t,t+1}$ is the stochastic discount factor, T_t are net lump sum taxes. On the right hand side we have revenue from work activity and the portfolio at the end of period t.

In appendix 1 we show that the budget constraint can be rewritten in the following simpler way:

$$P_t C_t + E_t Q_{t,t+1} D_{t,t+1} + T_t \leq D_t + W_t N_t \tag{9}$$

The first order condition (FOC) with respect to labor for the representative households is the following:

$$\frac{W_t}{P_t} = C_t^{\sigma} N_t^{\varphi} \tag{10}$$

whose log-linearized version is:

$$w_t - p_t = \sigma c_t + \varphi n_t \tag{11}$$

[16]The state-contingent notation is omitted for simplicity as is currently done in the literature. To be rigorous (as in Chari, Kehoe and McGrattan (2002)) the budget constraint has to hold at each time and at each state.

Equation (11) is the labor supply equation: real wage is equal to marginal rate of substitution given that the labor market is competitive and wages are flexible.

The second FOC is the Euler equation:

$$\beta \left(\frac{C_{t+1}}{C_t} \right)^{-\sigma} \left(\frac{P_t}{P_{t+1}} \right) = Q_{t,t+1} \tag{12}$$

that can be rewritten as:

$$\beta R_t E_t \left[\left(\frac{C_{t+1}}{C_t} \right)^{-\sigma} \left(\frac{P_t}{P_{t+1}} \right) \right] = 1 \tag{13}$$

where $R_t = \frac{1}{E_t(Q_{t,t+1})}$ is the gross return on a riskless bond paying one unit of domestic currency in any state of nature at time t+1.

The loglinearized version of equation (13) is:

$$c_t = E_t \left(c_{t+1} \right) - \frac{1}{\sigma} \left(r_t - E_t \left(\pi_{t+1} \right) - \rho \right) \tag{14}$$

where $\rho = \beta^{-1} - 1$ and π is CPI inflation.

3.2 Allocation of government spending

G_t is completely home-biased and thus the public sector buys only domestic goods. In the literature Corsetti and Pesenti (2001), Ganelli (2002a) and Pitterle and Steffen (2004) make the same choice. Obstfeld and Rogoff (1995) assume instead that the government buys foreign goods in the same proportion as domestic households.

The government spending index is given by:

$$G_t = \left(\int_0^1 G_t \left(j \right)^{\frac{\varepsilon - 1}{\varepsilon}} dj \right)^{\frac{\varepsilon}{\varepsilon - 1}} \tag{15}$$

Minimization of public spending $\int_0^1 P_{H,t} \left(j \right) G_t \left(j \right) dj$ given the aggregate level of G_t implies the following government demand function:

$$G_t \left(j \right) = \left(\frac{P_{H,t} \left(j \right)}{P_{H,t}} \right)^{-\varepsilon} G_t \tag{16}$$

The government budget is balanced each period:

$$P_{H,t} G_t = T_t \tag{17}$$

In this setting, where the representative agent optimizes intertemporally and infinitely lives, the introduction of a government bond would be redundant. A model with a one period government bond hold by the domestic representative agent would deliver exactly the same results. This is the case because the agent is rational and integrate the government budget constraint in the maximization process. In other words, Ricardian equivalence is satisfied.

3.3 Definitions and identities

We define the effective terms of trade as:

$$S_t = \frac{P_{F,t}}{P_{H,t}} \tag{18}$$

Loglinearizing (84) and using the fact that $s_t = p_{F,t} - p_{H,t}$ we obtain the following expression:

$$p_t = p_{H,t} + \alpha s_t \tag{19}$$

Taking the first differences we obtain a relation between CPI inflation (π) and domestic inflation (π_H):

$$\pi_t = \pi_{H,t} + \alpha \Delta s_t \tag{20}$$

We see that, as the economy become more open (α increases), the difference between CPI inflation and domestic inflation becomes larger. In the world economy there is no difference between domestic inflation and CPI inflation because the weight of domestic goods in the foreign consumption index is infinitely small. Thus:

$$\pi_t^* = \pi_{F,t}^* \tag{21}$$

We assume that the law of one price holds for all goods and at all times. After aggregation and log-linearization we have:

$$p_{F,t} = e_t + p_t^* \tag{22}$$

where e is the log nominal effective exchange rate. There is no wedge between the price in domestic currency of a foreign good and the price of the same good in local currency. In section 6 we relax this assumption and we allow the degree of pass-through to be incomplete.

The effective real exchange rate q in log-linear form is defined in the following way:

$$q_t = e_t + p_t^* - p_t \tag{23}$$

and using (22)(18) and (19) can be rewritten in the following way:

$$q_t = (1 - \alpha)\, s_t \tag{24}$$

This equation critically distinguishes this model from other models in NOEM. Here in fact the real exchange rate is allowed to vary and Purchasing Power Parity (PPP) does not hold because of home bias in consumption ($\alpha < 1$). We observe also that it holds a simple proportionality relationship between terms of trade and the real exchange rate.

3.4 Risk sharing

The model assumes complete markets and thus, under this specific market structure, a well known condition in international macroeconomics[17] holds:

$$c_t = c_t^* + \frac{1}{\sigma} q_t \tag{25}$$

and using (24) it can be rewritten as[18]:

$$c_t = c_t^* + \left(\frac{1 - \alpha}{\sigma}\right) s_t \tag{26}$$

This equation is very useful because we can immediately see that domestic shocks, affecting consumption in a negative way, appreciate the domestic currency in real terms.

A basic implication of the complete market set-up is that the price of a free-risk domestic bond is given by the sum of the prices of Arrow-Debreu securities :

$$\frac{1}{R_t} = E_t Q_{t,t+1} \tag{27}$$

Using equation (27) and its country i counterpart, aggregating over i and log-linearizing around a perfect-foresight steady state the uncovered interest parity (UIP) condition is found:

[17] see Backus and Smith (1993)

[18] equation (25) is obtained from condition (12) and from its country-i conterpart, aggregating and imposing symmetric initial conditions.

$$r_t - r_t^* = E_t \Delta e_{t+1} \tag{28}$$

The interested reader can found a detailed derivation of these equations in Gali-Monacelli (2005). Here it is more interesting to discuss the assumption of complete markets. In the literature this assumption is often used because it greatly simplifies the derivation of the model and it insures stationarity in the equilibrium dynamics of endogenous variables. In that way we prevent a transitory shock to have a long run effect on the economy. Schmitt-Grohe and Uribe (2002) compare this stationarity inducing mechanism with other four in an incomplete markets framework and show that equilibrium dynamics are virtually identical in all cases. Müller (2006) shows that this is the case also in a two-country model that is very similar to the one presented in this paper.

A more specific remark on the complete market assumption has been raised by Betts and Devereux (1999) with respect to the impact of fiscal shocks: they claim that the effect of fiscal shocks is crucially different in models with complete or incomplete markets. In their model, with complete markets and no home bias in government spending and in consumption, the economy behaves like a closed economy and in fact the real and the nominal exchange rate are not affected. The intuition is that costs and benefits are shared equally between domestic and foreign country with no consequences on prices and exchange rates. In the same model but with incomplete markets, an increase in output and a decrease in consumption are accompanied by a nominal depreciation.

In this paper we empathize that the structure of asset markets per se is not crucial. What makes the difference is the interplay between the assumption on asset market structure and the assumption on home-bias in government spending and in consumption. In our model we show that under complete markets we have a significant effect on the nominal and real exchange rate because the assumption of home-bias in government spending critically changes the results with respect to Betts and Devereux (1999).

3.5 Firms

The firm that produces variety j in the domestic economy operates with the following simple technology:

$$Y_t(j) = N_t(j) \tag{29}$$

The production function, after aggregation and up to a first order approximation, can be rewritten in log-linear form as:

$$y_t = n_t \tag{30}$$

The real marginal cost in loglinear is given by:

$$mc_t = w_t - p_{H,t} \tag{31}$$

Using (19) , (30) and (11) we obtain:

$$mc_t = \sigma c_t + \varphi y_t + \alpha s_t \tag{32}$$

Prices are set in a staggered fashion à la Calvo (1983). As shown in Gali and Monacelli (2005) (appendix 2) the Calvo pricing implies inflation dynamics that are well known in the literature as New Keynesian Phillips curve (NKPC):

$$\pi_{H,t} = \beta E_t \pi_{H,t+1} + \lambda \hat{mc}_t \tag{33}$$

where $\lambda = \frac{(1-\theta)(1-\beta\theta)}{\theta}$, θ is the fraction of firms that keep their price unchanged from one period to another and $\hat{mc}_t = mc_t - mc$ is the log deviation of real marginal cost from its steady state value given by $mc = -\mu = -\log \frac{\varepsilon}{\varepsilon - 1}$.

