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US trade balance dynamics: the role of fiscal policy and productivity shocks and of financial market linkages

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Abstract

This paper examines whether domestic and foreign productivity and fiscal policy changes can account for the wide swings in US net exports during the period 1975–1991. A two-country Real Business Cycle model is used for that purpose. The model is simulated using data on productivity, government purchases and taxes, for the G7 countries. A version of the model with incomplete asset markets, in which only bonds can be used for international capital flows, tracks the US trade balance fairly closely, provided permanent country-specific productivity shifts are assumed. The simulations suggest that US productivity changes were the main source of fluctuations in US net exports.

JEL classifications: F32, E32

Keywords: US trade balance; Total factor productivity; Fiscal policy; RBC models; Incomplete asset markets

1. Introduction

This paper examines whether domestic and foreign productivity and fiscal policy changes can account for the wide swings in US net exports during the period 1975–1991. A two-country Real Business Cycle (RBC) model with a government

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sector is used for that purpose. The analysis focuses on the response of optimizing, forward looking private decision makers to exogenous shocks, and on the way that this response is affected by international asset market linkages.

Historical quarterly series on total factor productivity, government consumption and average tax rates in the US and in an aggregate of the remaining G7 countries (G6, henceforth) are fed into the model. A version of the model in which international asset markets are incomplete, in the sense that only non-contingent debt contracts (bonds) can be used for international financial transactions, tracks the observed behavior of the US trade balance rather closely, provided permanent country-specific productivity shifts are assumed (statistical tests presented in the paper support the assumption of permanent idiosyncratic US and G6 productivity shocks).[1]

The simulations of the structural model suggest that US productivity changes were the major source of fluctuations in US net exports during the period 1975–1991; they show that tax changes too had a noticeable impact on the trade balance, but that government spending only played a secondary role. The simulations suggest, in particular, that the relatively rapid productivity growth and the large tax cuts that occurred in the US during the first half of the 1980s were important forces behind the sharp drop in US net exports during that period.

In contrast to the structure with incomplete asset markets, a version of the model that postulates complete international asset markets, as assumed in many International RBC models (see, e.g. Dellas, 1986; Baxter and Crucini, 1993; Backus et al., 1995), fails to explain the observed behavior of the US trade balance — predicted trade balance series generated by that version of the model are *negatively* correlated with the actual US trade balance.

The success of the incomplete markets structure is mainly due to the fact that, in that structure, a permanent country-specific productivity increase lowers the net exports of the country that experiences the productivity increase. This is important as, empirically, US net exports (and the net exports of the G6 countries) co-move *negatively* with domestic productivity. The complete markets structure cannot capture this empirical regularity — with complete markets, net exports are predicted to rise in response to a country-specific increase in domestic productivity.

The intuition for this difference in responses across asset market structures is that a productivity increase in a given country raises that country's wealth more strongly when asset markets are incomplete (than when complete markets exist), as the elimination of trade in state contingent assets limits international risk sharing. When markets are incomplete, consumption in the country that receives a positive productivity shock rises therefore more strongly (than when markets are complete), and that country's net exports are, hence, more susceptible of responding negatively to such a shock.

The results here provide strong evidence against the hypothesis of complete risk

[1] Two-country RBC models with a bonds-only asset market structure have recently been presented by Kollmann (1991, 1996) and by Baxter and Crucini (1995), among others.

sharing between the US and the G6 countries. However, asset market incompleteness alone is not sufficient to explain the observed behavior of US net exports — to rationalize that behavior, permanent (or extremely persistent) idiosyncratic productivity shifts are required, namely shocks that have a very long-lasting effect on the cross-country productivity differential. When even a relatively small degree of mean reversion of productivity is assumed — say, when productivity follows an AR(1) process with an autocorrelation of 0.95 — then the response of consumption in a given country to an idiosyncratic productivity increase in that country is much weaker than the response triggered by a permanent productivity shift; hence, net exports *rise* in response to such a non-permanent productivity increase — even when asset markets are incomplete. In contrast, the complete markets structure fails to explain the actual behavior of US net exports, irrespective of whether permanent or transitory idiosyncratic productivity shocks are assumed.

In a certain sense, the simulation results here might thus be viewed as 'indirect' support for the assumption of extremely long-lasting idiosyncratic US and G6 productivity shifts.

Section 2 discusses the basic facts on which this study focuses. Section 3 discusses the model. Simulation results are presented in Section 4. Section 5 summarizes the results.

2. Fiscal policy, productivity and net exports: US and G6 data

Fig. 1 plots quarterly US net exports (as a share of GDP) as well as average tax rates, government consumption and total factor productivity for the US and for the G6 during the period 1975:Q1–1991:Q3.

The net exports variable is exports minus imports of goods and services. Fig. 1 also shows net exports of the G6 countries. While G6 net exports are not an exact mirror image of US net exports (as they would be if — as assumed in the model discussed below — the G7 did not trade with other countries), the two series are highly negatively correlated.

The average tax rate shown in Fig. 1 is the ratio of total tax revenues and social security contributions received by governments (minus transfer payments made by governments) to the net domestic product (GDP minus consumption of fixed capital). The index of total factor productivity in country i (i = US, G6) is defined as:

$$\ln(\theta_t^i) = \ln(Y_t^i) - (1-\eta)\ln(K_t^i) - \eta\ln(N_t^i),$$

where Y_t^i, K_t^i and N_t^i are real GDP, physical capital and labor input (total hours worked) in country i, respectively. η is a parameter that represents the wage share; Fig. 1 uses $\eta = 0.75$.[2] The productivity and government consumption series in

[2] In the US (and in the other G7 countries), the ratio of labor income to capital income fluctuates around 2.5, which suggests a value of η in the range of 0.75.

