International Dimensions of Fiscal Policy Transmission*

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Abstract

The global integration of goods and asset markets alters alters how fiscal shocks impact the economy and are propagated across countries. Using standard business cycle analysis we explore this international dimension of fiscal policy transmission. Most importantly, we find that the smaller and the more open an economy, the more likely will private investment rise following a fiscal expansion. This is because it appreciates the terms of trade and lowers the price of capital goods in terms of their return. An immediate implication is that smaller and more open economies are more likely to experience twin deficits.

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1 Introduction

As the global economy is becoming increasingly integrated, it is crucial to account for international repercussions in fleshing out the fiscal transmission mechanism. In the present paper, we analyze how the international dimension, i.e. the size of a country relative to its trading partners, its integration into world markets and its risk sharing arrangements with the rest of the world fundamentally alters the fiscal transmission mechanism.

Our analysis is based on a standard two good international business cycle model similar to those studied by Backus, Kehoe and Kydland (1994), Heathcote and Perri (2002) or Chari, Kehoe and McGrattan (2002). We add some additional features in order to provide a quantitatively realistic account of the fiscal transmission mechanism. Most importantly, our framework allows us to study the role of country size and goods market integration in some detail. This aspect is reflected in a varying import content in final goods, both across countries and usage as private or public consumption goods or as capital goods. Goods market integration is thus closely related to the openness of a country and is modeled as resulting from home bias in preferences, see Obstfeld and Rogoff (2000) for an alternative modeling approach to limited goods market integration based on trading costs.

We calibrate the model to match key features of U.S. data and its trading parters and, alternatively, of U.K. data and its trading partners. On the basis of year 2005 data, both countries account for approximately 36 and 6 percent of OECD output, respectively. In addition, the import content in GDP is more than twice as high in the U.K. While both countries display considerable homogeneity in economic structure, they thus differ substantially in the international dimension as regards size and goods market integration. It is therefore instructive to study the difference in fiscal transmission implied by both parameterizations of the model. We refer to the home country in the two country model as either the 'U.S.' and the 'U.K.', depending on the parameterization under consideration.

As a benchmark scenario we consider exogenous variations in purely dissipative government spending and restrict international asset markets to trade in non-contingent bonds. As public expenditure mostly falls on domestically produced goods, an increase in public purchases raises the price of domestic goods relative to goods imported from abroad, i.e. it appreciates the terms of trade. This appreciation has several implication for the fiscal transmission mechanism as discussed in detail below. However, given earlier evidence obtained from vector autoregressions in Corsetti and Müller (2006), we particularly focus on how the adjustment of private investment to fiscal shocks is affected by terms of trade movements.

A central result of our analysis is that the sign of the response of private investment to the fiscal shock differs in both calibrations of the model: it increases in the U.K. and falls considerably in the U.S. scenario. We also find a substantially larger decline in the U.K. trade balance in response to the shock. In inspecting the transmission mechanism, we find a systematic interaction of goods market

integration and size shaping the dynamic adjustment to the fiscal innovation. The smaller and the more open an economy, the more likely is investment to increase in response to a fiscal shock and the stronger the fall in the trade balance. Our analysis is therefore related to the recent debate on the size and determinants of twin deficits, see, for instance Kim and Roubini (2003), Erceg, Guerrieri and Gust (2005) and Corsetti and Müller (2006).

To understand these results we follow earlier research which has distinguished wealth and substitution effects in dissecting the fiscal transmission mechanism, see King (1991), Baxter and King (1993) and Finn (1998) for a closed economy analysis and Baxter (1995) for an open economy model. Clearly, the international dimension possibly alters the wealth effects of (fiscal) shocks fundamentally. If, for instance, country specific shocks are completely insured across countries, an increase in government spending in an economy which accounts only for a small fraction of world output will have a relatively small wealth effect in per capita terms. Within a two good model, such risk sharing may be either the result of explicit state contingent contracts or achieved through movements of the terms of trade. In addition, the degree goods market integration may also have a bearing on the wealth effects induced by fiscal shocks.

A systematic assessment, however, reveals that wealth effects are unlikely to account for much of the difference in the transmission of fiscal shocks in the U.S. and the U.K. scenario under consideration. For the range plausible parameter values, the actual differences in size and openness make little difference for the wealth effects on consumption and labor supply in the calibrated versions of the model. Instead, we find that a direct effect of relative prices on investment decisions is key to account for the observed difference. As the import content in capital goods is high in the U.K. an appreciation of the terms of trade induced by a fiscal shock lowers the price of capital goods relative to the return earned on these goods and therefore stimulates investment. More generally, if an economy is relatively open, i.e. if the import content in capital goods is high, a terms of trade appreciation tends to crowd-in private investment.

A second important channel through which both size and openness affect the transmission mechanism is the response of the interest rate. Intuitively, the smaller the economy, the smaller the effect of the fiscal shock on the domestic interest rate. Note however, that openness also matters for the effect on the interest rate. If the import content in private consumption is low, the price of domestic consumption will generally be different from the price of foreign consumption. As a result there will be a differential in the consumption based interest rate emerging in response to a terms of trade appreciation. We intend to provide further evidence on the exact quantitative contributions of the different effects.

The remainder of the paper is organized as follows. Section 2 outlines the model. Section 3 discusses how openness and size may impact on the transmission mechanism mostly via investment. Section 4

calibrates the model using data for the U.S. and the U.K. and computes several numerical experiments. Section 5 concludes.

2 Model Setup

In this section, we outline a two good, two country business cycle model. It is similar to the models proposed by Backus et al. (1994) or Heathcote and Perri (2002) and Chari et al. (2002). As the latter, we also consider price rigidities, albeit of the Calvo type. Moreover, we allow for possible differences in country size and for the possibility that the composition of final goods depends on their use for either private and public consumption or investment, a point recently stressed by Erceg, Guerrieri and Gust (2006) when studying current account adjustment. Corsetti and Müller (2006) provide evidence for the empirical relevance of such a distinction.

The world economy consists of two countries. The countries are symmetric but may differ in size, i.e. in steady state per capita quantities are identical across countries and trade is balanced. In what follows we denote the population of country $i \in \{1, 2\}$ by N_i and measure the relative size of county 1 as $n = N_1/N_2$. We also refer to country 1 as the domestic economy or as 'home' and to country 2 as 'foreign'. In the following we describe in some detail the good market structure and then turn to the problems of the household and firms, before discussing the conduct of monetary and fiscal policies.

2.1 Good Market Structure

Final goods - used for either private consumption, investment or government consumption - are bundles of monopolistically produced goods. The weight of domestic and foreign goods in the composition of final goods may differ depending on the usage. In each period, final good consumers assemble monopolistically produced goods such as to minimize expenditures for a given level of final good consumption. These inputs are produced by a continuum of firms in both countries. We use $j \in [0, 1]$ to index those firms (or their products and prices). Specifically, let F_{it}, with $F \in \{C, X, G\}$, denote the final good basket used for either household consumption, government consumption or investment. Further, let $A^F_{it}(j)$ and $B^F_{it}(j)$, denote the amount of good j, originally produced in country 1 and 2, respectively, used in country i to assemble final good F. Then final good baskets are defined as

follows

$$F_{it} = \begin{cases} \left[\begin{array}{l} \left(\omega_F^1\right)^{\frac{1}{\sigma}} \left(\left[\int_0^1 A_{1t}^F(j)^{\frac{\epsilon-1}{\epsilon}} dj \right]^{\frac{\epsilon}{\epsilon-1}} \right)^{\frac{\sigma-1}{\sigma}} \\ + \left(1-\omega_F^1\right)^{\frac{1}{\sigma}} \left(\left[\int_0^1 B_{1t}^F(j)^{\frac{\epsilon-1}{\epsilon}} dj \right]^{\frac{\epsilon}{\epsilon-1}} \right)^{\frac{\sigma-1}{\sigma}} \end{array} \right]^{\frac{\sigma}{\sigma-1}}, \text{ for } i=1 \\ \left[\begin{array}{l} \left(\omega_F^2\right)^{\frac{1}{\sigma}} \left(\left[\int_0^1 B_{2t}^F(j)^{\frac{\epsilon-1}{\epsilon}} dj \right]^{\frac{\epsilon}{\epsilon-1}} \right)^{\frac{\sigma-1}{\sigma}} \\ + \left(1-\omega_F^2\right)^{\frac{1}{\sigma}} \left(\left[\int_0^1 A_{2t}^F(j)^{\frac{\epsilon-1}{\epsilon}} dj \right]^{\frac{\epsilon}{\epsilon-1}} \right)^{\frac{\sigma-1}{\sigma}} \end{array} \right]^{\frac{\sigma}{\sigma-1}}, \text{ for } i=2 \end{cases} \tag{2.1}$$

where σ measures the elasticity of substitution between foreign and domestic goods and ϵ measures the elasticity of substitution between goods produced within the same country. The parameter ω_F^i denotes the home bias in final goods.