4 Equilibrium

4.1 The goods market equilibrium

Goods market equilibrium implies for each variety j that:

$$Y_t(j) = C_{H,t}(j) + \int_0^1 C^i_{H,t}(j)\, di + G_t(j) \tag{34}$$

Equation (34) implies that production of good j must be equal to domestic consumption plus foreign consumption of domestic good j plus public consumption of the same good. Using equations (76),(79) (80) and (16) we can rewrite equation (34) as:

$$Y_t(j) = \left(\frac{P_{H,t}(j)}{P_{H,t}}\right)^{-\varepsilon} \left[(1-\alpha)\left(\frac{P_{H,t}}{P_t}\right)^{-\eta} C_t + \alpha \int_0^1 \left(\frac{P_{H,t}}{\Xi_{i,t} P^i_t}\right)^{-\eta} C^i_t di + G_t\right] \tag{35}$$

Ξ_i being the bilateral nominal exchange rate with respect to country i.[19]

Plugging (35) into the definition of aggregate domestic output $Y_t = \left[\int_0^1 Y_t(j)^{\frac{\epsilon-1}{\epsilon}} dj\right]^{\frac{\epsilon}{\epsilon-1}}$ we obtain the goods market equilibrium equation:

$$Y_t = \left[(1-\alpha)\left(\frac{P_{H,t}}{P_t}\right)^{-\eta} C_t + \alpha \int_0^1 \left(\frac{P_{H,t}}{\Xi_{i,t} P_t^i}\right)^{-\eta} C_t^i di + G_t\right] \tag{36}$$

Using the definition of the real exchange rate (Ω) and summing up we have:

$$Y_t - G_t = \left(\frac{P_{H,t}}{P_t}\right)^{-\eta} C_t \left[1 - \alpha + \alpha \int_0^1 \Omega_{i,t}^{\eta - \frac{1}{\sigma}} di\right] \tag{37}$$

Loglinearizing the last equation and using (19) we have:

$$y_t - \gamma g_t = (1-\gamma)\left(c_t + \frac{\alpha\omega}{\sigma} s_t\right) \tag{38}$$

γ being the ratio government spending/output in steady state $\left(\gamma = \frac{G}{Y}\right)$ and $\omega = \sigma\eta + (1-\alpha)(\sigma\eta - 1)$.

g_t is an exogenous variable subject to shocks with the following AR(1) structure:

$$g_t = \rho_g g_{t-1} + \varepsilon_g \tag{39}$$

We define net exports as a fraction of steady state output and in terms of domestic prices as $nx_t = \left(\frac{1}{Y}\right)\left(Y_t - G_t - \frac{P_t}{P_{H,t}} C_t\right)$. Taking a first order approximation and using (19) we obtain:

$$nx_t = (1-\gamma)\alpha\left(\frac{\omega}{\sigma} - 1\right) s_t \tag{40}$$

The market clearing condition in the world economy is much simpler because it refers to the closed economy approximation. Thus:

$$Y_t^* = C_t^* + G_t^* \tag{41}$$

[19]This equation is obtained using the fact that preferences are symmetric. We use equations (76) (78) (80) for country i and we find the demand function $C_{H,t}^i(j) = \alpha\left(\frac{P_{H,t}(j)}{P_{H,t}}\right)^{-\varepsilon}\left(\frac{P_{H,t}^i}{P_t^i}\right)^{-\eta} C_t^i$. Given that $P_{H,t}^i$ is determined by the law of one price.we have $C_{H,t}^i(j) = \alpha\left(\frac{P_{H,t}(j)}{P_{H,t}}\right)^{-\varepsilon}\left(\frac{P_{H,t}}{\Xi_{i,t} P_t^i}\right)^{-\eta} C_t^i$ and we put it in that form in equation (35).

or in log linear form:

$$y_t^* = (1-\gamma)\, c_t^* + \gamma g_t^* \tag{42}$$

Substituting (24),(25) and (42) in (38) we rewrite the market clearing condition as:

$$y_t - \gamma g_t = y_t^* - \gamma g_t^* + \frac{1-\gamma}{\sigma_\alpha} s_t \tag{43}$$

where $\sigma_\alpha = \frac{\sigma}{1-\alpha+\alpha\omega}$, . σ_α plays the role of an open economy version of the inverse of the elasticity of intertemporal substitution that takes into account that it is possible to substitute consumption not only intertemporally but also cross-country. σ_α is always lower than σ and is equal to σ in the closed economy case.

4.2 Flexible prices equilibrium and IS curve

To construct the dynamic IS relation we need as a basic ingredient a measure of the output gap (x_t) and to construct it we need a measure of potential output. We choose to consider the potential output as the one that would prevail under full price flexibility ($\bar{y_t}$) [20]:

$$x_t = y_t - \bar{y_t} \tag{44}$$

In case of price flexibility prices are fixed imposing a constant mark-up over nominal marginal cost. Equivalently, under price flexibility, the real marginal cost is constant and equal to $-\mu$. Imposing that condition on equation (32), substituting in the same equation the expressions for s_t that we find in (43) and for c_t in (25) we obtain a measure of potential output that depends only on exogenous shocks:

$$\bar{y_t} = \left(\frac{\sigma_\alpha \gamma}{\varphi(1-\gamma)+\sigma_\alpha}\right) g_t + \left(\frac{\sigma_\alpha - \sigma}{\varphi(1-\gamma)+\sigma_\alpha}\right) y_t^* - \left(\frac{(\sigma_\alpha-\sigma)\gamma}{\varphi(1-\gamma)+\sigma_\alpha}\right) g_t^* + \Gamma \tag{45}$$

[20] In the Gali-Monacelli paper (2005) a subsidy τ thet neutralizes the monopolistic competition distortion is introduced. Thus the steady-state in their economy is not distorted. Given that our paper does not deal with a welfare analysis we avoid the introduction of the subsidy to simplify the notation. Anyway the gap between the natural level of output ($\bar{y}_t$) and the efficient level is constant and invariant to shocks. Thus our analysis is not affected by the choice of the steady state.

where $\Gamma = \frac{-\mu}{\varphi + \frac{\sigma_\alpha}{1-\gamma}}$. We observe that potential output increases with respect to domestic government spending shocks.

Using Euler equation (14) and (38) we find an expression for the IS curve:

$$x_t = Ex_{t+1} - \left(\frac{1-\gamma}{\sigma_\alpha}\right)\left(r_t - E_t\pi^H_{t+1} - r\bar{r}_t\right) \tag{46}$$

$r\bar{r}_t$ is the natural rate of interest, the one that would prevail under price flexibility and is given by:

$$\begin{aligned} r\bar{r}_t &= \rho + \frac{\gamma\sigma_\alpha\varphi\left(1-\rho_g\right)}{\varphi\left(1-\gamma\right)+\sigma_\alpha}g_t + \frac{\varphi\left(1-\gamma\right)\left(\sigma-\sigma_\alpha\right)}{\varphi\left(1-\gamma\right)+\sigma_\alpha}\Delta y^*_{t+1} + \qquad (47)\\ &+ \frac{\gamma\varphi\left(\sigma-\sigma_\alpha\right)\left(1-\rho^*_g\right)}{\varphi\left(1-\gamma\right)+\sigma_\alpha}g^*_t \qquad (48)\end{aligned}$$

We see that a positive fiscal shock increases $r\bar{r}_t$.

4.3 The supply side

From equations (32) and (45) we can recover a link between real marginal cost in deviation from the flexible price equilibrium and output gap.

$$\hat{mc}_t = \left(\varphi + \frac{\sigma_\alpha}{1-\gamma}\right)x_t \tag{49}$$

And putting that into we rewrite the NKPC as.

$$\pi_{H,t} = \beta E_t\pi_{H,t+1} + \kappa_y x_t \tag{50}$$

where $\kappa_y = \lambda\left(\varphi + \frac{\sigma_\alpha}{1-\gamma}\right)$

4.4 Monetary policy

A widely known result in the literature is that, in an open economy model with sticky prices and monopolistic competition, a domestic inflation target (DIT) is the optimal monetary policy. This is the case because a DIT policy replicates the flexible price equilibrium. Unfortunately, this result holds under strict assumptions. The first is the introduction of a subsidy τ that eliminates the monopolistic competition distortion, the second is log utility

and unitary elasticity of substitution between domestic and foreign goods (Benigno and Benigno (2003)).

In this paper we are not interested in a welfare analysis to derive an optimal monetary policy and thus σ and η are allowed to be bigger than 1 to fully investigate the open economy peculiarity of the model. We look at the implications of fiscal shocks under three reasonable monetary policy rules having in mind that neither of the three is the optimal one.

The first rule is a domestic inflation target regime (DIT):

$$\pi_{H,t} = 0 \tag{51}$$

that can be implemented by the following rule[21]:

$$r_t = r\bar{r}_t + \phi_\pi E_t \pi_{H,t+1} \tag{52}$$

The second is a domestic inflation Taylor rule (DITR)[22]:

$$r_t = \phi_\pi E_t \pi_{H,t+1} + \phi_x x_t \tag{53}$$

The third is a fixed exchange rate:

$$e_t = 0 \tag{54}$$

Given that our focus is on the implications of fiscal shock we believe that the characterization of monetary policy as above is a realistic approximation.

4.5 The world economy

The world economy behaves like a closed economy and so we can rewrite the relevant equations imposing $\alpha = 0$ (this implies that $\sigma_\alpha = \sigma$)

The closed economy version of equation (45), (49) and (50) is:

$$\bar{y_t}^* = \left(\frac{\sigma \frac{\gamma}{(1-\gamma)}}{\varphi + \frac{\sigma}{1-\gamma}} \right) g_t^* \tag{55}$$

$$\hat{mc_t^*} = \left(\frac{\sigma}{1-\gamma} + \varphi \right) x_t \tag{56}$$

$$\pi_t^* = \beta E_t \pi_{t+1}^* + \lambda \hat{mc_t^*} \tag{57}$$

[21] ϕ_π must be bigger than one to satisfy the "Taylor principle" and avoid multiple equilibria (see Woodford (2004)).

[22] A consumer inflation Taylor rule (CITR) would lead to similar results.

We assume that in the world economy monetary policy is given by an inflation targeting regime ($\pi_t^* = 0$). Gali and Monacelli show that this policy, in a closed economy, can be implemented through the following policy rule:

$$r_t^* = \phi_\pi E_t \pi_{t+1} + \frac{\sigma\varphi\gamma\left(1-\rho_g^*\right)}{\sigma+\varphi\left(1-\gamma\right)} g_t^* \tag{58}$$

5 The effects of a fiscal shock

In this section we look at the qualitative and quantitative implications of a fiscal shock in the model of Gali and Monacelli. The size of the shock is an increase of 1% in government spending. In the figures we plot impulse response functions for the variables expressed in logs.