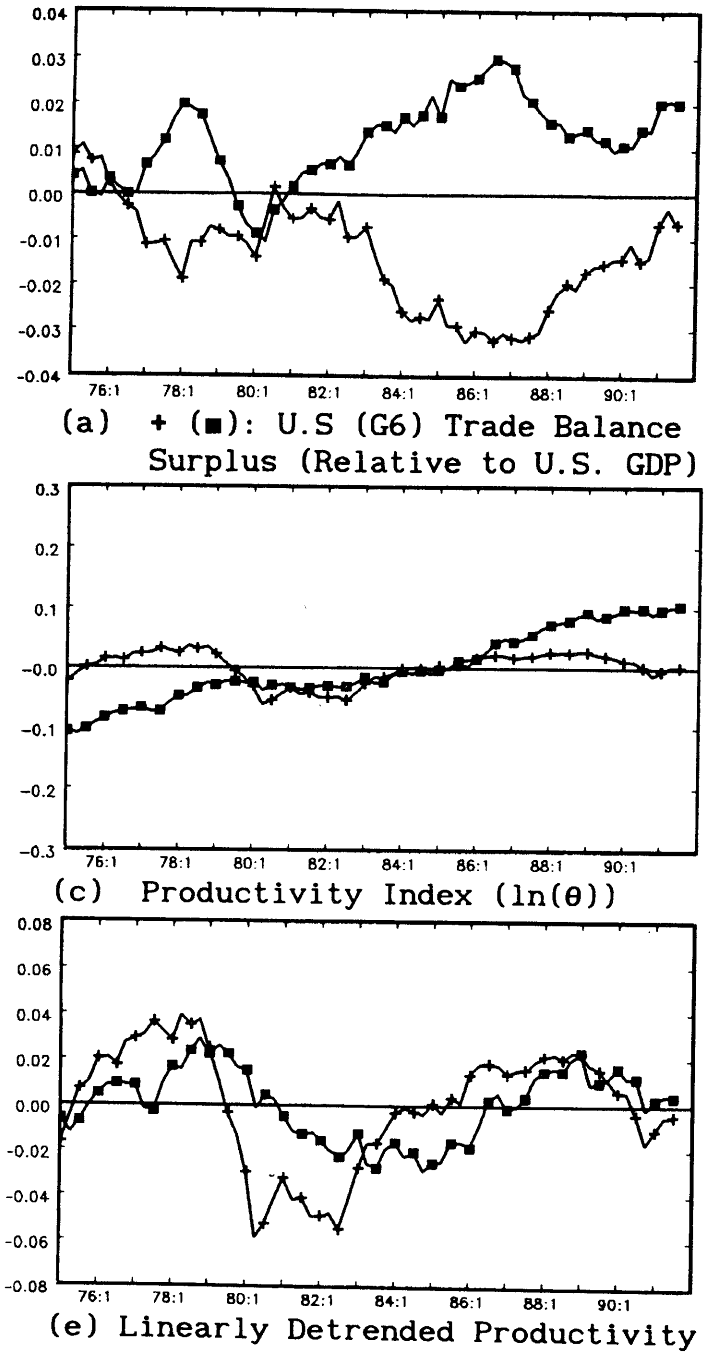

Fig. 1. Quarterly macroeconomic data, US (+), and G6 (■), 1975:Q1–1991:Q3.