Let $P_{it}^A(j)$ denote the price in country i of a generic good produced in county 1 and let $P_{it}^B(j)$ denote the price in country i of a generic good produced in county 2. Then, letting S_t denote the nominal exchange rate and assuming that the law of one price holds, we have

$$P_{1t}^B(j) = S_t P_{2t}^B(j); \quad P_{1t}^A(j) = S_t P_{2t}^A(j). \tag{2.2}$$

The price indices for final good baskets are given by

$$P_{it}^F = \begin{cases} \left[\omega_F^1 \left(P_{1t}^A\right)^{1-\sigma} + \left(1-\omega_F^1\right) \left(P_{1t}^B\right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}, & \text{for } i=1 \\ \left[\left(1-\omega_F^2\right) \left(P_{2t}^A\right)^{1-\sigma} + \omega_F^2 \left(P_{2t}^B\right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}, & \text{for } i=2 \end{cases}, \tag{2.3}$$

where

$$P_{it}^A = \left(\int_0^1 P_{it}^A(j)^{1-\epsilon} dj \right)^{\frac{1}{1-\epsilon}} \text{ and } P_{it}^B = \left(\int_0^1 P_{it}^B(j)^{1-\epsilon} dj \right)^{\frac{1}{1-\epsilon}} \tag{2.4}$$

denotes the producer price index (PPI) in home and foreign, respectively. The domestic and foreign demand for domestically and foreign produced goods is given by:

$$A_{1t} = \sum_{F \in \{C,X,G\}} \omega_F^1 \left(\frac{P_{1t}^A}{P_{1t}^F} \right)^{-\sigma} F_{1t}, \tag{2.5}$$

$$B_{1t} = \sum_{F \in \{C,X,G\}} \left(1-\omega_F^1\right) \left(\frac{P_{1t}^B}{P_{1t}^F} \right)^{-\sigma} F_{1t}, \tag{2.6}$$

$$B_{2t} = \sum_{F \in \{C,X,G\}} \omega_F^2 \left(\frac{P_{2t}^B}{P_{2t}^F} \right)^{-\sigma} F_{2t}, \tag{2.7}$$

$$A_{2t} = \sum_{F \in \{C,X,G\}} \left(1-\omega_F^2\right) \left(\frac{P_{2t}^A}{P_{2t}^F} \right)^{-\sigma} F_{2t}. \tag{2.8}$$

Note that A_{2t} and B_{1t} corresponds to domestic exports and imports in terms of per capita values of country 2 and country 1 respectively. Global demand for a generic good j produced in country i is

then given by

$$Y_{it}^D(j) = \begin{cases} \left(\frac{P_{1t}^A(j)}{P_{1t}^A}\right)^{-\epsilon} \left[A_{1t} + \frac{1}{n}A_{2t}\right], & \text{for } i = 1 \\ \left(\frac{P_{2t}^B(j)}{P_{2t}^B}\right)^{-\epsilon} \left[nB_{1t} + B_{2t}\right], & \text{for } i = 2 \end{cases}. \tag{2.9}$$

Finally, for future reference, we define an index for aggregate production in country i:

$$Y_{it} = \left(\int_0^1 Y_{it}(j)^{\frac{\epsilon-1}{\epsilon}} dj\right)^{\frac{\epsilon}{\epsilon-1}}, \tag{2.10}$$

where $Y_{it}(j)$ denotes actual production of firm j in country i.

2.2 Households

A representative household in country i allocates consumption expenditures on final goods, C_{it}, and supplies labor, H_{it}, to monopolistic firms. Preferences are given by

$$E_0 \sum_{t=0}^{\infty} \bar{\beta}_{it} U(C_{it}, H_{it}) \tag{2.11}$$

$$\bar{\beta}_{i0} = 1 \tag{2.12}$$

$$\bar{\beta}_{it+1} = \beta(\bar{C}_{it}, \bar{H}_{it})\bar{\beta}_{it}, \qquad t \geq 0, \tag{2.13}$$

with $\beta_{\bar{C}} > 0$ and $\beta_{\bar{H}} < 0$. Here the discount factor is endogenous such that discounting is higher if *average* consumption and leisure are above their steady state values.[1]

Labor and capital are internationally immobile; households in each country own the capital stock K_{it} of that country. It may be costly to adjust the level of investment, X_{it}, as in Christiano, Eichenbaum and Evans (2005). Specifically, the law of motion for capital is given by

$$K_{it+1} = (1-\delta)K_{it} + \Phi(X_{it}, X_{it-1}), \tag{2.14}$$

where δ denotes the depreciation rate. The function Φ governs the transformation of current and past investment into new installed capital, see Christiano et al. (2005).

As a baseline scenario, we consider the case that only nominal non-contingent bonds, Θ_{it}, denominated in the currency of country i, are traded across countries (incomplete financial markets). The budget constraint of the representative household in country i reads as

$$\begin{aligned} & (1-\tau_{it})(W_{it}H_{it} + R_{it}K_{it} + \Upsilon_{it}) + T_{it} - P_{it}^C C_{it} + P_{it}^X X_{it} \\ = & \begin{cases} \left(\frac{\Theta_{1t+1}+D_{1t+1}}{1+i_{1t}} + \frac{S_t\Theta_{2t+1}}{1+i_{2t}} - \Theta_{1t} - D_{1t} - S_t\Theta_{2t}\right), & \text{for } i = 1 \\ \left(\frac{\Theta_{2t+1}+D_{2t+1}}{1+i_{2t}} + \frac{\Theta_{1t+1}}{(1+i_{1t})s_t} - \Theta_{2t} - D_{2t} - \Theta_{1t}/S_t\right), & \text{for } i = 2 \end{cases}, \end{aligned} \tag{2.15}$$

[1] See Schmitt-Grohé and Uribe (2003) for further discussion and Corsetti, Dedola and Leduc (2004) for an application in a two country model.

where W_{it} and R_{it} denote the nominal wage rate and the rental rate of capital and Υ_{it} denote nominal profits earned by monopolistic firms and transferred to households, which are the owner of the firms. τ_{it} denotes the tax rate on the household's income; P_{it}^C and P_{it}^X denote the price of final consumption and investment goods, respectively; T_{it} denotes lump-sum transfers from the government; i_{it} denotes the nominal interest rate denominated in the currency of country i and D_{it} denotes debt issued by the government in country i held by domestic residents.

2.3 Firms

In each country, there is a continuum of firms each of which produces a unique good. A generic firm $j \in [0,1]$ in country i engages in monopolistic competition, given the demand functions (2.9). Production is Cobb-Douglas

$$Y_{it}(j) = Z_{it} K_{it}(j)^{\theta} H_{it}(j)^{1-\theta}, \tag{2.16}$$

where Z_{it} denotes technology common to all firms. $H_{it}(j)$ and $K_{it}(j)$ denote labor and capital employed by firm j. Minimizing the costs of producing intermediate goods implies for (nominal) marginal costs):[2]

$$MC_{it}(j) = MC_{it} = \frac{W_{it} H_{it}(j)}{(1-\theta) Y_{it}(j)} = \frac{R_{it} K_{it}(j)}{\theta Y_{it}(j)}, \tag{2.17}$$

where the first equality follow from the fact that as factors of production can be freely adjusted in each period and production has constant returns to scale. Therefore marginal costs are independent of the level of production and identical across firms.

We assume that price setting is constrained exogenously by a discrete time version of the mechanism suggested by Calvo (1983). Each firm has the opportunity to change its price with a given probability $1-\xi$. When a firm has the opportunity, it sets the new price in order to maximize the expected discounted value of net profits. In setting the new price $P_{1t}^A(j)$ and $P_{2t}^B(j)$ in country 1 and 2, respectively, the problem of a generic intermediate good firm j is given by

$$\max \sum_{k=0}^{\infty} \xi^k E_t \begin{cases} \rho_{it,t+k} Y_{it+k}^d(j) \left[P_{it}^A(j) - MC_{it+k} \right] / P_{it+k}^C, & \text{for } i = 1 \\ \rho_{it,t+k} Y_{it+k}^d(j) \left[P_{it}^B(j) - MC_{it+k} \right] / P_{it+k}^C, & \text{for } i = 2 \end{cases} \tag{2.18}$$

subject to demand functions defined by (2.9), the production function (2.16), the optimality condition on factor inputs (2.17) as well as the constraint that the demand of intermediate good j is satisfied, i.e. $Y_{it}^D(j) = Y_{it}(j)$. Profits are discounted with the factor $\rho_{it,t+k}$. As firms are owned by households, we assume

$$\rho_{it,t+k} = \frac{\bar{\beta}_{it+k-1} U_C(C_{it+k}, H_{it+k})}{\bar{\beta}_{it} U_C(C_{it}, H_{it})}. \tag{2.19}$$

[2] This follows from the problem $\min_{H_{it}(j), K_{it}(j)} (W_{it} H_{it}(j) + R_{it} K_{it}(j))$ s.t. $Z_{it} K_{it}(j)^{\theta} H_{it}(j)^{1-\theta} \geq Y_{it}^D(j)$, where $MC_{it}(j)$ is the multiplier on the constraint.