Calibration. Our calibration closely follows Gali and Monacelli (2005) but departs from it with respect to the parameters σ (the inverse of the elasticity of intertemporal substitution) and η (the cross-country elasticity of substitution). In our paper we do not deal with welfare issues and so we are not forced to fix these two parameters at one. We assume $\sigma = 2$ and $\eta = 1.5$. In that way the open economy peculiarity of the model emerges more clearly because many terms in the equations are multiplied by the factor $(\sigma\eta - 1)$.

The inverse of the elasticity of labor supply φ is set at 3, the elasticity of substitution between domestic varieties (ε) is 6 (implying a mark up of 20%). θ is set at 0.75, consistent with prices fixed for 4 quarters on average. The degree of openness (or home-bias in consumption) is 0.4, which is consistent with Canadian data. We fix the discount factor β at 0.99, a value consistent with a steady state nominal interest rate of 4% in a quarterly model. The two coefficients in the monetary policy rule are the ones suggested by Taylor: $\phi_\pi = 1.5$ and $\phi_x = 0.5$. The government spending share on GDP (γ) is 0.2, the consumption share is 0.8.

The persistence parameter of the shock $\left(\rho_g\right)$ is set at 0.9.

5.1 Fiscal shock under DIT

We first look at the implications of an increase in government spending under a domestic inflation target policy. In that case an analytical solution is available because DIT is able to replicate the flexible prices equilibrium.

Effect on interest rate. We already know from (47) that a fiscal shock implies an increase in the natural rate of interest given by:

$$\frac{\partial r_t}{\partial g_t} = \frac{\partial r\bar{r}_t}{\partial g_t} = \frac{\gamma\sigma_\alpha\varphi\left(1-\rho_g\right)}{\varphi\left(1-\gamma\right)+\sigma_\alpha} \tag{59}$$

As mentioned before the effect is unambiguously positive (figure 1a)

Effect on real exchange rate. From (43) we have an expression for terms of trade in the flexible price equilibrium:

$$\bar{s_t} = \frac{\sigma_\alpha}{1-\gamma}\left(\bar{y}_t - \gamma g_t - y_t^* + \gamma g_t^*\right) \tag{60}$$

If the law of one price holds, $q_t = (1-\alpha)\, s_t$. Thus, using (45) and (43), it is straightforward to look at the implications for the real exchange rate:

$$\frac{\partial \bar{q}_t}{\partial g_t} = (1-\alpha)\,\frac{\sigma_\alpha\gamma}{1-\gamma}\left(\frac{\sigma_\alpha}{\sigma_\alpha+\varphi\left(1-\gamma\right)}-1\right) \tag{61}$$

Under DIT the model predicts unambiguously a real appreciation of the real exchange rate given that the term in parenthesis is always negative (figure 1a).

This result contrast some of the conclusions found in the literature: in the Obstfled-Rogoff model PPP holds and thus the real exchange rate is constant at one. We observe that we recover the result of Obstfeld and Rogoff if we remove the only source of deviations from PPP in this setting, i.e. home-bias in consumption. In that case $\alpha = 1$ and the real exchange rate does not move.

Effect on nominal exchange rate. The difference for the nominal exchange rate is even more striking: the Obstfeld-Rogoff model predicts a depreciation of the exchange rate (if no home-bias in G_t) or no effect at all in case of home bias in G_t (Ganelli, 2003). Here UIP holds and thus an increase in the natural rate of interest implies an appreciation of the exchange rate (figure 1a). This result holds even in the case of PPP and is consistent with the Mundell-Flemming-Dornbush model.

Effect on consumption. The recent literature on small scale dynamic general equilibrium models has shown the importance of looking at the effect of fiscal shocks on consumption (Gali, Lopez-Salido and Valles, 2005). The open economy model predicts a more muted response of consumption with respect to the closed economy.

From (25) we have:

$$\frac{\partial \bar{c_t}}{\partial g_t} = \frac{(1-\alpha)}{\sigma}\frac{\sigma_\alpha\gamma}{1-\gamma}\left(\frac{\sigma_\alpha}{\sigma_\alpha+\varphi\left(1-\gamma\right)}-1\right) \tag{62}$$

The impact on consumption is always negative independently of the calibrated parameters (figure 1b). From figure 2 we observe that the impact is much lower in an open economy.

In figures 1b and 2 we plot the log-multiplier that represents the response of $\log C_t$ to a unitary shock to $\log G_t$. For a quantitative evaluation it is more useful to consider the level multiplier representing $\frac{\partial C_t}{\partial G_t}$[23]: this multiplier can be obtained by multiplying the log multiplier by 4. Our model predicts a level multiplier of around -0.6 for the closed economy and a multiplier of around -0.25 for the open economy ($\alpha = 0.4$).

This multiplier is always negative but its amplitude is decreasing in the degree of openness. The explanation for this result is intuitive if we rewrite (62) in the following way:

$$\frac{\partial \bar{c}_t}{\partial g_t} = \frac{\gamma \sigma_\alpha}{(1-\gamma)\,\sigma}\left(-1 + \frac{\sigma_\alpha}{\sigma_\alpha + \varphi\,(1-\gamma)} - \alpha\left(\frac{\sigma_\alpha}{\sigma_\alpha + \varphi\,(1-\gamma)} - 1\right)\right) \quad (63)$$

In the big parenthesis the three effects at work are included. The first (-1) is a wealth effect: the increase in government spending is financed through an increase in lump sum taxation that reduces disposable income. Thus the representative agent cuts consumption and leisure. The second, $\left(\frac{\sigma_\alpha}{\sigma_\alpha+\varphi(1-\gamma)}\right)$, is a substitution effect: the agent increases his labor supply because leisure is a normal good.

The third effect, $\left(-\alpha\left(\frac{\sigma_\alpha}{\sigma_\alpha+\varphi(1-\gamma)} - 1\right)\right)$, is absent in the closed economy and is due to the appreciation of the exchange rate: foreign goods are cheaper, the price of domestic goods has not changed (because the monetary authority is able to target zero domestic inflation) and so imports increase, stimulating domestic consumption.

In the case of PPP ($\alpha = 1$, figure 2) there is no effect on consumption because the positive effect of the appreciation exactly compensates the net effect of wealth and substitution effect. That happens because, if there is no home bias in consumption, the domestic representative agent consumes only foreign goods given the infinitely small open economy assumption. In that case we recover the quasi-neutrality result of Ganelli (2003).

These results replicate quite well the empirical evidence for small open economies presented in Perotti (2004) and Giuliodori and Beetsma (2004). However, there is still a puzzle: the model predicts a consumption multiplier that is increasing in the degree of openness when in the data we observe the

[23] $\frac{\partial c_t}{\partial g_t} = \frac{\partial \ln C_t}{\partial \ln G_t} = \frac{G}{C}\frac{\partial C_t}{\partial G_t}$

opposite: in the US and Australia (that can be considered as relatively closed economies) the consumption multiplier is positive and the model is not able to reproduce this feature.

In the literature four ingredients have been proposed to obtain a positive effect on consumption in a closed economy: a complementarity between private and public consumption in the utility function (Bouakez and Rebei (2003)), a utility function that is non additively separable in leisure and consumption (Linnemann (2005)), the introduction of government spending in the production function (Linnemann and Shabert (2005) and the introduction of Non Ricardian or Rule of Thumb consumers in the model (Gali, Lopez-Salido and Valles (2005)). However, it is not evident that these mechanisms can reproduce a consumption multiplier that is declining in the degree of openness. We will check this conjecture in section 6 where we propose some extensions of the model.

Effect on output. From (45) we see that the effect on potential output is given by:

$$\frac{\partial \bar{y_t}}{\partial g_t} = \frac{\gamma \sigma_\alpha}{\varphi (1-\gamma) + \sigma_\alpha} \tag{64}$$

The effect is positive for all the range of admissible parameters but in our baseline calibration the effect is small (figure 1b). In figure 2 we plot the log multiplier with respect to the degree of openness. Two important results emerge:

1) The output level multiplier is largely below one as found by Perotti (2004).[24]

2) The same multiplier is decreasing in openness. On impact our impulse response functions find a level multiplier of around 0.45 in the closed economy case and around 0.2 in the open economy under our baseline calibration. These results are consistent with a significant negative effect on net exports as shown in figure 1b and as documented in Giuliodori and Beetsma (2004) and Lane and Perotti (1998).

Effect on inflation. On one hand the fiscal shock has no effect on domestic inflation because the central bank increases the interest rate hitting the target of zero domestic inflation. On the other hand the effect on CPI inflation is even negative because import prices decrease following the appreciation of the exchange rate (figure 1b). From (19) the effect on CPI prices is given by:

[24]The output level multiplier is obtained by multiplying the log multiplier by 5 given that the government spending/output ratio is 0.2.

$$\frac{\partial \bar{p_t}}{\partial g_t} = \frac{\alpha \sigma_\alpha \gamma}{1-\gamma} \left(\frac{\sigma_\alpha}{\sigma_\alpha + \varphi (1-\gamma)} - 1 \right) \tag{65}$$

In the literature, as we have shown in section 2, the evidence is mixed.

5.2 Fiscal shock under Taylor rule

Implementing the monetary policy that we described in the preceding section may not be an easy task. To hit the zero inflation target the central bank must keep track of the movements of the natural rate of interest that is an unobservable variable. Thus, it is natural to look at the implications of simpler monetary policy rules in the form of the one popularized by Taylor. In figures 3a and 3b we see that a Taylor rule approximate very well the DIT policy. Real variables (consumption, output, real exchange rate) follow the same path, the only significant discrepancy with respect to a DIT policy is that on impact the monetary authority rises the interest rate more than the variation in the natural rate: this creates a bigger expected depreciation through UIP and in fact in the long run the nominal exchange rate depreciates with respect to the pre-shock level.

In their paper (2005) Gali and Monacelli look at the implications of productivity shocks and find a similar result: the Taylor rule does a good job in approximating the DIT policy.

5.3 Fixed exchange rate and money growth rule

In this section we look at the implications of a fiscal shock under a fixed exchange rate and under a monetary growth rule to show that the assumption of endogenous monetary policy affects the results in a crucial way.