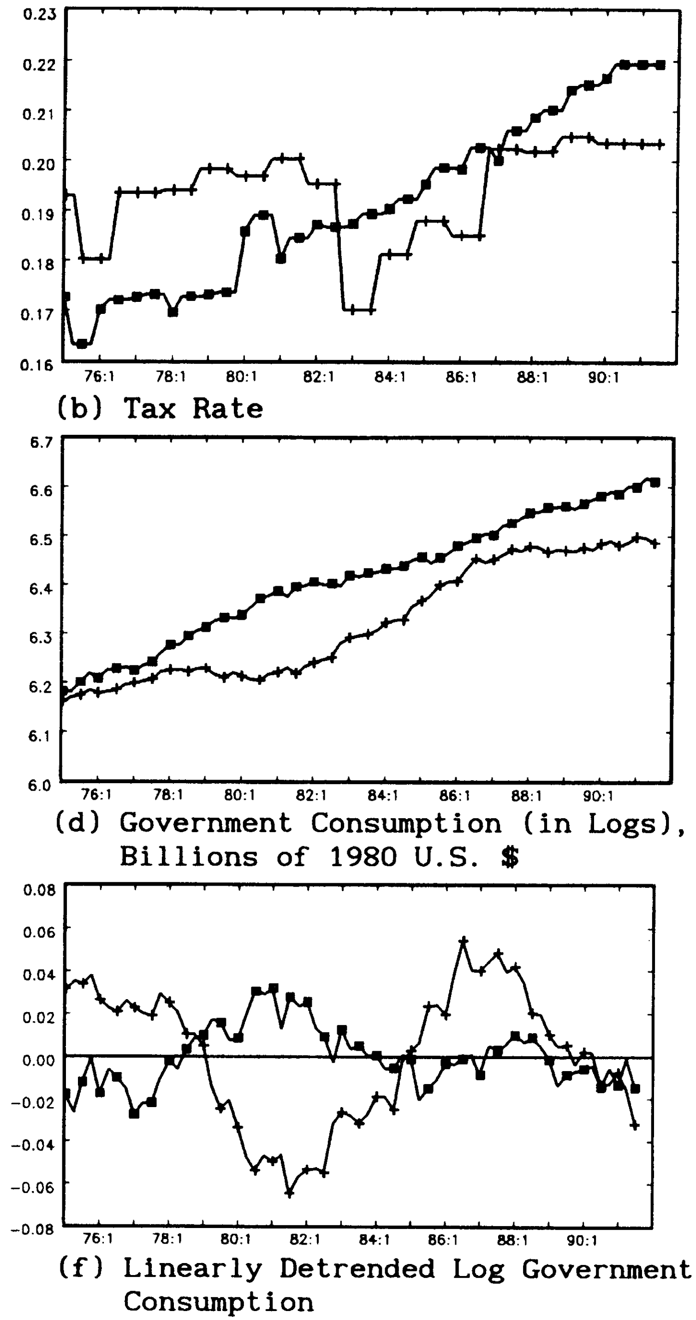

Fig. 1. *Continued*

Fig. 1 are presented in (log) levels, as well as in linearly detrended form. Further information about the data is provided in Appendix A.

The most striking aspect of the net exports series is the strong increase in the US trade deficit during the first half of the 1980s, as well as the persistence of that deficit.

As possible explanations of the behavior of the US trade balance, the following features of the other time series plotted in Fig. 1 seem noteworthy:

1. The average US tax rate dropped sharply in 1982 and stayed below its pre-1982 level during the next 4 years; during the sample period as a whole, the US tax rate showed no pronounced trend, in contrast to the G6 tax rate that increased steadily (from approx. 17% in the mid-1970s to 22% in 1991).
2. US net exports co-move negatively with (detrended) US productivity and government consumption; note, in particular, that during the first half of the 1980s (i.e. during the sharp drop in US net exports), US productivity and government consumption grew much more rapidly than during the sample period as a whole.[3] Note also that detrended productivity and government consumption show more variation in the US than in the G6.

This paper investigates whether the behavior of US net exports can be explained by the changes in productivity, government consumption and tax rates in the US and the G6 that are documented in Fig. 1. The next Section presents the model that will be used for that purpose.

3. The model

3.1. Preferences and technologies

The world considered here consists of two countries, indexed by $i = 1,2$. Each country is inhabited by consumers and by a government. There exists a unique good in this world. This good is produced and consumed by both countries, and it can also be used as an investment good. Private sector preferences and technologies are similar to those assumed in the International RBC literature (for a survey of that literature, see Backus et al., 1995).

All residents of the same country are identical. Private sector decisions in country i are taken by a representative consumer whose intertemporal preferences are given by

$$E_t \sum_{j=0}^{j=\infty} \beta^j u\left(c^i_{t+j}\right), \tag{1}$$

[3]The correlations between US net exports (expressed as a share of US GDP) and the linearly detrended US (log) productivity and (log) government consumption are −0.35 and −0.33, respectively, during the sample period. The correlations between US net exports and linearly detrended G6 productivity and government consumption are positive (0.14 and 0.10, respectively).

where E_t denotes the mathematical expectation conditional on information available at date t. β is the country's subjective discount factor and C^i_t denotes country i's aggregate consumption. A CRRA period utility function is assumed:

$$u(C) = [1/(1-\sigma)]C^{1-\sigma}, \quad \text{with}\, \sigma > 0. \tag{2}$$

Country i's output in period t is given by:

$$Y^i_t = \theta^i_t\,(K^i_t)^{1-\eta}(N^i_t)^{\eta}, \tag{3}$$

where K^i_t is country i's aggregate capital stock, while N^i_t is the country's labor force. Labor is immobile internationally. The labor force grows at a constant rate: $N^i_t = \mathscr{g}^i_N N^i_{t-1}$. Total factor productivity (θ^i_t) is given by

$$\theta^i_t = (Z^i_t)^{\eta}\exp(\nu^i_t), \tag{4}$$

where ν^i_t is an exogenous random variable with mean zero, while Z^i_t is a deterministic geometric trend. Z^i_t grows at a constant rate: $Z^i_t = \mathscr{g}^i_Z Z^i_{t-1}$. Let $X^i_t \equiv Z^i_t N^i_t$ denote the deterministic trend of country i's labor force measured in efficiency units. The growth factor of this variable is identical in the two countries: $\mathscr{g}_X \equiv X^1_{t+1}/X^1_t = X^2_{t+1}/X^2_t$ (thus, $\mathscr{g}_X = \mathscr{g}^1_Z\mathscr{g}^1_N = \mathscr{g}^2_Z\mathscr{g}^2_N$; this makes balanced growth possible).