2.4 Government Policies

The budget constraint of the government in country i is given by

$$D_{it} - \frac{D_{it+1}}{1+i_{it}} + T_{it} = \tau_{it}(W_{it}H_{it} + R_{it}K_{it} + \Upsilon_{it}) - P_{it}^{G}G_{it}. \tag{2.20}$$

As in Kollmann (1998) assume that government spending and possibly the tax rate adjust are adjusted to stabilize government debt

$$G_{it} = G_{it}^{a}D_{it}^{-\phi_g} \tag{2.21}$$

Similarly,

$$\tau_{it} = \tau_{it}^{a}D_{it}^{\phi_\tau}, \tag{2.22}$$

where $\ln(G_{it}^{a})$ and $\ln(\tau_{it}^{a})$ follow an AR(1) process and $\phi_g, \phi_\tau \geq 0$. In the numerical simulation of the model we choose values for those elasticities such that government debt eventually returns to its steady state level. Alternatively, we employ the assumption that the government budget is balanced in each period through appropriately adjusted lump-sum transfers.

Letting $\Pi_{it} = P_{it}^{C}/P_{it-1}^{C}$ denote consumer price inflation, monetary policy is characterized by an interest feedback rule such that

$$1 + i_{it} = (1 + i_{it-1})^{\rho_i}\Pi_{it}^{\phi_\pi(1-\rho_i)}, \tag{2.23}$$

with $\rho_i \geq 0$ capturing interest rate smoothing and $\phi_\pi > 0$ capturing the long-run adjustment of interest rate to consumer price inflation.

2.5 Equilibrium

The equilibrium is a set of prices and quantities for all $t \geq 0$ such that - given the shock processes, initial conditions for the state variables and the policy rules of the government - i) households maximize (2.11) subject to the capital accumulation equation (2.14) and to the budget constraint (2.15); ii) firms solve (2.18); and iii) markets clear: goods market clearing is imposed as a constraint on monopolistic firms, such that $Y_{it}^{D}(j) = Y_{it}(j)$ for all j. Market clearing on factor markets requires

$$H_{it} = \int_0^1 H_{it}(j)dj \tag{2.24}$$

$$K_{it} = \int_0^1 K_{it}(j)dj; \tag{2.25}$$

and the asset market clears by Walras' law.

2.6 Additional variables of interest and functional forms

Taking the perspective of country 1, it is convenient to define the terms of trade as the price of imports relative to the price of exports

$$P_t = P_{1t}^B / P_{1t}^A; \tag{2.26}$$

the real exchange rate as

$$RX_t = S_t P_{2t}^C / P_{1t}^C; \tag{2.27}$$

and the trade balance as total exports less total imports over total output

$$NX_t = \frac{N_2 P_{1t}^A A_{2t} - N_1 P_{1t}^B B_{1t}}{N_1 P_{1t}^A Y_{1t}}. \tag{2.28}$$

We make the follow assumptions regarding functional forms for the preferences of the household:

$$U(C_{it}, H_{it}) = \frac{[C_{it}^{\mu}(1 - H_{it})^{1-\mu}]^{1-\gamma}}{1-\gamma}, \tag{2.29}$$

$$\beta(\bar{C}_{it}, \bar{H}_{it}) = \left(1 + \psi[\bar{C}_{it}^{\mu}(1 - \bar{H}_{it})^{1-\mu}]\right)^{-1}. \tag{2.30}$$

The parameter γ measures the degree of risk aversion and the parameter μ measures the weight of consumption in the utility function relative to leisure. The parameter ψ determines how the discount factor responds to the level of consumption and leisure; it pins down the value of the discount factor in steady state.

Regarding investment adjustment costs, we assume

$$\Phi = [1 - \Psi(X_{it}/X_{it-1}))]X_{it}. \tag{2.31}$$

Restricting $\Psi(1) = \Psi'(1) = 0$ and $\chi = \Psi''(1) > 0$ ensures that the steady state capital stock is independent of investment adjustment costs captured by the parameter χ.

3 Openness and Size

In this section, we provide some theoretical considerations into the role of goods market integration and its interaction with the terms of trade in the fiscal transmission mechanism. We then briefly and informally discuss the role of the country size.

3.1 The terms of trade and investment

In this section we consider in more detail the first order condition for investment. We abstract from adjustment costs, price rigidities and focus on country 1. Our numerical experiments below will establish whether the mechanism discussed in the current section is quantitatively relevant in a properly calibrated model.

Optimality of investment requires

$$\lambda_{1t}\frac{P_{1t}^X}{P_{1t}^C}=\beta_{1t}E_t\left\{(1-\tau_{1t+1})\lambda_{1t+1}\frac{R_{1t+1}}{P_{1t+1}^C}+\lambda_{1t+1}\frac{P_{1t+1}^X}{P_{1t+1}^C}(1-\delta)\right\}, \tag{3.1}$$

where λ_{1t} denotes the multiplier on the budget constraint, measuring marginal utility of income. Note that, absent price rigidities

$$R_{1t}=\frac{\epsilon-1}{\epsilon}P_{1t}^A\theta\frac{Y_{1t}}{K_{1t}} \tag{3.2}$$

Substituting for R_{1t+1} in (3.1) using (3.2), imposing the appropriate transversality condition when iterating forward gives

$$\frac{P_{1t}^X}{P_{1t}^C}=E_t\left\{\sum_{j=1}^{\infty}\frac{\beta_{1t+j-1}\lambda_{1t+j}}{\lambda_{1t}}\frac{P_{1t+j}^A}{P_{1t+j}^C}\frac{\epsilon-1}{\epsilon}\theta(1-\tau_{1t+j})\frac{Y_{t+j}}{K_{t+j}}(1-\delta)^{j-1}\right\}. \tag{3.3}$$

To simplify, we define the physical net return to investment period $t+j$ as $MPK_{t+j}=\frac{\epsilon-1}{\epsilon}\theta(1-\tau_{1t+j})\frac{Y_{t+j}}{K_{t+j}}(1-\delta)^{j-1}$ and recall the definition of the discount factor (2.19) such that (3.3) reads as

$$\frac{P_{1t}^X}{P_{1t}^C}=E_t\sum_{j=1}^{\infty}\rho_{1t,t+j}\frac{P_{1t+j}^A}{P_{1t+j}^C}MPK_{t+j} \tag{3.4}$$

This expression gives new insights into how home bias is key to understand the investment decision in the face of terms of trade movements. In particular, here we aim to understand the distinct role of home bias in consumption and/or investment. We consider three cases.

Case I: $\omega_c=\omega_x<1$ In other words, both consumption and investment goods have the same import content. We discuss this case at length in Corsetti and Müller (2006). In this case $P_{1t}^X=P_{1t}^C$ such that (3.4) simplifies to

$$1=E_t\sum_{j=1}^{\infty}\rho_{1t,t+j}\frac{P_{1t+j}^A}{P_{1t+j}^C}MPK_{t+j} \tag{3.5}$$

In this case, an increase in the relative price of domestically produced goods induced by an increase in domestic government spending implies $P_{1t+j}^A>P_{1t+j}^C$. Hence, ceteris paribus, a rise in the terms of trade will raise investment more, if home bias is small (i.e. the capital goods sector has a high import content) in order to lower MPK_{t+j} such that (3.5) continues to hold.

Case II: $\omega_x<\omega_c=1$ In other words, we consider a case with complete home bias in consumption, but some import content in capital expenditures. In this case $P_{1t+j}^A=P_{1t+j}^C$ such that (3.4) simplifies to

$$\frac{P_{1t}^X}{P_{1t}^A}=E_t\sum_{j=1}^{\infty}\rho_{1t,t+j}MPK_{t+j} \tag{3.6}$$

Now, given an increase in the price of domestically produced goods $P_{1t}^X < P_{1t}^A$, i.e. capital goods are cheap relative to domestic goods. Therefore, ceteris paribus, investment expands as a result of the terms of trade appreciation.

Case III: $\omega_c < \omega_x = 1$ In other words there is some import content in consumption, but none in investment. Note that this case is somewhat counterfactually given the evidence reported in table 1 in Corsetti and Müller (2006). We treat it as a theoretical curiosity. We cannot simplify (3.4) further. However, we know that $P_{1t}^X > P_{1t}^C$ such that the left hand side of (3.4) increases. On the other hand, we also know that $P_{1t}^A > P_{1t}^C$ also increases. In this case, the effect of a terms of trade appreciation is theoretically ambivalent.

3.2 Size

To understand the role of country size, we do not provide a formal argument, but simply recall the key insights from the closed economy analysis of the fiscal transmission mechanism. The basic idea in King (1991), Baxter and King (1993) and Finn (1998) is that, the more persistent the shock, the stronger the resource loss which - eventually - is faced by the private sector. This triggers a reduction both in consumption and leisure, such that hours worked go up (wealth effect). This makes capital more productive which is found to be crowded in by fairly persistent increases in government spending. At the same time, a rise in the interest rate exerts a negative effect (the more so, if the shock is short lived, see Baxter (1995)) on investment. Hence, which short lived spending shocks investments may fall in the closed economy.