A credible fixed exchange rate implies the loss of monetary policy independence and is equivalent to the case of European Monetary Union (EMU). A growing literature is looking at the implications of the Stability Pact (Gali and Monacelli (2005b) among others) and this model is very well suited to look at this question: our small open economy can be thought as one small country in EMU whose action cannot influence union-wide variables.

From UIP (28) we see that a fixed exchange rate regime implies that the domestic interest rate will follow movements in the union-wide interest rate:

$$r_t = r_t^* \tag{66}$$

We see from dotted red lines (PEG) in figure 3a and 3b that now the implications of a fiscal shock are quite different with respect to the preceding

sections. The nominal interest rate does not move because r_t^* is not affected by a domestic shock. The fact that monetary policy is now prevented from reacting to the shock implies a considerable effect on inflation and output gap: the effect on output is twice expansionary as before but at the cost of an increase in domestic inflation. The output level multiplier is around 0.9 compared to around 0.35 under flexible exchange rates (being $\alpha = 0.4$). Thus another well-known result in the MFD model is confirmed: fiscal shocks are more effective under a fixed exchange rate than under a flexible rate because the decline in net exports and the increase in the interest rate are prevented.

Still we observe a negative effect on consumption and a real appreciation, but the effect is more muted and the reaction has a hump-shaped form. Thus the participation to a monetary union is another factor that plays a role when we look at the impact of a fiscal shock on consumption. This implication of the model could be an interesting topic for some empirical analysis.

We turn now to another exogenous monetary policy rule such as a money growth targeting. To study this case we introduce a money demand function given by[25]:

$$m_t - p_t = c_t - \xi i_t \tag{67}$$

We parametrize the interest semielasticity ξ equal to 28 and we fix the consumption elasticity at one following the estimation of Lucas (2000). The behavior of the economy is very similar to the fixed exchange rate case (figure 4). A fixed money growth rate policy is not able to generate a sufficient increase in the interest rate to track the behavior of the natural rate and thus the economy is not able to replicate the flexible price equilibrium. The results do not depend on the choice of the calibrated parameters in the money demand equation.

6 Extensions

6.1 Government spending in the utility function

In the baseline version of our model government spending entered the utility function in a separable way. In this section we introduce a non separability:

[25]This function can be obtained from first principles introducing money in the utility function

in that way we want to test the robustness of our preceding results with a different assumption on the role of government spending in the economy.

In the literature Ganelli (2003) has explored the implications of government spending being a substitute for private consumption ("useful government spending"). In this section we use a more general form for the utility function that has been used in a closed economy model by Bouakez and Rebei (2003):

$$U\left(C_t, G_t, N_t\right) = \frac{\left[\left(\phi C_t^{\frac{\nu-1}{\nu}} + (1-\phi)\, G_t^{\frac{\nu-1}{\nu}}\right)^{\frac{\nu}{\nu-1}}\right]^{1-\sigma}}{1-\sigma} - \frac{N_t^{1+\varphi}}{1+\varphi} \tag{68}$$

This function allows for complementarity or substitutability between private consumption and government spending depending on the value of the elasticity of substitution ν. If $\nu = 0$ the two bundles are perfect complements, if $\nu \to \infty$ they become perfect substitutes.

The main implication of non-separability is that now government spending affects the marginal utility of consumption λ_t that can be written in loglinear form as[26]:

$$\lambda_t = \left(\frac{1}{\nu} - \sigma\right)\left(\phi\left(\frac{C}{\tilde{C}}\right)^{\frac{\nu-1}{\nu}} c_t + (1-\phi)\left(\frac{G}{\tilde{C}}\right)^{\frac{\nu-1}{\nu}} g_t\right) - \frac{1}{\nu} c_t \tag{69}$$

The impact of a fiscal shock on the marginal utility of consumption is given by:

$$\frac{\partial \lambda_t}{\partial g_t} = \left(\frac{1}{\nu} - \sigma\right)(1-\phi)\left(\frac{G}{\tilde{C}}\right)^{\frac{\nu-1}{\nu}} \tag{70}$$

We see that the sign of this expression crucially depends on $\left(\frac{1}{\nu} - \sigma\right)$. If $\frac{1}{\nu} = \sigma$ we are back to the baseline model, if $\frac{1}{\nu} > \sigma$ there is a complementarity effect that, for each each level of consumption, increases marginal utility, if $\frac{1}{\nu} < \sigma$ substitutability is at work and a fiscal shock implies a decline in marginal utility of consumption. The parameter ϕ is set at 0.8.

[26] $\tilde{C} = \left(\phi C^{\frac{\nu-1}{\nu}} + (1-\phi)\, G^{\frac{\nu-1}{\nu}}\right)^{\frac{\nu}{\nu-1}}$

In the baseline calibration the inverse of the elasticity of intertemporal substitution (σ) is equal to 2 and thus we observe complementarity (substitutability) if $\nu < 0.5$ ($\nu > 0.5$) .

In figure 5 we plot the response of the main variables to a fiscal shock in case of complementarity ($\nu = 0.4$) and in case of substitutability ($\nu = 1000$). From a qualitative point of view all the preceding results (except for consumption) are confirmed. However, from a quantitative point of view, the impact of a high degree of substitutability is very limited with respect to the baseline model. On the contrary the impact of complementarity is more relevant: it amplifies the transmission mechanism for all the variables, in particular we observe a bigger real and nominal appreciation which in turn implies a higher negative response of net exports..

But the only variable whose reaction changes sign following the introduction of government spending in the utility function is private consumption. A government spending shock pushes up consumption if the complementarity effect is strong enough to compensate the wealth effect. To finance the increase in consumption on one hand agents are willing to work more and on the other hand they run a bigger current account deficit. A bigger trade deficit is consistent with a higher nominal and real appreciation.

We think that this extension improves the baseline model along two dimensions:

1)it is relatively easy to obtain a positive consumption multiplier (which is a realistic feature according to Perotti (2004)) and in an open economy we need less complementarity to have a positive response of consumption ($\nu < 0.45$, when in the closed economy case it happens for $\nu < 0.3$): the appreciation of the exchange rate mitigates the negative wealth effect of the fiscal shock and the additional effect of the complementarity overturn the implication of the baseline model.

2) Chari, Kehoe and McGrattan (2002) show that the real exchange rate exhibits too little volatility in NOEM models. A complementarity between consumption and government spending can reproduce a consistently bigger reaction of the real exchange rate after fiscal shocks (and the real appreciation can be even bigger under incomplete pass-through, see section 6.3).

However these results hold only if the condition $\frac{1}{\nu} > \sigma$ is satisfied. This condition is rather strong and unfortunately ν is an unobservable parameter. Moreover, the uncertainty on which is a plausible value for σ is very high in the macroeconomic literature: this parameter is calibrated on a range going from 1 to 6. Bouakez and Rebei (2003) estimate their closed economy model through maximum likelihood and find a value for ν of 0.35. As long as σ is lower than 1/0.35 this is an evidence of complementarity.

Whether a positive response of consumption can be considered as a stylized empirical fact is still an open question. All the empirical literature seems to agree that this is the case in the United States but the evidence provided in section 2 for other countries is much less convincing: in most of them the response of consumption is negative or not significant. Furthermore our "consumption puzzle" is still present: neither our baseline model, nor a model with complementarity is able to reproduce a response of consumption that is declining in the degree of openness. The effect of complementarity is the same in an open economy and in a closed economy: in both cases the response of consumption is pushed up but still the multiplier is higher in the open economy case, which is a counterfactual phenomenon.

6.1.1 Productive government spending

Linnemann and Shabert (2005) introduce productive government spending in a closed economy, sticky prices model of the business cycle. In their model government spending is not completely wasteful but improves the productivity of labor. An increase in government spending has the usual expansionary demand effect but also a cost saving effect because an increase in public spending acts as a productivity shock. Both effects have a positive effect on output. In a closed economy model where the Taylor principle holds the response of consumption is positive if and only if the response of the interest rate is negative (this is an implication of the Euler equation). And a negative response of the interest rate is compatible only with a decline in inflation (through the Taylor rule). Inflation is linked one to one with the marginal cost and thus consumption can augment only if the marginal cost declines. This is the case if the cost alleviating effect of the government spending shock is bigger than the demand effect. In the model of Linnemann and Shabert a sufficient condition to obtain a positive response of consumption is that the elasticity of the production function with respect to the government spending must be bigger than the government spending share to output.

In this section we introduce productive government spending in our open economy model to check if we can improve the performance of the model is replicating the stylized facts proposed in section 2. In particular we want to see if, aside a positive response of consumption, we can obtain a consumption multiplier that is declining in the degree of openness of the economy.

The production function is modified as follows:

$$Y_t(j) = G_t^{1-\kappa} N_t(j)^{\kappa} \tag{71}$$

where $1-\kappa$ is the elasticity of the production function with respect to government spending.

Accordingly the real marginal cost is now defined as:

$$mc_t = w_t - p_{H,t} + (1-\kappa)\, n_t - (1-\kappa)\, g_t \tag{72}$$

The main modification with respect to the baseline model is the presence of the cost alleviating term $(1-\kappa)\, g_t$ in the equation for the marginal cost. The basic structure of the model is still given by the IS equation, the NKPC and the monetary policy rule but, as explained in appendix **(to be added)**, the introduction of productive government spending affects the definitions of the variables under the flexible prices equilibrium and the relation between the marginal cost and the output gap.