The law of motion of the capital stock in country i is

$$K^i_{t+1} + \phi(K^i_{t+1},K^i_t) = (1-d)K^i_t + I^i_t, \tag{5}$$

where I^i_t denotes how much output is required to change the capital stock from K^i_t to K^i_{t+1}. $0 \le d \le 1$ is the depreciation rate of the capital stock and $\phi(K^i_{t+1},K^i_t)$ is a convex adjustment cost function that is homogeneous of degree 1 in K^i_{t+1} and K^i_t:

$$\phi(K^i_{t+1},K^i_t) = 0.5\,\Phi\,\{K^i_{t+1} - \vartheta K^i_t\}^2/K^i_t, \quad \Phi > 0,\ \vartheta > 0. \tag{6}$$

3.2. Government behavior

Governments purchase units of the homogeneous good and finance these purchases by levying a distorting tax. In addition, governments trade in real one-period bonds. The budget constraint of the government of country i is

$$G^i_t + D^i_t\,(1+r_t) = T^i_t + D^i_{t+1}, \tag{7a}$$

where G^i_t and T^i_t are, respectively, government purchases and tax revenues, while D^i_t is government debt that matures in period t, and r_t is the real risk-free interest rate. The only tax available to governments is a flat-rate tax on net output (output net of capital depreciation and of adjustment costs). Government tax revenues are, hence, given by

$$T_t^i = s_t^i \left[Y_t^i - dK_t^i - \phi(K_{t+1}^i, K_t^i) \right], \quad (7b)$$

where s_t^i is the rate of the flat-rate tax.

Government purchases and the tax rate depend on government debt and on the ratio of debt to the tax base, respectively:

$$G_t^i = -\mu_G D_t^i + \gamma_t^i, \quad (8a)$$

$$s_t^i = \mu_T D_t^i / \left[Y_t^i - dK_t^i - \phi(K_{t+1}^i, K_t^i) \right] + \sigma_t^i. \quad (8b)$$

Here, γ_t^i and σ_t^i are exogenous random variables. Eq. (8a) and Eq. (8b) are assumed because, by selecting appropriate values for μ_G and μ_T (in particular, $\mu_G > 0$ and/or $\mu_T > 0$), one can guarantee that government solvency conditions are satisfied (fiscal policy rules similar to Eq. (8a) and Eq. (8b) have frequently been used in the public finance literature and in macroeconometric models (see, e.g., Buiter, 1990, pp. 265–266; and Masson et al., 1990).

Autonomous fiscal spending (γ_t^i) is given by

$$\gamma_t^i = X_t^i \bar{\gamma}^i \exp(\varepsilon_t^i), \quad (9)$$

where $\bar{\gamma}^i$ is a constant and ε_t^i is an exogenous random variable with mean zero (X_t^i is defined after Eq. (4); the fact that X_t^i appears in Eq. (9) makes balanced growth possible).

In contrast to productivity and autonomous government spending, the exogenous tax rate shock, σ_t^i, does not have a deterministic trend.

3.3. Asset markets

Two asset market structures are considered. In the first (incomplete asset markets), agents have to use real risk-free one-period bonds in their international financial transactions (agents are, thus, unable to buy foreign assets with state-contingent pay-offs, such as equity). In contrast, the second asset market structure assumes complete international markets for date- and state-contingent claims.

3.3.1. Incomplete asset markets

Two-country models with the incomplete asset market structure considered here have recently been studied by Kollmann (1991, 1996) and Baxter and Crucini (1995), among others. The assumption that agents' financial transactions are restricted to risk-free bonds is a key assumption in permanent income models of consumption behavior (see, e.g., Sargent, 1987, ch. 12). This asset markets structure has also been assumed in much research on small open economies (see, e.g., Obstfeld and Rogoff, 1996, ch. 2).

In the version of the model with incomplete asset markets, the budget constraint of the private sector of country i is given by:

$$C_t^i + I_t^i + A_{t+1}^i = Y_t^i - T_t^i + (1 + r_t) A_t^i, \quad (10)$$

where T_t^i denotes the period t tax liability of the private sector, while A_t^i denotes the (net) stock of one-period bonds held by the private sector that mature in t (r_t is the real risk-free interest rate on these bonds).

The decision problem of country i's private sector is to maximize the intertemporal utility defined in Eq. (1) subject to the restriction that the budget constraint Eq. (10) holds in all periods. The solution to this decision problem satisfies the following Euler equations (assuming that Ponzi games are ruled out):

$$u_t^{i,} = (1 + r_{t+1}) \beta E_t \left[u_{t+1}^{i,} \right] \quad (11a)$$

and

$$u_t^{i,} = \beta E_t \left[\mathrm{MPK}_{t+1}^i \, u_{t+1}^{i,} \right]. \quad (11b)$$

Here, $u_t^{i,}$ is country i's marginal utility of consumption at date t, while MPK_{t+1}^i is its intertemporal marginal rate of transformation between t and $t+1$ ($\mathrm{MPK}_{t+1}^i \equiv \{(1 - s_{t+1}^i)[\theta_{t+1}^i (1 - \eta)(K_{t+1}^i)^{-\eta}(N_{t+1}^i)^{\eta} - \phi_{2,t+1}^i - d] + 1\} / \{1 + (1 - s_t^i)\phi_{1,t}^i\}$, where $\phi_{s,t}^i$ is the derivative of the adjustment cost function $\phi(K_{t+1}^i, K_t^i)$ with respect to the sth argument of that function).