If the economy is open but small, both effects are likely to be smaller. The interest rate increases less, but the wealth effect should also be smaller if there is some risk sharing arrangement (either explicit or implicit through terms of trade movements). Baxter (1995) highlights this issue: if the country is small and financial markets are complete, then the shock to world wealth is approximately zero. If financial markets are incomplete, the size of the wealth effect depends on whether terms of trade movements provide implicit risk sharing across countries. In a one good world, the case considered by Baxter (1995), the terms of trade are constant and cannot insure country risk. Therefore, in this case the negative wealth effect is strong under incomplete markets, but essentially absent,if financial markets are complete and the country is small. We will have to perform numerical experiments to assess the size of the wealth effect in a multi good world with incomplete markets but some degree of implicit risk sharing.

4 Numerical experiments

In this section we solve the model numerically in order to assess the quantitative importance of the transmission channel highlighted in the previous section. In our simulation we rely on a linear approximation of the model around the deterministic and symmetric steady state. We use the numerical procedure discussed in Klein (2000).

4.1 Calibration

We calibrate the model twice, using both time series data for the U.S. and the U.K. Both countries differ in size and with respect to their integration to world markets. In order to pin down parameter values not related to size and openness we draw on studies which have be largely focusing on the U.S. While this might imply that we do not pick the most accurate values for the U.K., it allows us to focus on the international dimension in the fiscal transmission mechanism.

The first panel in table 1 displays the values of parameters which are uncontroversial in the literature. The discount factor, the degree of risk aversion, the depreciation rate and the elasticity of substitution between domestic and foreign goods are set to values used in Backus et al. (1994). The parameters governing the extent of investment adjustment costs and the mean duration of prices are set to 2 and 0.66, close to the values reported by Christiano et al. (2005). The elasticity of substitution between domestically produced goods is set to 8, implying a markup in steady state close to 15 percent.

In the second panel, we display the values used to characterize fiscal and monetary policy. Government spending in steady state is 20 percent of GDP, the tax rate in steady state is $1/3$. In case the government issues debt to finance its expenditures, we assume that $\phi_g = 0.1$ to stabilize debt in the long run, while $\phi_\tau = 0$. Alternatively, we consider the case where the government budget is balanced in each period through adjusting lump-sum taxes. Monetary policy is characterized by a simple interest rate feedback rule, with some degree of interest rate smoothing ($\rho_i = 0.75$) and a long-run response to inflation of $\phi_\pi = 1.5$.

The third panel of figure 1 displays the values for the parameters which govern openness and country size. Regarding size we assume that $n = 0.06$ for the U.K. which corresponds to a share of 6 percent in total OECD output. For the U.S., in turn we assume $n = 0.58$ which corresponds to a share of 36 percent in total OECD output.[3] To pin down the parameters which determine the home bias in final goods consumption, we use the figures reported in table 1 of Corsetti and Müller (2006). Clearly, in all categories of final good consumption the import content is substantially higher in the U.K. relative to the U.S. In this sense, the U.K. is a much more open economy or more integrated into world markets.

[3]These numbers were calculated on the basis of OECD Economic Outlook data for the year 2005; GDP is measured in year 2000 USD (PPP).

Table 1: PARAMETER VALUES OF THEORETICAL ECONOMIES

Preferences and Technologies:		
Discount factor (steady state)	$\beta = 0.99$	
Consumption share	$\mu = 0.34$	
Risk aversion	$\gamma = 2$	
Capital share	$\theta = 0.36$	
Depreciation rate	$\delta = 0.025$	
Elasticity of substitution between domestic and foreign goods	$\sigma = 1.5$	
Investment adjustment costs	$\chi = 2$	
Fraction of prices kept unchanged	$\xi = 0.66$	
Elasticity of substitution between domestically produced goods	$\epsilon = 8$	
Policy :		
Government spending (steady state)	$g = 0.2$	
Persistence of government spending shock	$\rho_g = 0.95$	
Flat tax rate (steady state)	$\tau = 0.33$	
Debt stabilization spending	$\phi_g = 0.1$	
Debt stabilization tax rate	$\phi_\tau = 0.0$	
Long-run inflation elasticity	$\phi_\pi = 1.5$	
Interest rate smoothing	$\rho_i = 0.75$	
Size and Openness :	U.K.	U.S.
Size	$n = 0.06$	0.58
Import content government spending	$1 - \omega_g = 0.12$	0.06
Import content consumption	$1 - \omega_c = 0.20$	0.12
Import content investment	$1 - \omega_x = 0.36$	0.16

4.2 Results

In our first experiment we consider an increase in domestic government purchases of one percent of GDP. In the first case, we assume that the government balances its budget in each period by adjusting lump-sum taxes. Figure 1 displays the results for the U.K. (left column) and U.S. (right column). The first row shows the responses of government spending, output and the terms of trade (in percent of steady state), which are quantitatively very similar across calibrations: output increases by a about 0.5 percent on impact and gradually returns to its steady state level. The terms of trade appreciate, reflecting the relative scarcity of the good produced by country 1, which makes up for a substantial part of government consumption under both calibrations. Overall, the responses are quite similar to those of the standard international business cycle model.[4]

[4]The similarities to the results reported in figure 10 of Backus et al. (1994) are particularly noteworthy as these authors consider an essentially frictionless two country model.

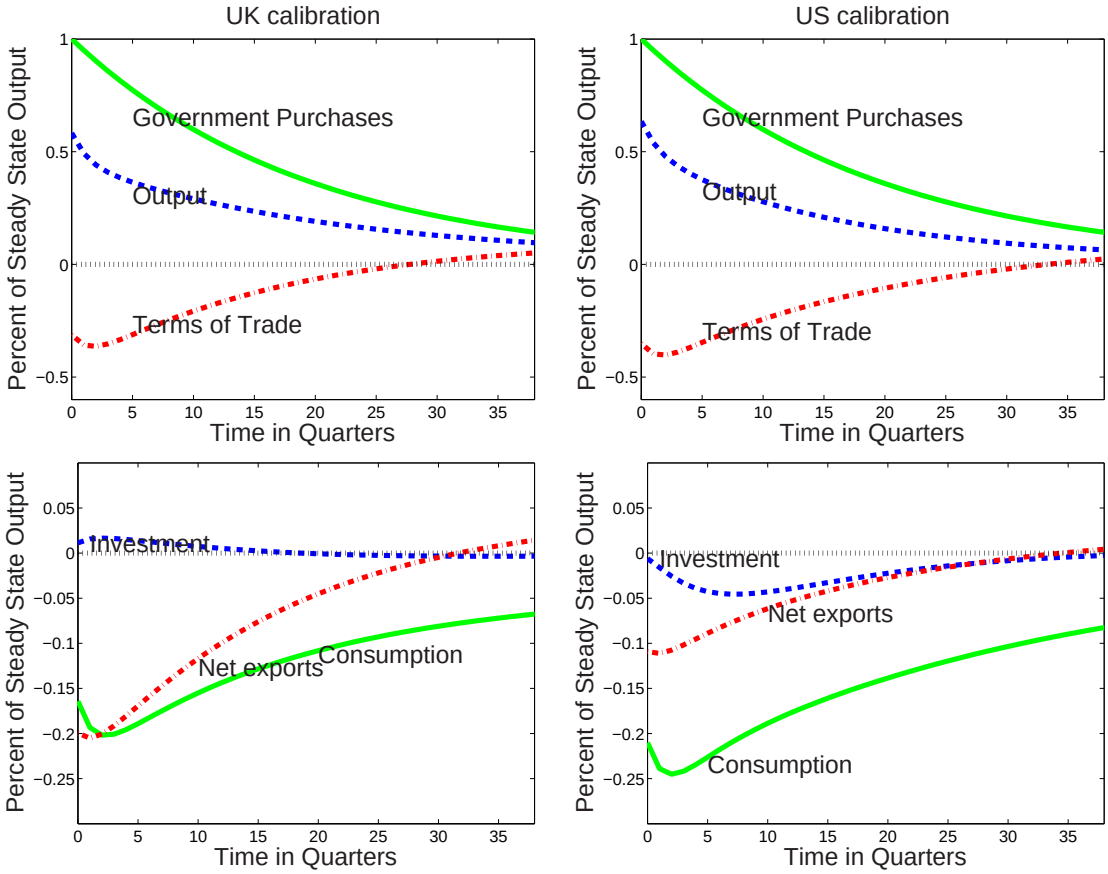

Figure 1: RESPONSES TO A POSITIVE DOMESTIC GOVERNMENT SHOCK (LUMP-SUM TAXES)

The second row shows the responses of the components of domestic absorption other than government spending. Here one notes a substantial difference across calibrations: while consumption falls in both cases by about 0.2 percent, investment increases in the U.K. but it falls in the U.S. As a result, net exports in the U.K. (0.2 percent of steady state output) fall about twice as much as in the U.S. (0.12 percent of steady state output).