In figure 6 we simulate our model for different values of κ under a DIT rule[27]. We confirm that it is possible to obtain a positive response of consumption for κ lower than 0.8. In this case the cost alleviating effect is bigger than the demand effect and the real marginal cost decreases. Prices start declining as well and to avoid a deflation the central bank track the natural rate of interest and decreases the interest rate. A decline in the interest rate is linked to an increase in consumption through the Euler equation. However, this result on consumption is accompanied by a series of counterfactual implications for the other variables, especially the open economy variables. In fact the model predicts a decline in the interest rate that is reflected in a depreciation of the exchange rate and in a surplus in the trade balance. All these three results contrast sharply with the evidence proposed in section 2. Moreover we found two other disappointing results: the output multiplier is now increasing in the degree of openness (essentially because of the trade surplus) whereas the consumption multiplier remains also increasing in the degree of openness **(to be checked ..multipliers non monotonic in openness?)**. Both results are clearly at odds with the empirical evidence. Thus we can say that the introduction of productive government spending considerably worsens the performance of the model with respect to the empirical evidence.

6.1.2 Incomplete pass-through

Up to now we have considered the case of complete pass-through from exchange rate to import prices: in this literature this assumption is called "pro-

[27] Results are similar using different monetary policy rules.

ducer currency pricing" (PCP) and has been adopted by Gali and Monacelli (2005), Benigno and Benigno (2003), Müller (2006) just to cite the closest papers to our work. A second strand of the literature takes the opposite approach and assume no pass-through from exchange rate to prices: in that case the prices of imported goods are totally unresponsive to exchange rate movements at least in the short run. This second approach is called "local currency pricing". According to the empirical literature, both assumptions seem extreme: Campa and Goldberg (2002) provide evidence in favor of a partial degree of pass-through in the short run that becomes complete in the long run. Thus we follow Monacelli (2005) and we assume a Calvo mechanism on the determination of prices in domestic currency of imported goods. Foreign goods are imported by domestic retailers who fix the price of imported goods in a staggered way. The degree of pass through θ_F is fixed exogenously and corresponds to the probability that price of imported goods optimally chosen today will still sty in place next period. Of course and endogenous determination of the degree of pass-through, as in Bacchetta and Van Wincoop (2005) among others, would be more elegant but given that this is not the core of our paper we see our choice as a useful simplification.

Under incomplete pass-through the law of one price does not hold anymore and the variable $\psi_{F,t}$ represents the wedge between the domestic price of imports $p_{F,t}$ and the price of the same goods in the world market:

$$\psi_{F,t} = (e_t + p_t^*) - p_{F,t} \tag{73}$$

This implies that equation (24) for the real exchange rate has to be rewritten as:

$$q_t = \psi_{F,t} + (1-\alpha)\, s_t \tag{74}$$

The deviation from the law of one price introduce a second deviation from PPP aside home bias in consumption.

As shown in Monacelli (2005) a sort of NKPC for import prices takes the place of the law of one price and has the following form:

$$\pi_{F,t} = \beta E_t \pi_{F,t+1} + \lambda_F \psi_{F,t} \tag{75}$$

where $\lambda_F = \frac{(1-\theta_F)(1-\beta\theta_F)}{\theta_F}$. When θ_F tends to 0 the preceding equation collapses to the law of one price equation $p_{F,t} = e_t + p_t^*$. In the appendix **(to be added)** we show the derivation of equation (75) from the maximization program of domestic retailers and we show how the wedge $\psi_{F,t}$ affects the other equations in the model. Here we test the robustness of our results with

respect to different degrees of exchange rate pass-through. From figure 7 we can see that even for low degrees of pass-through ($\theta_F = 0.75$) the conclusions of our model are not critically affected. The multipliers on the components of aggregate demand behave more like the closed economy case, the real exchange rate has to appreciate more to equilibrate the goods markets after the government spending shock. The variation in the terms of trade is now very low because of the additional stickiness in the price of imported goods but all the results of our simpler model are confirmed from a qualitative and quantitative point of view.

Thus we see this extension as a realistic improvement of the baseline model that, however, confirms all the results proposed above.

7 Conclusion

To conclude we include some comments that shed light on the aim of the paper and on its contribution to the existing literature.

As said before, the first contribution concerns the impact of a government spending shock in a New Keynesian Open Economy model. Fiscal policy issues in open economy have not been investigated in depth by the recent literature, and in particular in the New Keynesian literature. The model we built on integrates staggered pricing and endogenous monetary policy in a microfounded setting. Deviations from PPP and UIP allow a rich analysis of economic shocks in this framework. Our simulations confirm the main results of the Mundell-Flemming-Dornbush literature and in particular predict an appreciation of the nominal and real exchange rate and a bigger expansionary effect under fixed exchange rates.

The second contribution concerns the link between theory and empirical evidence. Recent empirical evidence provided by Perotti (2004) is compared with the model's implications. The model, among other things, is able to reproduce a low output level multiplier (lower than one) and decreasing in the degree of openness of the economy. This result is consistent with a negative reaction of net exports.

Still there is a puzzle on the impact of fiscal shocks on consumption: the baseline version of the model and its extensions with complementarity in the utility function cannot reproduce a positive effect in the closed economy and a lower effect in the open economy as it is observed in the data.

Two useful extensions of the model would be the integration of investment and the insertion of a non Ricardian feature in this open economy framework.

8 Appendix 1

Minimization of the expenditure, given the constant elasticity of substitution functions, implies the following demand functions:

$$C_{H,t}(j) = \left(\frac{P_{H,t}(j)}{P_{H,t}}\right)^{-\varepsilon} C_{H,t} \tag{76}$$

$$C_{i,t}(j) = \left(\frac{P_{i,t}(j)}{P_{i,t}}\right)^{-\varepsilon} C_{i,t} \tag{77}$$

$$C_{i,t} = \left(\frac{P_{i,t}}{P_{F,t}}\right)^{-\eta} C_{F,t} \tag{78}$$

$$C_{H,t} = (1-\alpha)\left(\frac{P_{H,t}}{P_t}\right)^{-\eta} C_t \tag{79}$$

$$C_{F,t} = \alpha\left(\frac{P_{F,t}}{P_t}\right)^{-\eta} C_t \tag{80}$$

given the following price indexes:

$$P_{H,t} \equiv \left(\int_0^1 P_{H,t}(j)^{1-\varepsilon}\, dj\right)^{\frac{1}{1-\varepsilon}} \tag{81}$$

(where $P_{H,t}$ is the domestic price index)

$$P_{i,t} \equiv \left(\int_0^1 P_{i,t}(j)^{1-\varepsilon}\, dj\right)^{\frac{1}{1-\varepsilon}} \tag{82}$$

(where $P_{i,t}$ is a price index for goods imported from country i expressed in domestic currency)

$$P_{F,t} \equiv \left(\int_0^1 {P_{i,t}}^{1-\eta} dj\right)^{\frac{1}{1-\eta}} \tag{83}$$

(where $P_{F,t}$ is a price index for imported goods expressed in domestic currency)

$$P_t \equiv \left[(1-\alpha)(P_{H,t})^{1-\eta} + \alpha(P_{F,t})^{1-\eta}\right]^{\frac{1}{1-\eta}} \tag{84}$$

(where P_t is the consumer price index (CPI) that is a weighted average of the domestic prices and imported goods prices. For future reference it is

important to distinguish between domestic prices and prices (CPI) because in the latter are included prices of imported goods.

equations imply that:

$$\int_0^1 P_{H,t}(j) C_{H,t}(j) dj = P_{H,t} C_{H,t} \tag{85}$$

$$\int_0^1 P_{i,t}(j) C_{i,t}(j) dj = P_{i,t} C_{i,t} \tag{86}$$

$$\int_0^1 P_{i,t} C_{i,t} di = P_{F,t} C_{F,t} \tag{87}$$

$$P_{H,t} C_{H,t} + P_{F,t} C_{F,t} = P_t C_t \tag{88}$$

Using the above equations we can write the budget constraint in a simpler way:

$$P_t C_t + E_t Q_{t,t+1} D_{t,t+1} + T_t \leq D_t + W_t N_t \tag{89}$$

(to be completed)

Using the relation because real marginal cost now looks like:

$$\hat{mc}_t = \left(\frac{1 + \varphi - \kappa}{\kappa} + \frac{\sigma_\alpha}{1 - \gamma} \right) x_t \tag{90}$$

$$\frac{\partial \tilde{y}_t}{\partial g_t} = \frac{\sigma_\alpha \gamma \kappa + (1 - \kappa)(1 + \varphi)(1 - \gamma)}{\sigma_\alpha \kappa + (1 + \varphi - \kappa)(1 - \gamma)} \tag{91}$$

$$\frac{\partial \tilde{rr}_t}{\partial g_t} = \left(\frac{\gamma (1 + \varphi - \kappa) - (1 - \kappa)(1 + \varphi)}{\sigma_\alpha \kappa + (1 + \varphi - \kappa)(1 - \gamma)} \right) (1 - \rho_g) \sigma_\alpha \tag{92}$$

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Fig.1a Impulse Responses to a Goverment spending Shock (alfa=0.4)