Given exogenous processes $\{\theta_t^i, \gamma_t^i, \sigma_t^i\}$ $i = 1,2$, an equilibrium in the economy with incomplete asset markets is a set of stochastic processes for the endogenous variables $\{Y_t^i, K_t^i, C_t^i, I_t^i, D_t^i, G_t^i, T_t^i, s_t^i, A_t^i, r_t\}$ for $i = 1,2$ that satisfies Eqs. (3), (5), (7a), (7b), (8a), (8b), (10), (11a) and (11b) as well as the condition that the goods market clears:

$$C_t^1 + C_t^2 + I_t^1 + I_t^2 + G_t^1 + G_t^2 = Y_t^1 + Y_t^2. \quad (12)$$

By Walras' law, equilibrium in the goods market implies that the asset market clears as well.

3.3.2. Complete asset markets

Two-country RBC models typically assume that asset markets are complete (see, e.g., Baxter and Crucini, 1993; Backus et al., 1995) . The existence of complete asset markets implies that (weighted) marginal instantaneous utilities of consumption are equated in the two countries, and that for all states of the world:

$$u_t^{1,} = \Lambda u_t^{2,}, \quad (13)$$

where $\Lambda > 0$ is a time- and state-invariant term reflecting the distribution of private sector wealth between the two countries.[4] When the CRRA utility function Eq. (2) is assumed, this risk-sharing condition implies that consumption is perfectly correlated across countries:

$$C_t^1 = \Lambda C_t^2.$$

Obviously, the first-order conditions Eqs. (11a),(11b) and the market clearing condition Eq. (12) continue to be valid equilibrium conditions in an economy with complete asset markets.

Given a weight Λ and exogenous processes $\{\theta_t^i,\gamma_t^i,\sigma_t^i\}$ $i = 1,2$, an equilibrium in the economy with complete asset markets is therefore a set of stochastic processes for the endogenous variables $\{Y_t^i,\ K_t^i,\ C_t^i,\ I_t^i,\ D_t^i,\ G_t^i,\ T_t^i,\ s_t^i,\ r_t\}$ for $i = 1,2$ that satisfies equations Eqs. (3), (5), (7a), (7b), (8a), (8b), (11a), (11b), (12) and (13).

3.4. Solving the model

A solution of the model is obtained by considering the 'detrended' variables $\hat{Y}_t^i \equiv Y_t^i/X_t^i$, $\hat{K}_t^i \equiv K_t^i/X_t^i$, $\hat{C}_t^i \equiv C_t^i/X_t^i$, $\hat{I}_t^i \equiv I_t^i/X_t^i$, $\hat{D}_t^i \equiv D_t^i/X_t^i$, $\hat{G}_t^i \equiv G_t^i/X_t^i$, $\hat{T}_t^i \equiv T_t^i/X_t^i$, $\hat{A}_t^i \equiv A_t^i/X_t^i$, $\hat{\theta}_t^i \equiv \theta_t^i/(Z_t^i)^\eta$ and $\hat{\gamma}_t^i \equiv \gamma_t^i/X_t^i$ (N.B. $X_t^i \equiv Z_t^i N_t^i = X_0^i \cdot (\mathscr{g}_X)^t$). Under the assumptions about preferences and technologies stated above, the model can be written as a system of equations in the variables $\hat{\theta}_t^i$, $\hat{\gamma}_t^i$, $\hat{\sigma}_t^i$, $\hat{Y}_t^i$, $\hat{K}_t^i$, $\hat{C}_t^i$, $\hat{I}_t^i$, $\hat{D}_t^i$, $\hat{G}_t^i$, $\hat{T}_t^i$, s_t^i, r_t and $\hat{A}_t^i$, for $i = 1,2$ (the variable $\hat{A}_t^i$ is only relevant when asset markets are incomplete). The model is solved using a linear approximation of this system of equations near a deterministic steady state, i.e. near an equilibrium in which the (detrended) endogenous and exogenous variables are constant (this solution method is standard in the RBC literature (see, e.g. King et al., 1988)). In the simulations described below, the model is linearized around a symmetric deterministic steady state in which the variables have the same value in each country (in the simulations of the complete markets structure, the weight Λ in the risk sharing condition Eq. (13) is, thus, set at $\Lambda = 1$).

The linearized versions of the incomplete markets structure and of the complete markets structure can be expressed as

$$E_t h_{t+1} = \mathscr{G} h_t + \mathscr{H} q_t + \mathscr{J} E_t q_{t+1}, \quad \text{and} \quad E_t w_{t+1} = \mathscr{S} w_t + \mathscr{Q} q_t + \mathscr{R} E_t q_{t+1}, \tag{14}$$

respectively, where $h_t \equiv (\nabla r_t, \nabla\hat{D}_t^1, \nabla\hat{D}_t^2, \nabla\hat{A}_t^1, \nabla\hat{K}_t^1, \nabla\hat{K}_t^2, \nabla\hat{C}_t^1, \nabla\hat{C}_t^2, \nabla\hat{K}_{t+1}^1)'$, $w_t \equiv (\nabla\hat{D}_t^1, \nabla\hat{D}_t^2, \nabla\hat{K}_t^1, \nabla\hat{K}_t^2, \nabla\hat{C}_t^1, \nabla\hat{C}_t^2, \nabla\hat{K}_{t+1}^1)'$ and $q_t \equiv (\nabla\hat{\theta}_t^1, \nabla\hat{\theta}_t^2, \nabla\hat{\gamma}_t^1, \nabla\hat{\gamma}_t^2, \nabla\sigma_t^1, \nabla\sigma_t^2)'$. $\nabla\alpha_t \equiv (\alpha_t - \alpha)/\alpha$ denotes the relative deviation of variable α_t from its value in the deterministic steady state around which the linearization is taken (α).[5]