Next, we repeat the experiment, but assume that that government spending is financed through debt. Public debt is gradually brought back to its steady state level through lowering government spending for an expended period as specified by equation (2.21). Figure 2 displays the results, which are qualitatively in line with the results obtained under the balanced budget financing rule. However, investment falls more strongly relative to the earlier case. This is quite likely to be the result of the lower present discounted value of the total resource absorption by the government (smaller negative wealth effect). However, it is important to stress that the fall in investment in the U.K. is small relative to the fall observed in the U.S. In the following subsection, we conduct further experiments in order to examine the factors which drive the difference in fiscal policy transmission between the U.S. and

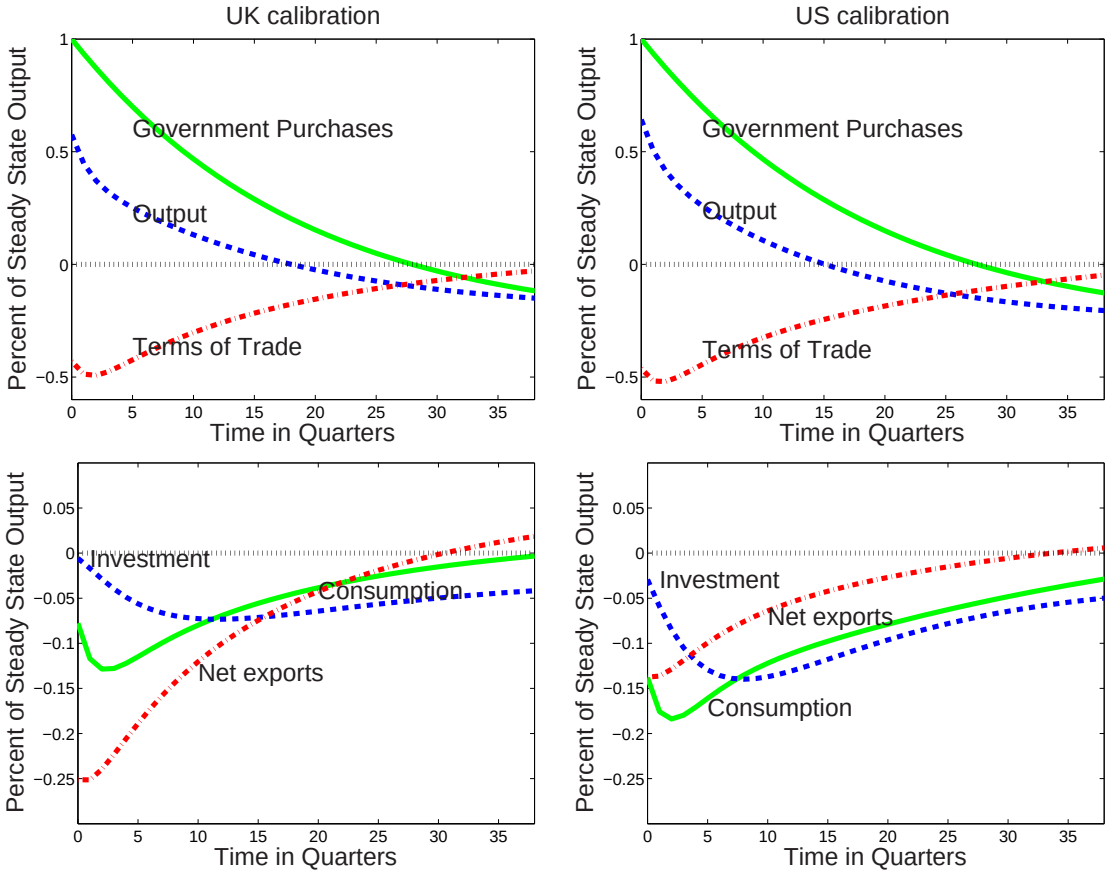

Figure 2: RESPONSES TO A POSITIVE DOMESTIC GOVERNMENT SHOCK (DEBT FINANCE)

the U.K.

4.3 Inspecting the mechanism

4.3.1 Counterfactuals

Given that we are working with a structural model it is straightforward to assess the impact of various model features on the transmission process. We thus repeat the above experiment and increase government spending by one percent of GDP (balanced budget) and compute the responses of consumption, investment and the trade balance for the U.S. and the U.K. In addition, however, to examine the role of openness and size, we consider an third, counterfactual calibration: we consider an economy with the size of the U.S. ($n = 0.58$ instead of 0.06) but the degree of good market integration of the U.K, see table 1.

The results are displayed in figure 3. Output (upper left panel) shows no and consumption (upper right panel) shows little difference across calibrations. This is different for investment displayed in the lower left panel. Increasing size somewhat lowers the response of investment relative to the U.K.

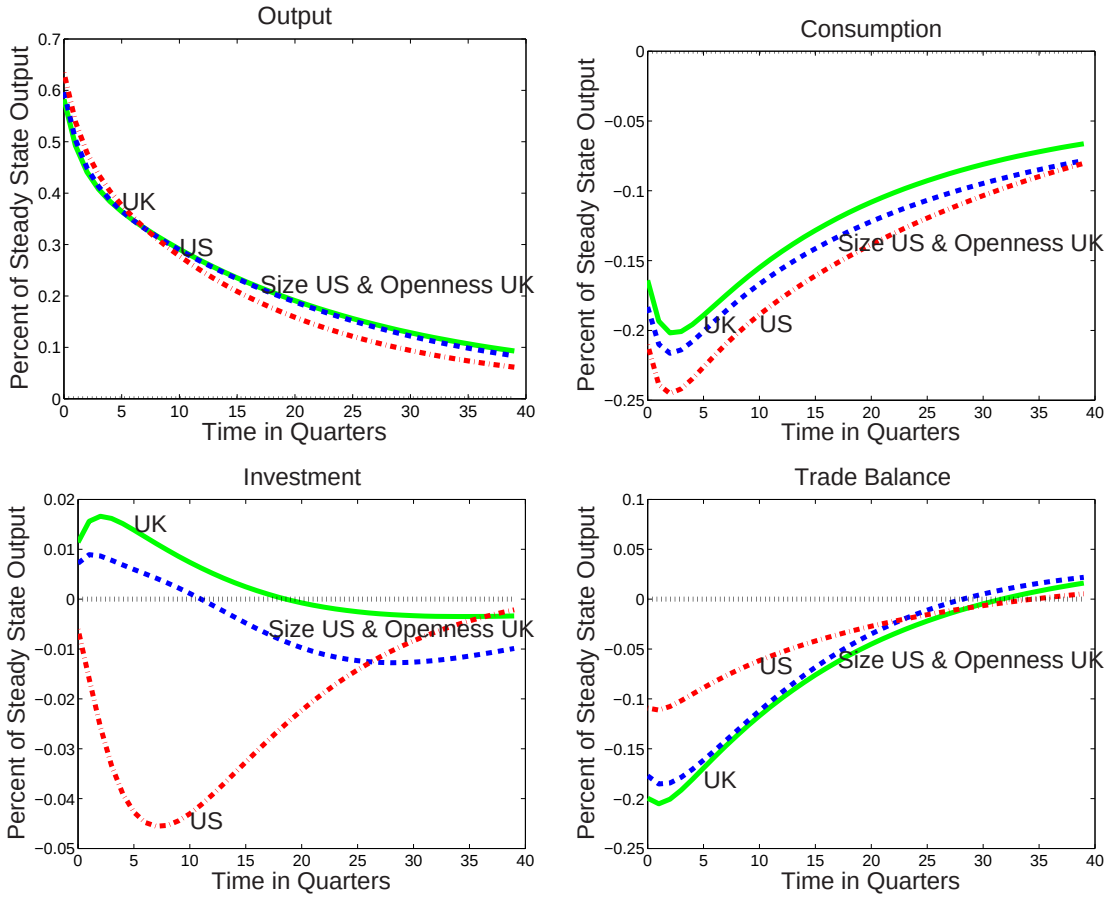

Figure 3: ACTUAL AND COUNTERFACTUAL RESPONSES

scenario. It is, however, still positive for the first ten quarters after the shock. It thus appears, that the degree of goods market integration plays a bigger role in account for the difference in the response of investment across countries. The response of the trade balance (lower right panel) suggests that the difference between the U.K. and the U.S. is largely driven by the difference in the investment response (and thus openness). In the following we investigate these issues more systematically.

4.3.2 Size and goods market integration: cumulative effects of spending shock

To gain insights in the role played by openness and size in the transmission process, we consider once more an increase in government spending of one percent of GDP but vary country size and the import content in private output (openness). Throughout we keep the import content of government spending fixed at $\omega_g = 0.9$. We display the cumulative responses for 40 quarters of hours, consumption, investment and net exports in the four panels of figure 4, respectively. On the vertical axis, we display the cumulative responses in percent of steady state values, on the horizontal axis we vary the degree of openness ($\omega_c = \omega_x$). We plot the results for three different values of country size, i.e.