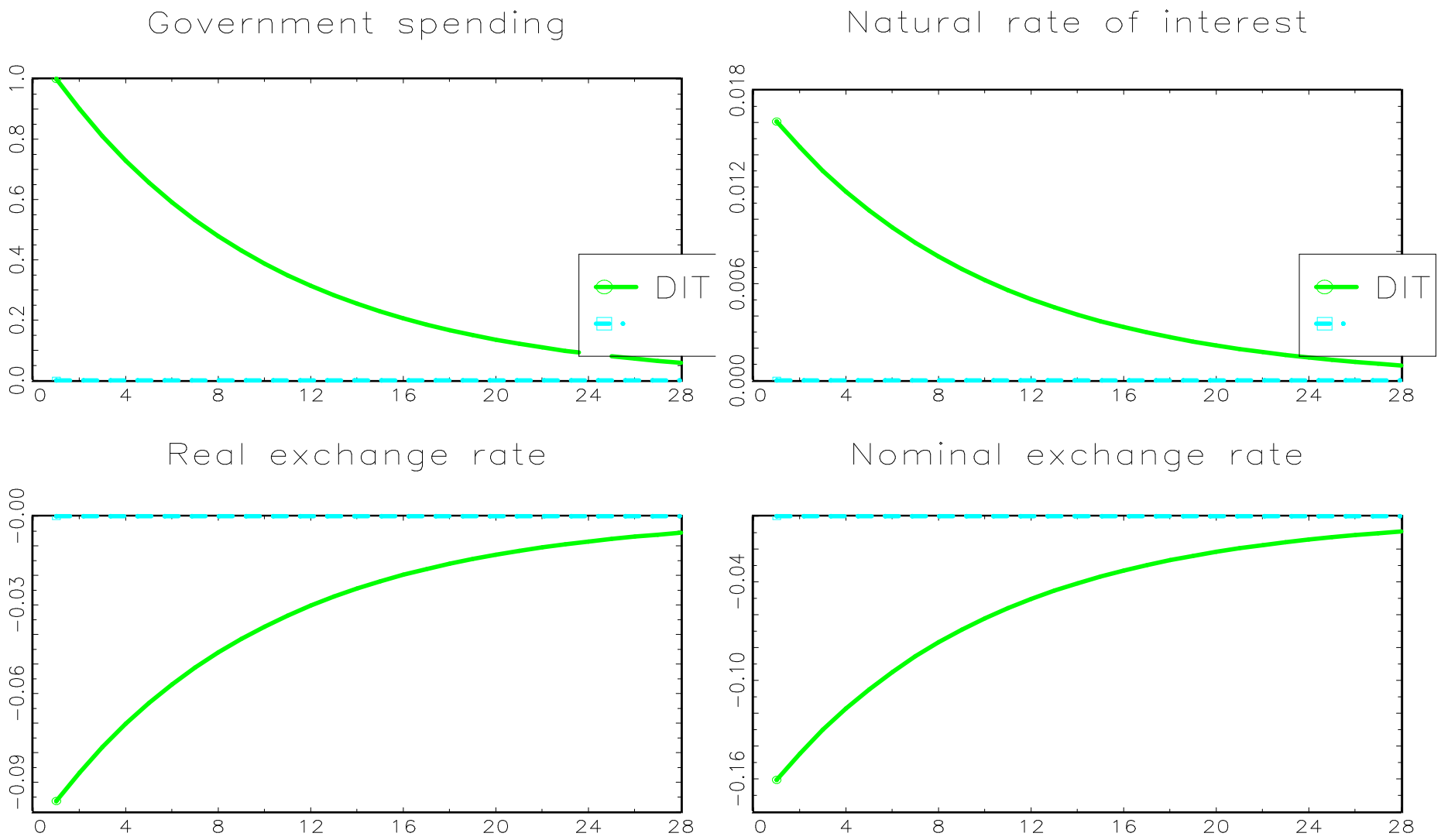

Fig.1b Impulse Responses to a Goverment spending Shock (alfa=0.4)

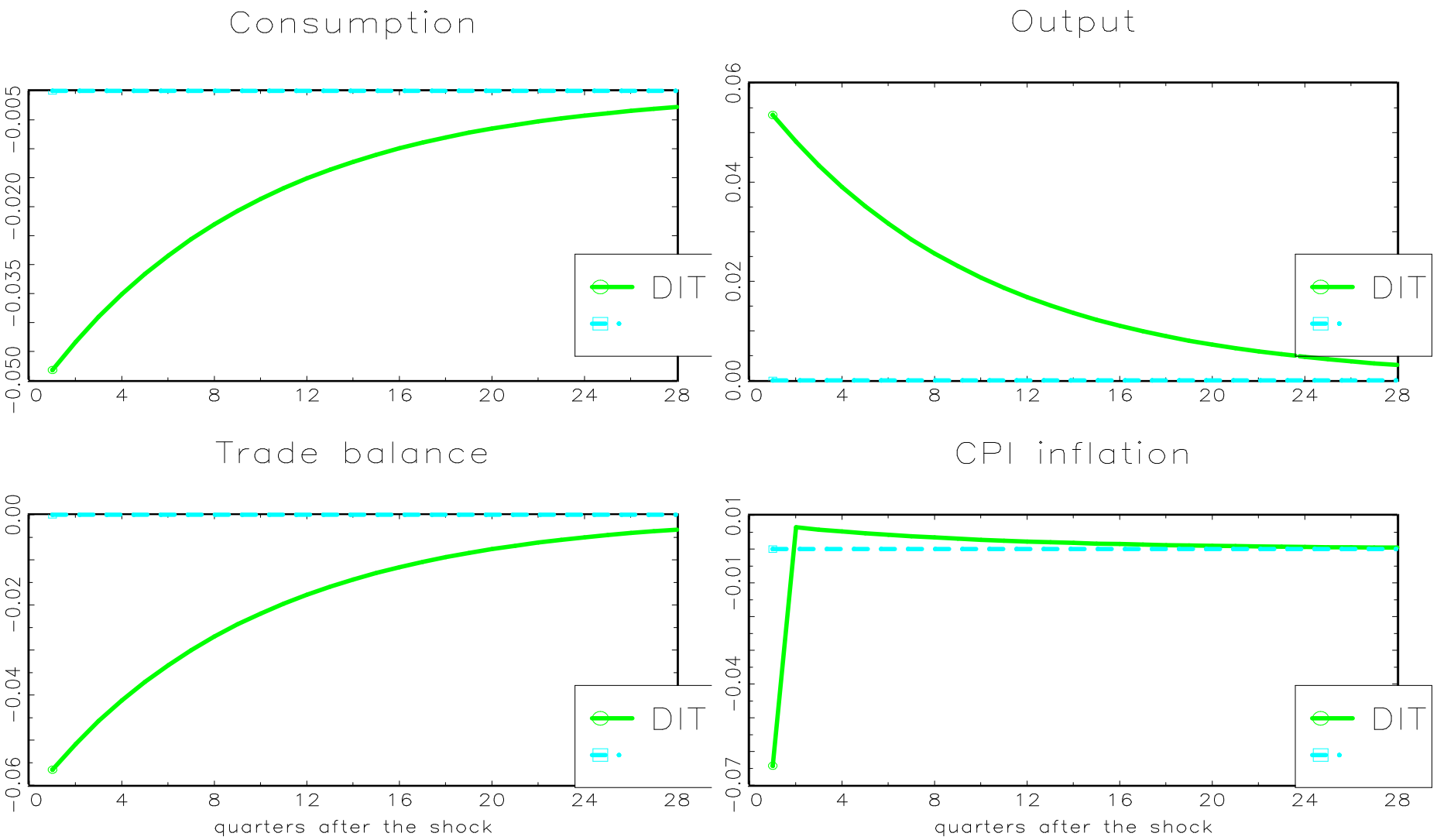

Fig.2 closed vs open economy vs PPP

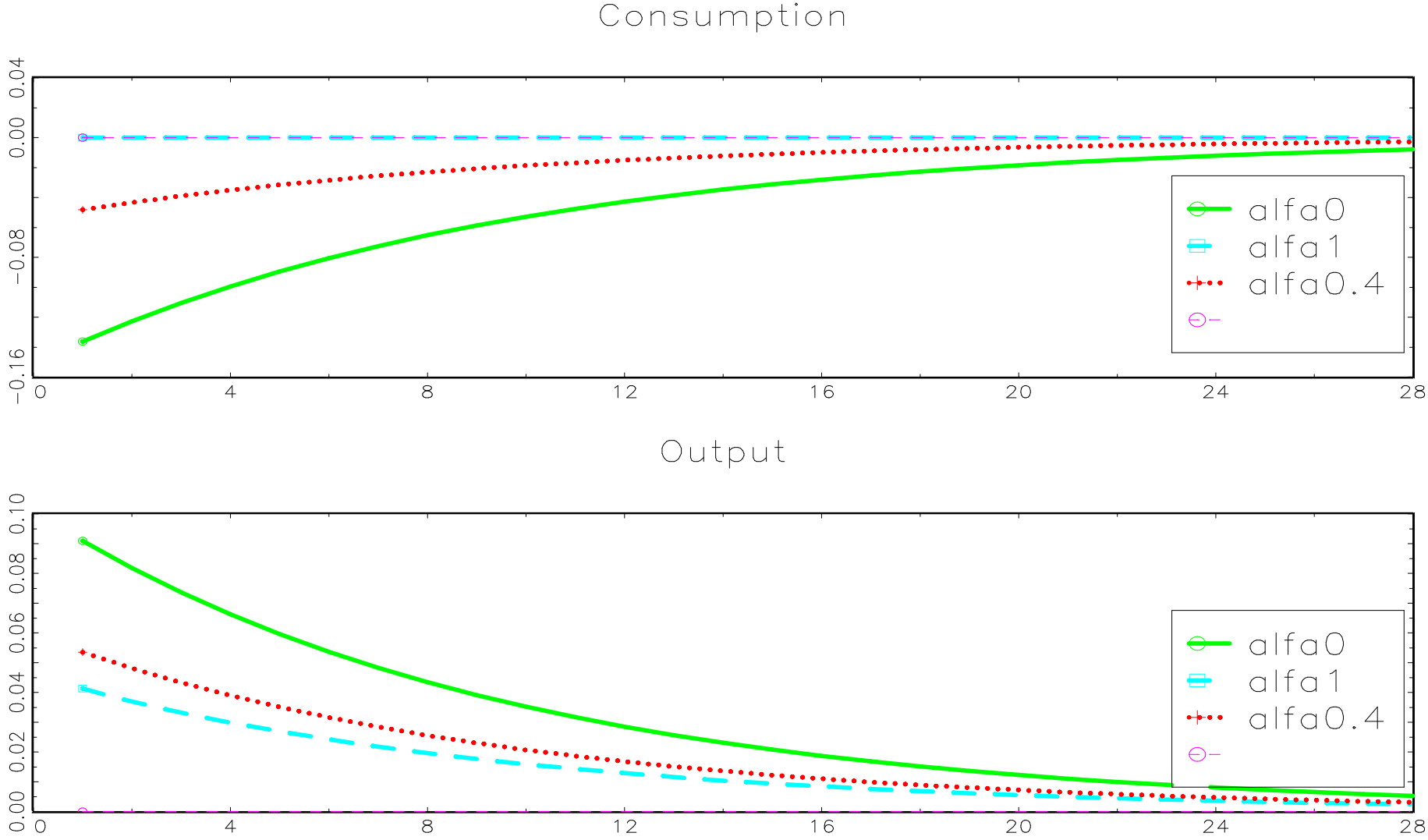

Fig.3a Impulse Responses to a Goverment spending Shock (alfa=0.4)