[4] See, e.g., Obstfeld and Rogoff (1996, ch. 5) and Kollmann (1995), for derivations of this fundamental risk sharing condition. Eq. (13) holds as intertemporal marginal rates of substitution are equated across countries, and that for all possible states of the world, when complete asset markets exist: $\beta u_{t+1}^1/u_t^1 = \beta u_{t+1}^2/u_t^2$. In the bonds-only world, marginal rates of substitution are merely equated in expected value: $\beta E_t u_{t+1}^1/u_t^1 = \beta E_t u_{t+1}^2/u_t^2$ (as Eq. (11a) holds for $i = 1,2$ in equilibrium).

the deterministic steady state around which the linearization is taken (α).[5] $\mathscr{G}$, $\mathscr{H}$, $\mathscr{J}$, $\mathscr{S}$, $\mathscr{Q}$ and $\mathscr{R}$ are matrices. The first six elements of the vector h_t and the first four elements of w_t are predetermined at date t (i.e. they are known at $t-1$), while the remaining elements are non-predetermined. The simulations assume that the forcing variables (q_t) are AR(1) processes. Under this assumption, the solutions of Eq. (14) are of the following form (see Blanchard and Kahn, 1980):

$$Q_t = \mathscr{K}_0 Q_{t-1} + \mathscr{K}_1 q_{t-1}, \quad P_t = \mathscr{F}_0 Q_t + \mathscr{F}_1 q_t, \tag{15}$$

where Q_t is the vector of variables that are predetermined at date t, while P_t is the vector of non-predetermined endogenous variables ($\mathscr{K}_0$, $\mathscr{K}_1$, $\mathscr{F}_0$ and $\mathscr{F}_1$ are matrices). The trade balance and other variables of interest are functions of Q_t and P_t and can be computed easily once one has solved for Q_t and P_t.

3.5. Parameters

3.5.1. Technology and preference parameters, growth rates

The technology parameter η is set at $\eta = 0.75$ (see Section 2 for a discussion of that value). Aggregate data indicate a capital depreciation rate of approx. 2.5% per quarter, and hence $d = 0.025$ is used. The steady state real interest rate is set at $r = 0.01$, a value close to the long run average real return on capital. These (or very similar) values of η, d and of r are generally used in RBC models. The adjustment cost parameter Φ (see Eq. (6)) is set at $\Phi = 3$, in order to match the variability of net exports seen in the data (for lower values of ϕ, the simulated net exports series are excessively volatile). The second parameter of the adjustment cost function (ϑ) is selected in such a way that, in deterministic steady state, adjustment costs are zero; this requires $\vartheta = \mathscr{g}_X$ (recall that $\mathscr{g}_X \equiv X_{t+1}^i/X_t^i$). In the model, the steady state growth factor of output is $\mathscr{g}_X$; $\mathscr{g}_X = 1.0061$ is assumed (1.0061 is the average quarterly growth factor of total G7 output during the sample period, 1975:Q1–1991:Q3).

The relative risk aversion coefficient is set at $\sigma = 2$. This value lies in the range of risk aversion coefficients usually assumed in RBC studies (Friend and Blume (1975) present empirical evidence suggesting that σ is in the range of 2). β is set at $\beta = 1.0022$, as $(1+r)\beta\mathscr{g}_X^{-\sigma} = 1$ holds in steady state (N.B. despite $\beta > 1$, the representative agents' lifetime utility Eq. (1) is finite, as $\beta\mathscr{g}_X^{1-\sigma} < 1$ holds, i.e. the agents' decision problem is well behaved).

3.5.2. Fiscal policy parameters

The model is linearized around a deterministic steady state in which the share of government purchases in output is 0.15, which is close to the average value of the government consumption-to-GDP ratio in the US (16%) and the G6 (14%) during the sample period. It is also assumed that, in steady state, the stock of government

[5] To allow for cases where steady state net private asset holdings ($\hat{A}^i$) and government debt ($\hat{D}^i$) are zero, $\nabla\hat{A}_t^i, \nabla\hat{D}_t^i$ are defined as $\nabla\hat{A}_t^i \equiv \hat{A}_t^i - \hat{A}^i$, $\nabla\hat{D}_t^i \equiv \hat{D}_t^i - \hat{D}^i$.

Table 1
Augmented Dickey–Fuller unit root tests

	$k=0$	$k=1$	$k=2$	$k=3$	$k=4$	$k=5$
(a) US and G6 forcing variables						
US productivity	−1.31	−1.76	−1.89	−2.03	−2.23	−2.27
G6 productivity	−1.62	−1.76	−1.50	−1.48	−1.74	−1.95
US govt. consumption	−1.13	−1.30	−1.24	−1.70	−2.29	−2.27
G6 govt. consumption	−2.62‡	−2.27	−2.09	−1.53	−1.89	−1.69
US tax rate	−2.24	−2.30	−2.27	−2.34	−1.82	−1.85
G6 tax rate	−4.71**	−3.68*	−3.53*	−2.82§	−2.68‡	−2.87§
(b) US–G6 differentials						
US–G6 productivity	−1.53	−1.80	−1.74	−1.99	−2.07	−2.25
US–G6 govt. consumption	−1.49	−1.59	−1.56	−1.50	−2.01	−1.95
US–G6 tax rate	−2.79‡	−2.76‡	−2.59	−2.56	−2.24	−2.36