$n = \{0.01, 0.5, 1\}$.

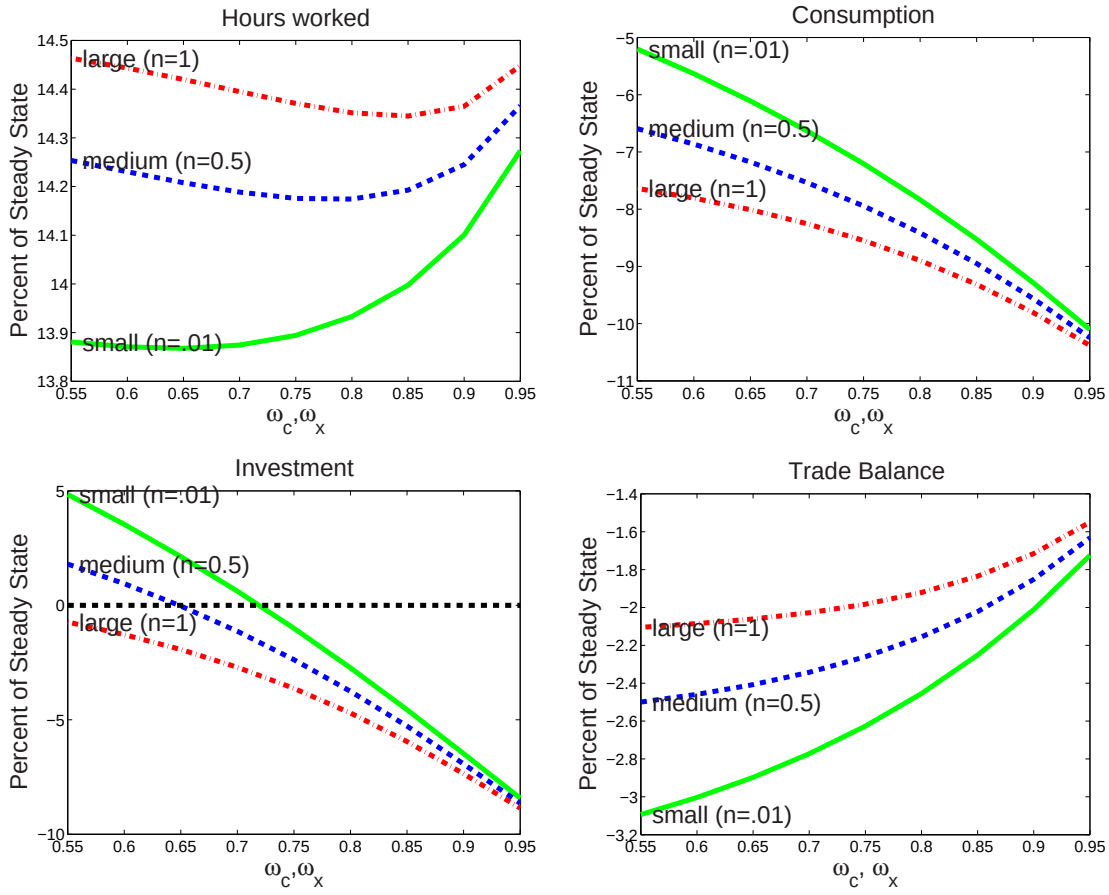

Figure 4: CUMULATIVE RESPONSES FOR VARIOUS DEGREES OF SIZE AND IMPORT CONTENT IN PRIVATE OUTPUT (WITH $\bar{\omega}_g = 0.9$) FOR 40 QUARTERS

The upper left panel shows that cumulative hours worked increase, irrespectively of openness and size. However, the increase in hours is larger, in the larger economy ($n = 1$). This reflects the negative wealth effect inflicted on the private sector by the increase in government spending. It induces hours worked to rise and consumption to fall (upper right panel). Note that the fall in consumption increases substantially with the degree of home bias in private output. Regarding the response of investment (lower left panel), we observe that both size and openness may alter the sign of the cumulative investment response. If the economy is either very small or relatively open, the cumulative investment response is positive. Finally, in the lower right panel, we display the cumulative response of net exports. Reflecting the impact of openness and size on investment and consumption, one observes the strongest fall in net export for a small economy which is very open to trade.

4.3.3 Wealth effects

We now turn to a systematic assessment of how the international dimension alters the wealth effect of the government spending shock. We follow King (1991) and compute a Hicksian Decomposition in a dynamic setting in order to the isolate the wealth effect of the shock on consumption and labor supply. The procedure is as follows: First, one computes the change in lifetime utility resulting from the change in the paths of consumption and labor induced by the shock. Second, one computes a lump-sum transfer payment which, in steady state, would imply the same change in lifetime utility. Third, to compute the wealth effect one considers the change in consumption and leisure induced by the lump-sum transfer payment in steady state.

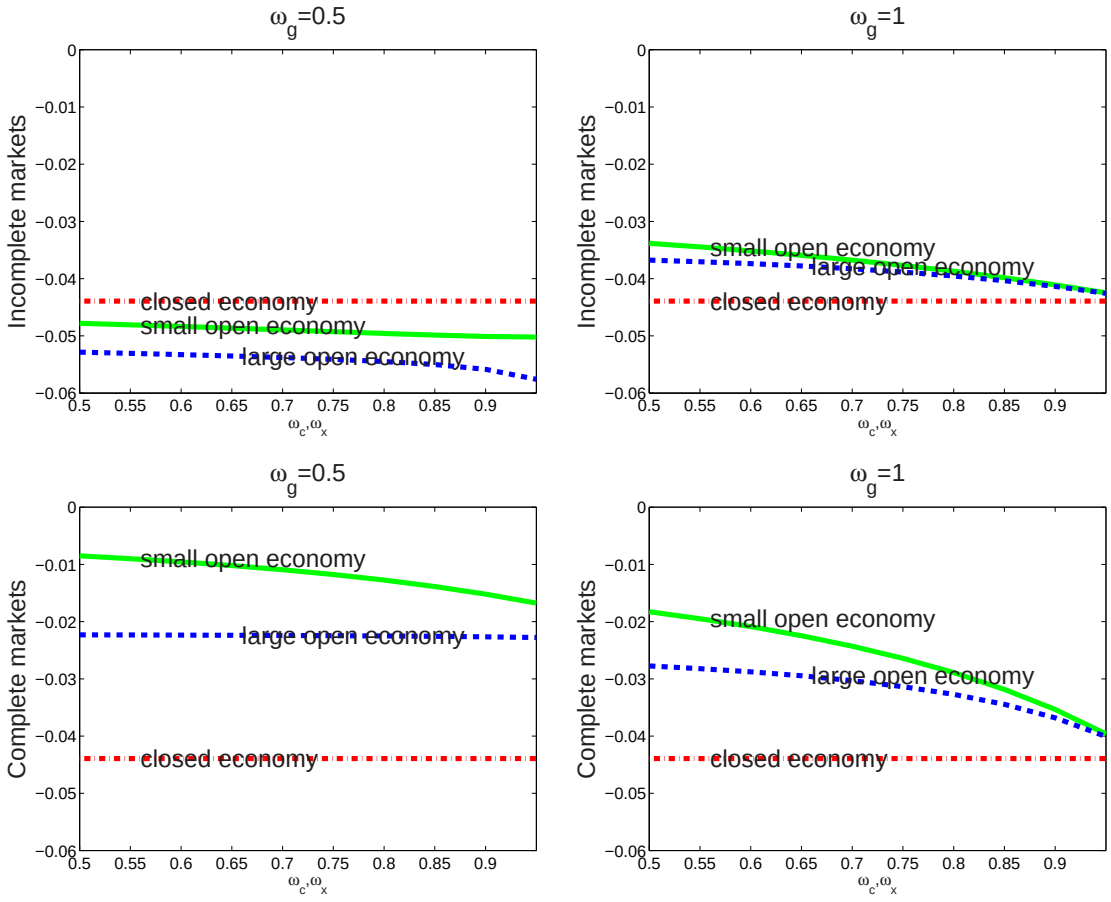

Figure 5: THE WEALTH EFFECT ON CONSUMPTION (PERCENT OF STEADY STATE OUTPUT): OPENNESS, SIZE AND ASSET MARKET STRUCTURE. Notes: small economy is $n = 0.01$, large is $n = 0.9$

We compute the wealth effect resulting from a one percent increase in government spending and various degrees of openness and country size. As a benchmark, we compute the wealth effect of the same increase in government spending in a closed economy. We approximate this case by assuming $\sigma = 100$, $\omega_c = \omega_x = \omega_g = 0.5$, such that domestic and foreign goods are perfect substitutes, see

Backus et al. (1994). In addition, we assume $n = 100$. This will prove a valuable comparison to assess how the open economy dimension alters the fiscal transmission mechanism. Moreover, in addition to the incomplete markets economy considered so far, we also consider an open economy with complete financial markets such that there is explicit insurance against country specific risks.