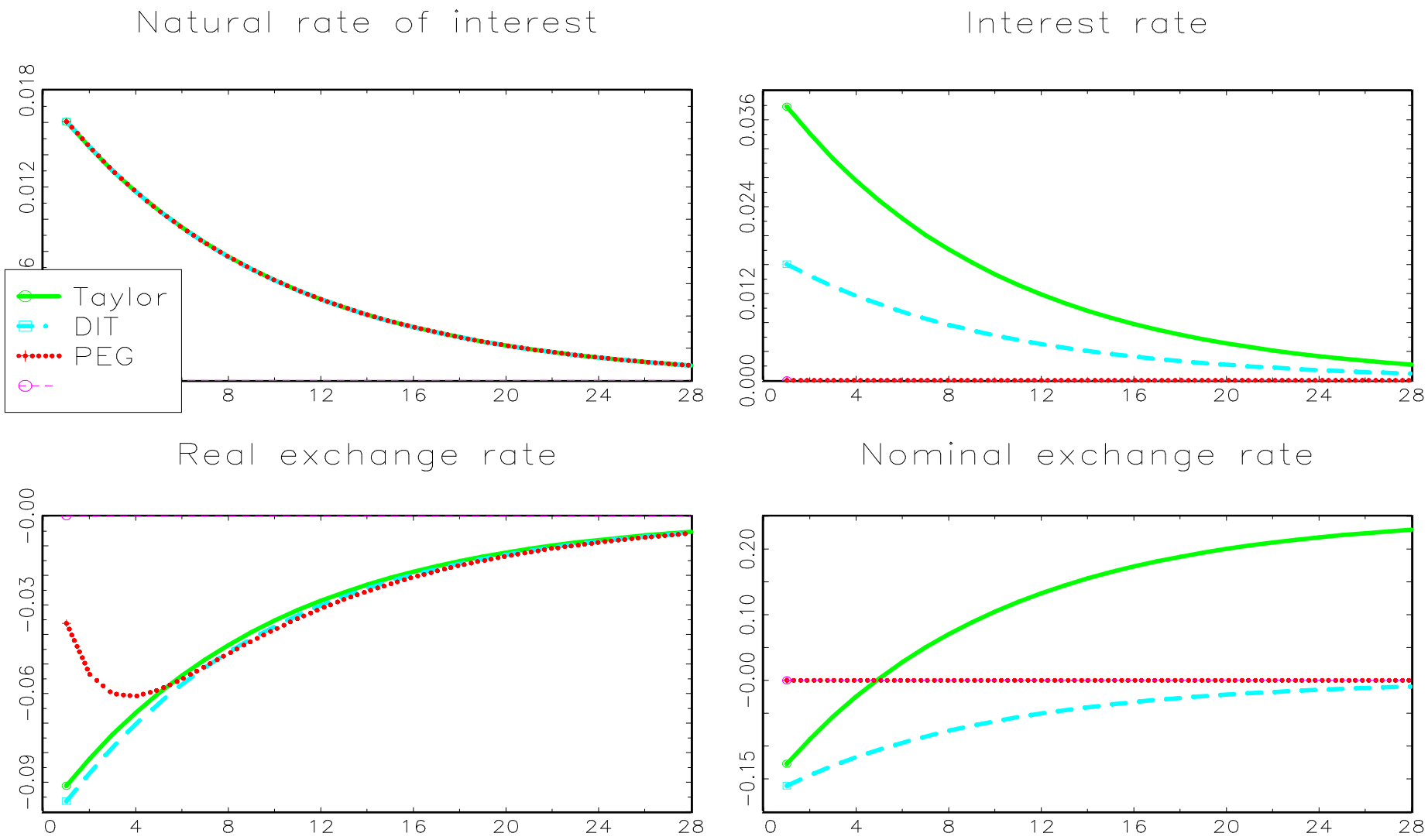

Fig.3b Impulse Responses to a Goverment spending Shock (alfa=0.4)

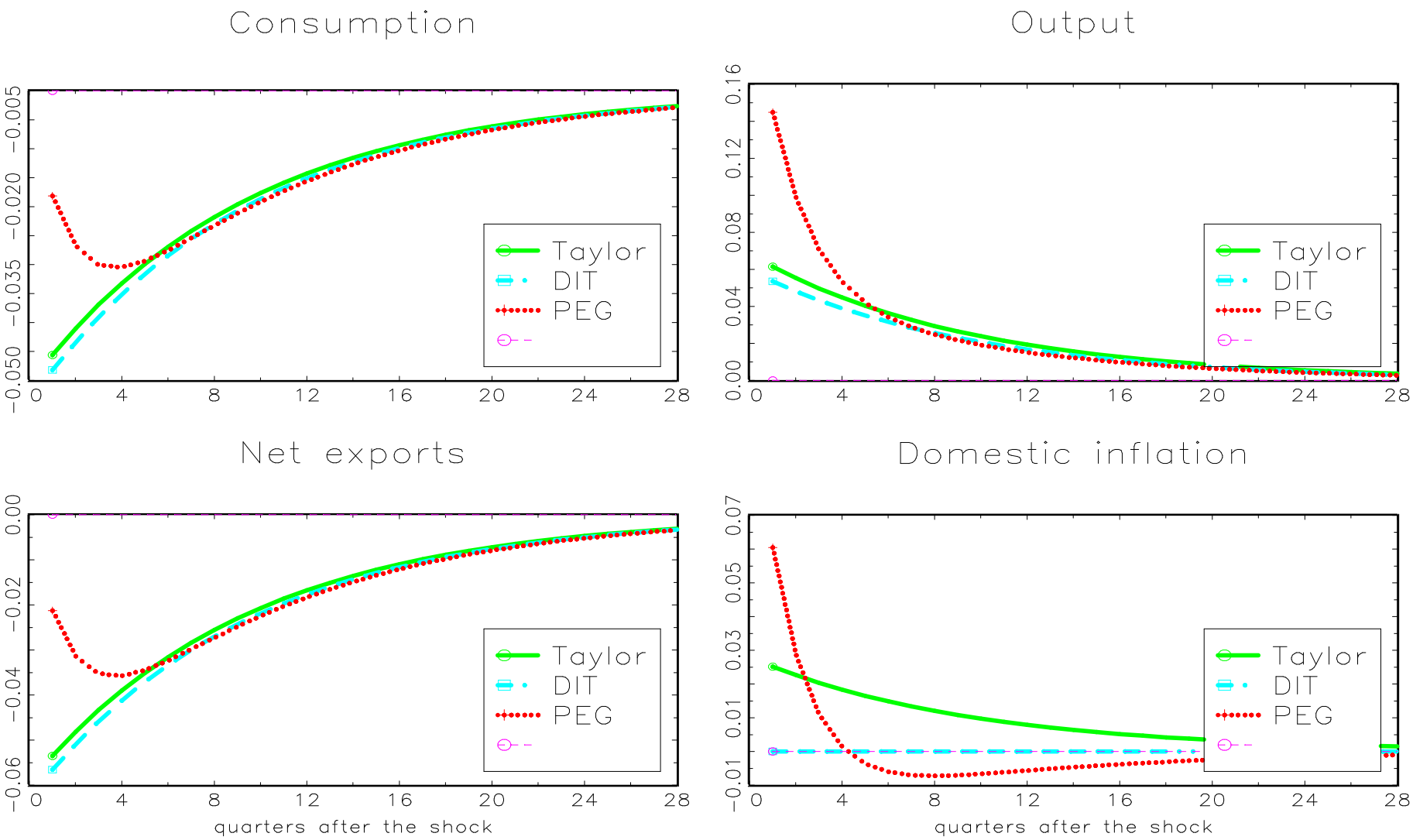

Fig.4 Impulse Responses to a Goverment spending Shock (exog money)