Notes: ADF test statistics based on the following regression are reported: $\Delta x_t = \alpha_0 + \alpha_1 t + \alpha_2 x_{t-1} + \Sigma_{s=1}^{s=k} \varphi_s \Delta x_{t-s} + u_t$, where $\Delta x_t \equiv x_t - x_{t-1}$, and k is the number of lagged Δx terms included on the right-hand side of this regression. The ADF test statistic is the studentized value of the OLS estimate of α_2. In Panel (a), the ADF test is applied to each of the six forcing variables (productivity and government purchases are logged); in Panel (b), the ADF test is applied to US–G6 differences of (logged) productivity, of (logged) government consumption, and of the tax rate. The time series used for these tests are those shown in Fig. 1 (1975:Q1–1991:Q3).
**, *, †, §, ‡: Rejection of unit root hypothesis at 1, 5, 10, 20 and 50%, respectively.

debt is zero (this assumption is made because governments in the G7 countries own large stocks of capital — the simulation results are not sensitive to this particular choice for steady state government debt). Given these values, the government budget constraint implies that the steady state tax rate equals 18% (which is close to the mean value of the US and G6 average tax rates during the sample period: 19%). The fiscal policy parameters μ_G and μ_T are set at $\mu_G = \mu_T = 0.005$ (the aim in setting μ_G and μ_T is to use values that are numerically 'small' and that ensure that the government debt to output ratio D_t^i/Y_t^i is non-explosive in equilibrium; the latter ensures that government Ponzi schemes are ruled out, as the steady state growth factor of output is smaller than the gross interest rate; N.B. $\mathcal{g}_X < 1 + r$).

3.5.3. Forcing variables

The graphs in Fig. 1 suggest that US and G6 productivity, government consumption and tax rates are highly serially correlated. Table 1 presents Augmented Dickey–Fuller (ADF) unit root tests for these six variables. The results yield little evidence against the unit root hypothesis.[6] Table 1 tests also whether the difference between US and G6 productivity, as well as the US–G6 differences in

[6] A possible exception is the G6 tax rate. For lag lengths $k = 0,1,2$ the ADF test statistic yields strong evidence against the unit root hypothesis; it appears, however, that for $k \geq 3$, there is little evidence against this hypothesis.

Table 2
Phillips and Ouliaris cointegration tests

	(1)	(2)	(3)	(4)	(5)	(6)
$\hat{Z}_\alpha$ statistic	−18.65	−20.82	−16.18	−30.60‡	−14.62	−25.09
$\hat{Z}_t$ statistic	−3.79‡	−3.62	−3.05	−4.20‡	−3.33	−5.01†

Notes: Phillips and Ouliaris (1990) $\hat{Z}_\alpha$ and $\hat{Z}_t$ test statistics are reported for the set of six forcing variables considered in the paper. These tests set up the null hypothesis that the set of variables is not cointegrated. The $\hat{Z}_\alpha$ and $\hat{Z}_t$ statistics labelled (1) use US productivity as the left-hand side variable in the cointegrating regressions used to compute these statistics (see Phillips and Ouliaris, 1990). The columns labelled (2)–(6) use G6 productivity, US government consumption, G6 government consumption, the US tax rate and the G6 tax rate, respectively, as left-hand side variables. A linear time trend was included in all cointegrating regressions. The Newey–West method (allowing for 10 autocorrelations) was used to correct for serial correlation in the residual of the cointegrating regressions. The time series used for the tests are those shown in Fig. 1 (1975:Q1–1991:Q3). Productivity and government purchases are used in logs.
**, *, †, §, ‡: Rejection of null of no cointegration at 1, 5, 10, 20 and 50% levels, respectively.

government consumption and in tax rates, have a unit root. For these US–G6 differentials, the unit root hypothesis fails likewise to be rejected. Table 2 reports Phillips and Ouliaris (1990) test statistics that suggest that the six forcing variables are not cointegrated. This implies that these series can be modeled as a vector autoregression (VAR) in first differences (see Campbell and Perron, 1991, p. 170). Estimation results for a six-variable VAR in first differences are reported in Table 3. The autoregressive coefficients are almost all statistically insignificant, at conventional significance levels. The results here suggest, hence, that shifts in the forcing variables (and in the cross-country differences of these variables) are permanent and that there are little or no 'spillovers' between these forcing variables.

The baseline case assumes, thus, that the six forcing variables are random walks:

$$q_t = q_{t-1} + \zeta_t,$$

where $q_t \equiv (\nabla\hat{\theta}_t^1, \nabla\hat{\theta}_t^2, \nabla\hat{\gamma}_t^1, \nabla\hat{\gamma}_t^2, \nabla\sigma_t^1, \nabla\sigma_t^2)'$ is the vector of exogenous variables in the linearized version of the model (see Eq. (14) and Eq. (15)), while ζ_t is a vector of white noises.[7]

4. Simulations

4.1. Impulse response functions

Figs. 2 and 3 show impulse responses functions for the incomplete and the

[7] Using the estimated coefficients of the VAR in Table 3 to simulate the model yields results that are very similar to those that are obtained when the forcing variables are random walks.