Figure 5 displays the part of the consumption response (in percent of steady state output) which is due its wealth effect for two cases: in the left column we set $\omega_g = 0.5$, while in the right column we assume $\omega_g = 1$.[5] These extreme cases will help us to illustrate the role of the terms of trade in implicity providing insurance against country specific shocks when financial markets are incomplete (upper panels). The case of complete financial markets is displayed in the lower panels.

In all four panels, the closed economy wealth effect is given by the dashed line - a decline in steady state consumption of 0.04 percent of steady state output, given an increase in government spending of 1 percent of GDP. Consider first the case of complete markets. In case government spending falls evenly on domestic and foreign goods ($\omega_g = 0.5$), the wealth effect is about half the wealth effect in the closed economy for the large economy (-0.02). Intuitively, this makes sense, given that the domestic economy makes up for about half of the world population and complete financial markets imply an explicit insurance of country specific risk, viz. government spending shocks. Note also that the effect does not depend on openness: this is because government spending consists to the same extent of domestic and foreign goods. In the small economy, the wealth effect is smaller, since the 'entire world' shares the burden of the increase in government spending in the small open economy. Interestingly, openness matters. This is because as countries differ in country size and domestically produced good make up for a very small fraction in the rest of the worlds consumption. Hence, if the private output is biased towards domestic inputs, which are relatively scarce globally due to increased domestic government spending, domestic households suffer a stronger wealth effect. In the case of $\omega_g = 1$, things are very similar under complete markets (lower right panel).

Yet, there are striking difference under incomplete markets. In case government spending is not home biased, domestic agents suffer a larger wealth effect than in the open economy. Only if government spending is home biased ($\omega_g = 1$), the negative wealth effect is reduced in the open economy relative to the closed economy (-0.035) in the relatively open economy. This illustrated the role of the terms of trade in sharing country specific risks in the absence of complete markets, a point stressed in Cole and Obstfeld (1991). The increase in government spending, appreciates a terms of trade and therefore mitigates the wealth effect.

Figure 6 displays the wealth effect on labor supply, the mirror image of the wealth effect on consumption. Specifically, in case of incomplete financial markets with complete home bias in government

[5]Given the evidence reported in Corsetti and Müller (2006) both cases appear somewhat counterfactual. The case of complete home bias in government spending, however, is probably a good first approximation to the realities in the U.S. and the U.K.

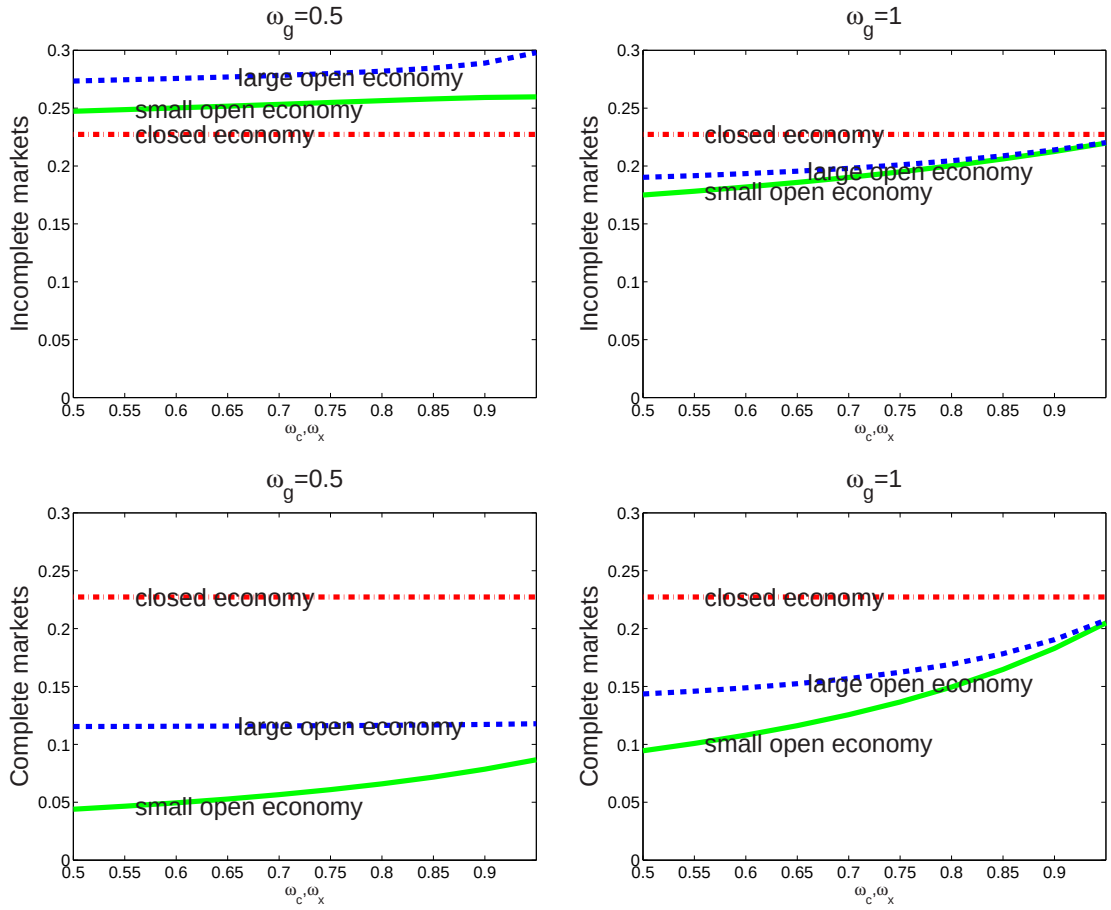

Figure 6: THE WEALTH EFFECT ON LABOR SUPPLY (PERCENT OF STEADY STATE): OPENNESS, SIZE AND ASSET MARKET STRUCTURE Notes: see figure 5

spending (upper left panel of figure 6) the increase in labor supply due to the wealth effect is smaller than in the closed economy.

Figure 7, in turn, displays the wealth effect on investment (measured in percent of steady state output), reflecting the wealth effect on labor supply. Specifically, in case of incomplete financial markets with complete home bias in government spending (upper left panel of figure 6) the increase in investment due to the wealth effect is smaller than in the closed economy.

Most importantly, however, the upper right panels of both figures 6 and 5 illustrate that the wealth effect of government spending shocks on consumption and labor is not fundamentally altered with country size and/or openness in case financial markets are incomplete and government spending is home biased. This is an important result when it comes to accounting for the differences in the transmission process in the U.S. and the U.K. apparent from figures 1 and 2 above. It is therefore quite likely that the difference are driven by how size and openness determine how the open economy dimension alters or introduced new relative price channels.

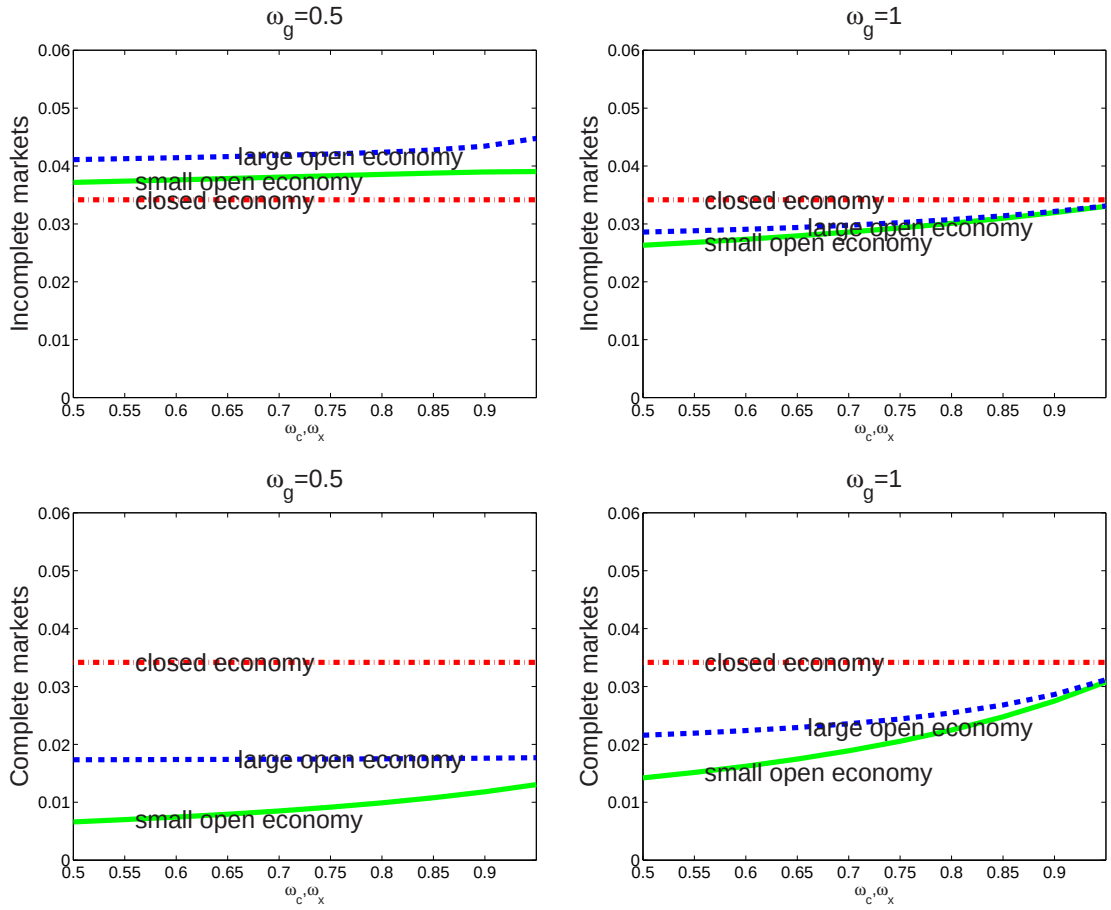

Figure 7: THE WEALTH EFFECT ON INVESTMENT (PERCENT OF STEADY STATE OUTPUT): OPENNESS, SIZE AND ASSET MARKET STRUCTURE. Notes: small economy is $n = 0.01$, large is $n = 0.9$