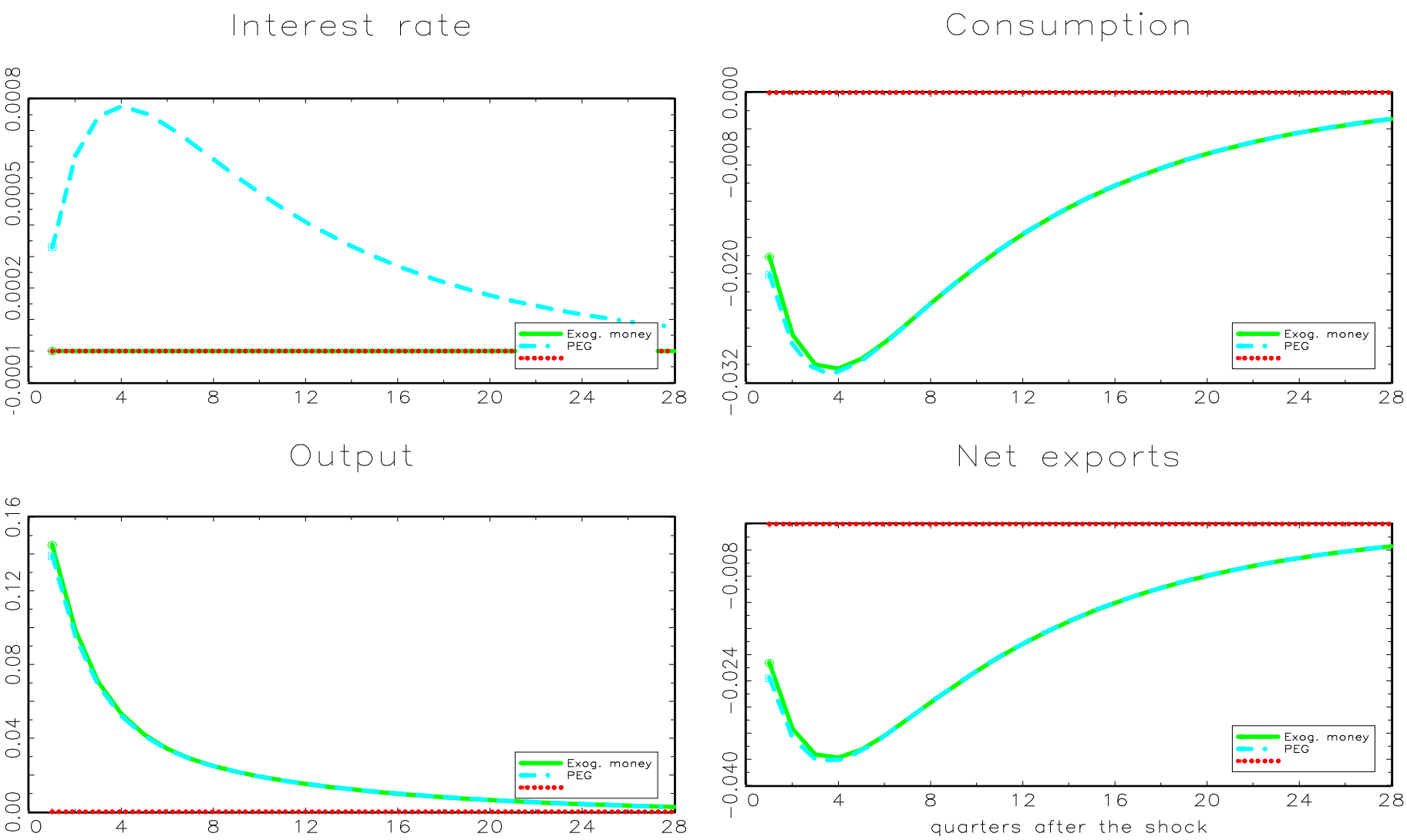

Fig.5 Complementarity and substitutability

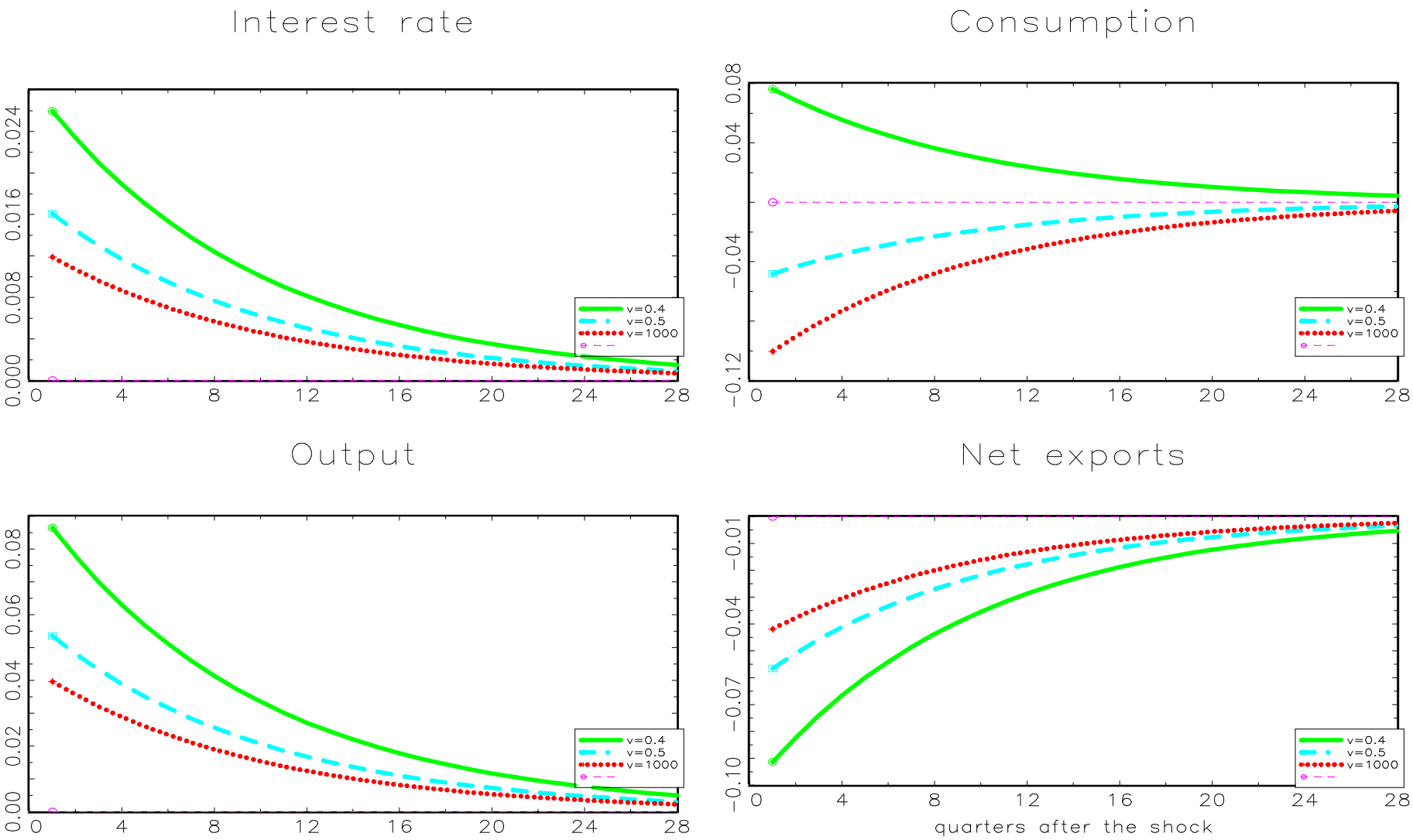

Fig.6 Complete vs incomplete pass—through

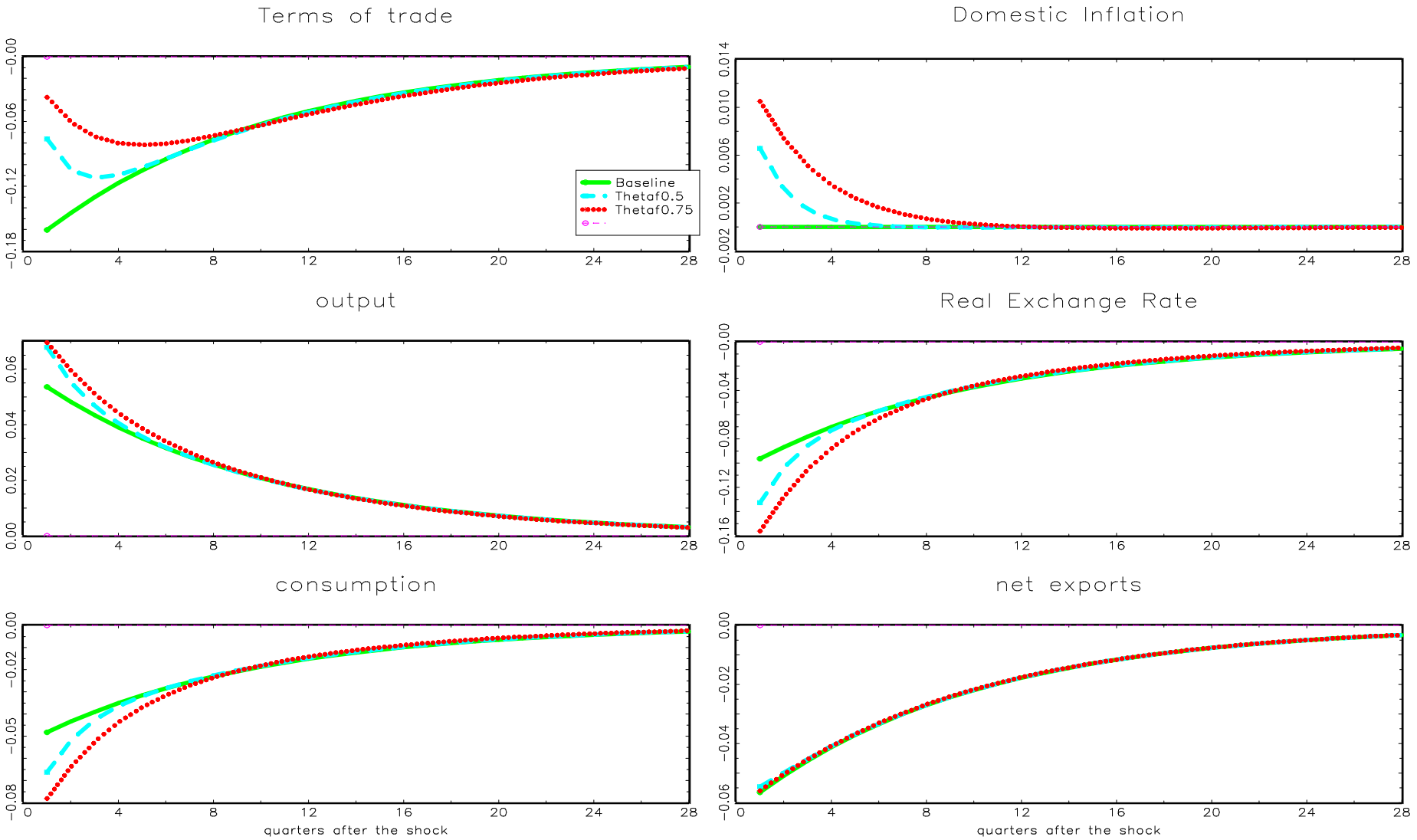

Fig.7 Productive government spending vs baseline