4.3.4 Price effects

We now explore the quantitative relevance of the argument put forward in section 3.1. We assign parameter values as reported in table 1 except for country size and the parameters governing the home bias (openness). Regarding size we assume $n = 1$, such that the domestic economy makes up for half of world GDP, an assumption often made in standard two country business cycle models. Regarding openness, we assume throughout that the import content in government spending is 10 percent, but vary the import content in consumption and investment goods.

We repeat the experiment from above and consider an increase in government spending by one percent of GDP. Figure 8 displays the dynamic adjustment of investment, the price of investment and domestically produced goods relative to consumption goods, Q^X_{1t} and Q^A_{1t}, respectively. These relative prices govern investment decisions according to the Euler equation (3.4). In the upper left panel, we consider the the case of strong home bias, or limited goods market integration, assuming that both

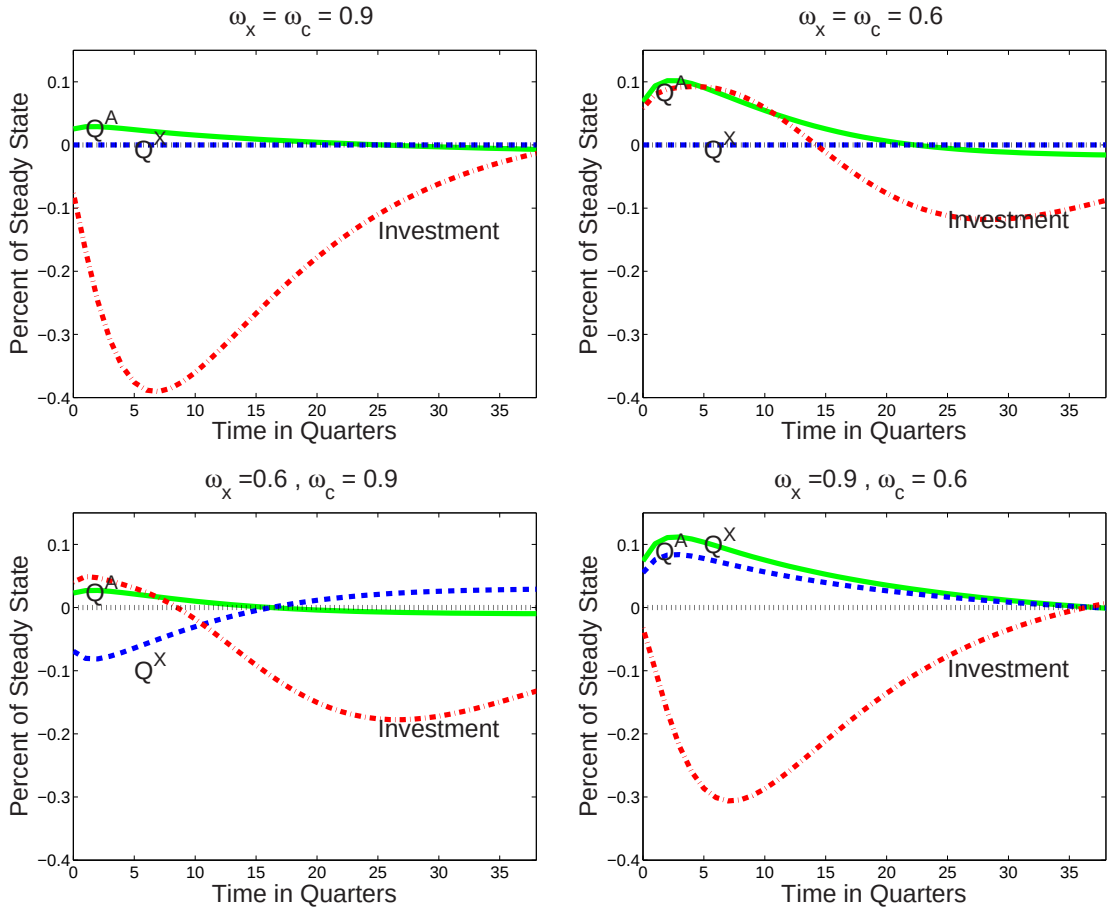

Figure 8: THE ROLE OF OPENNESS: RELATIVE PRICES AND INVESTMENT

investment and consumption have an import content of 10 percent. ($\omega_x = \omega_c = 0.9$). Unsurprisingly, in this case Q_{1t}^X remains constant. The relative price of domestically produced goods Q_{1t}^A increases thereby reflecting the appreciation of the terms of trade. Most importantly, investment falls considerably by 0.4 percent. In the upper right panel, we increase the import content in both consumption and investment to 40 percent. Qualitatively, the response of relative prices is identical. From a quantitative point of view, however, the increase in Q_{1t}^A is considerably larger. This - by equation (3.4) - provides an incentive to invest. In fact, investment increases by about 0.05 percent after about 4 quarters.

In the lower panels, we assess whether this result is driven by the import content in consumption or investment. The numerical experiments confirm our theoretical arguments. In the lower left panel, we consider case II of section 3.1, i.e. a high import content in investment (40 percent) and a low import content in consumption (10 percent). In this case, the response of relative prices is stimulating investment. In the lower right panel, in contrast, investment falls. Here we assume high import content in consumption (40 percent), but a low import content in investment (10 percent), i.e. case III

of section 3.1. As a result, not only Q_{1t}^A but also Q_{1t}^X increases and investment falls.

Hence, these experiments show that the theoretical insights gained in section 3.1 are quantitatively relevant. These results suggest that openness is key factor in shaping the response of investment to fiscal shocks. More specifically, it appears that the channel through which openness affect the transmission mechanism is through changing the margin of optimal investment by affecting relative prices rather than by changing wealth effects.

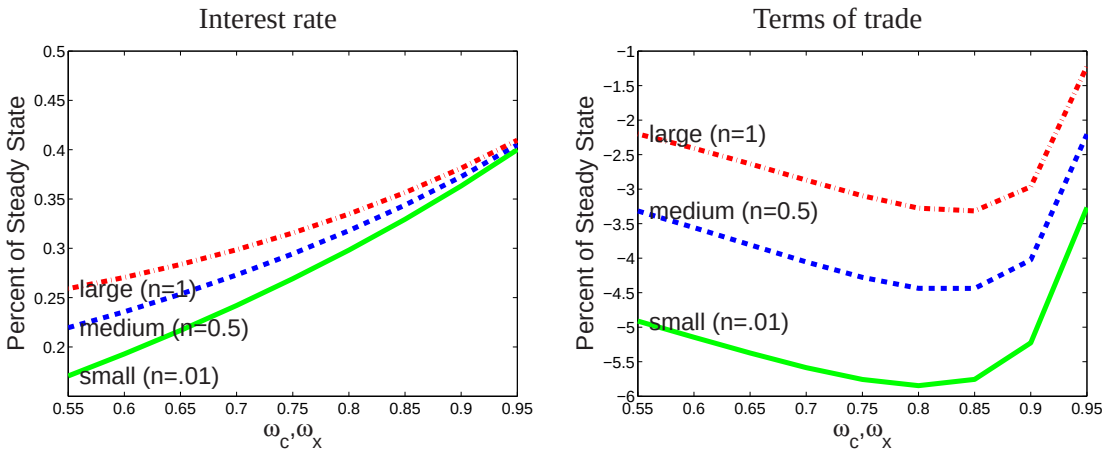

Figure 9: SIZE AND OPENNESS: IMPACT ON KEY RELATIVE PRICES ($\bar{\omega}_g = 0.9$)

Does size matter at all? There is one particular channel through which one would expect size to exert an important influence on investment: the interest rate. However, if one considers the consumption based interest rate, openness may also affect how the domestic interest rate is affected by the fiscal shock. Therefore, in the left panel figure 9 we display the cumulative interest rate response of the first 40 quarters in response to an government spending shock of one percent of GDP. The Increase in the interest rate is smallest in case of the economy being small and open.

5 Conclusion

TBC

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