Table 3
Six-variable VAR fitted to forcing variables (in first-differences)

$\hat{RHO}$ =	0.21 (0.13)	−0.04 (0.16)	0.24* (0.11)	0.05 (0.11)	−0.02 (0.19)	−0.63† (0.33)
	0.02 (0.10)	−0.04 (0.13)	0.14 (0.09)	0.06 (0.09)	−0.18 (0.16)	−0.15 (0.28)
	0.12 (0.16)	0.00 (0.21)	0.03 (0.14)	0.00 (0.14)	0.02 (0.25)	−0.42 (0.43)
	−0.17 (0.14)	0.12 (0.17)	0.00 (0.12)	−0.32** (0.12)	−0.54** (0.20)	0.15 (0.36)
	−0.01 (0.08)	0.13 (0.11)	0.01 (0.07)	0.07 (0.07)	0.00 (0.13)	0.26 (0.22)
	−0.04 (0.04)	0.12 (0.05)	0.01 (0.04)	−0.01 (0.04)	−0.06 (0.07)	−0.09 (0.12)

Notes: Let $z_t \equiv (\Delta\ln(\theta_t^{US}), \Delta\ln(\theta_t^{G6}), \Delta\ln(G_t^{US}), \Delta\ln(G_t^{G6}), \Delta s_t^{US}, \Delta s_t^{G6})'$, where θ_t^i, G_t^i, s_t^i are productivity, government consumption and the tax rate, for i = US, G6, respectively (N.B. $\Delta x_t \equiv x_t - x_{t-1}$). The following model is fitted to the time series shown in Fig. 1 (1975:Q1–1991:Q3): $z_t = b + \text{RHO}\, z_{t-1} + \varepsilon_t$, where b is a column vector and RHO a matrix. The table reports OLS estimates of the elements of RHO (standard deviations in parentheses).
**, *, †: Significant at 1, 5 and 10%, respectively.

complete markets versions of the model, respectively. The following shocks are considered: a permanent 1% increase in country 1 productivity (θ^1), a permanent 1% increase in country 1 autonomous government purchases (γ^1) and a permanent one percentage point reduction in the autonomous component of the country 1 tax rate (σ^1). The figures show the responses of net exports, output, consumption, investment and government purchases (in countries 1 and 2) to these shocks (note that country i net exports are $Y_t^i - C_t^i - I_t^i - G_t^i$). The responses of all variables are expressed as percentages of the value of output in the steady state around which the model is linearized (initially, the system is assumed to be in that steady state).

The simulations show that the responses of output and investment to exogenous shocks are identical across the two asset market structures;[8] differences in the behavior of net exports across these asset structures are thus entirely due to differences in consumption behavior.

[8] Kollmann (1991) shows that this is due to the fact that labor supplies are inelastic in the model here. Fixed labor supplies are assumed merely to simplify the presentation. With variable labor supplies, the responses of labor would differ across asset structures, and hence output and investment behavior would differ too. However, assuming variable labor would not affect the key predictions concerning the behavior of net exports (simulation results for a version of the model with variable labor are available from the author).

4.1.1. Response to permanent increase in country 1 productivity

In both asset market structures, a permanent rise in country 1 productivity raises worldwide consumption. It induces a rise in country 1 investment and output, but it has only a relatively small impact on output and investment in country 2. The productivity shock induces a rise in country 1 net exports when asset markets are complete and a fall when markets are incomplete.

To understand this difference in the response of net exports across asset market structure, note that with *complete markets* consumption in both countries rises by the same amount. As output, investment (and government purchases) change relatively little in country 2, that country's net exports fall — country 1 net exports rise, hence, when markets are complete. Intuitively, complete international sharing implies that resources are transferred from the country that experiences a favorable productivity shock to the other country — thus, the net exports of the country that receives the shock rise.

When asset markets are *incomplete*, then country 1 consumption rises much more strongly than when complete markets exist, while consumption falls in country 2.[9] Intuitively, the reason why country 1 consumption increases more strongly in the bonds-only structure is that a productivity increase in country 1 raises that country's wealth more strongly when asset markets are incomplete (than when complete markets exist), as the elimination of trade in state-contingent assets restricts international risk sharing.[10] The much stronger rise of country 1 consumption explains why country 1 net exports fall, on impact, in the bonds-only structure. Note that country 1 output continues to rise *after* the permanent productivity shock has occurred, as that shock induces a long run rise in the country 1 capital stock — gross investment in country 1 rises, on impact, and it decreases gradually thereafter. The 'cash flow' that is at the disposal of the country 1 household, in the *bonds-only structure* (country 1 output minus taxes minus gross investment; see the budget constraint Eq. (10)) is thus larger in the long run than in the current period; the household's consumption smoothing motive thus induces it to reduce its net financial asset position — hence, the current account of country 1 deteriorates and its net exports fall, in the bonds-only structure.

4.1.2. Fiscal policy shocks

A reduction in the tax rate of country 1 increases private sector wealth and the after-tax marginal product of capital, in that country. This raises the consumption

[9] The world interest rate (not shown in Fig. 2) rises as a result of a permanent productivity shock, which induces country 2 to lower its current consumption.

[10] King (1990) has presented a method for decomposing the responses of consumption to an exogenous shock into 'Hicksian' wealth and intertemporal substitution effects. The working paper version of the paper (available from the author) applies that method and shows that the much stronger response of country 1 consumption to a permanent rise in country 1 productivity, when markets are incomplete, is due to the fact that the (Hicksian) wealth effect of the shock on country 1 consumption is much stronger, in that asset structure (than when markets are complete).

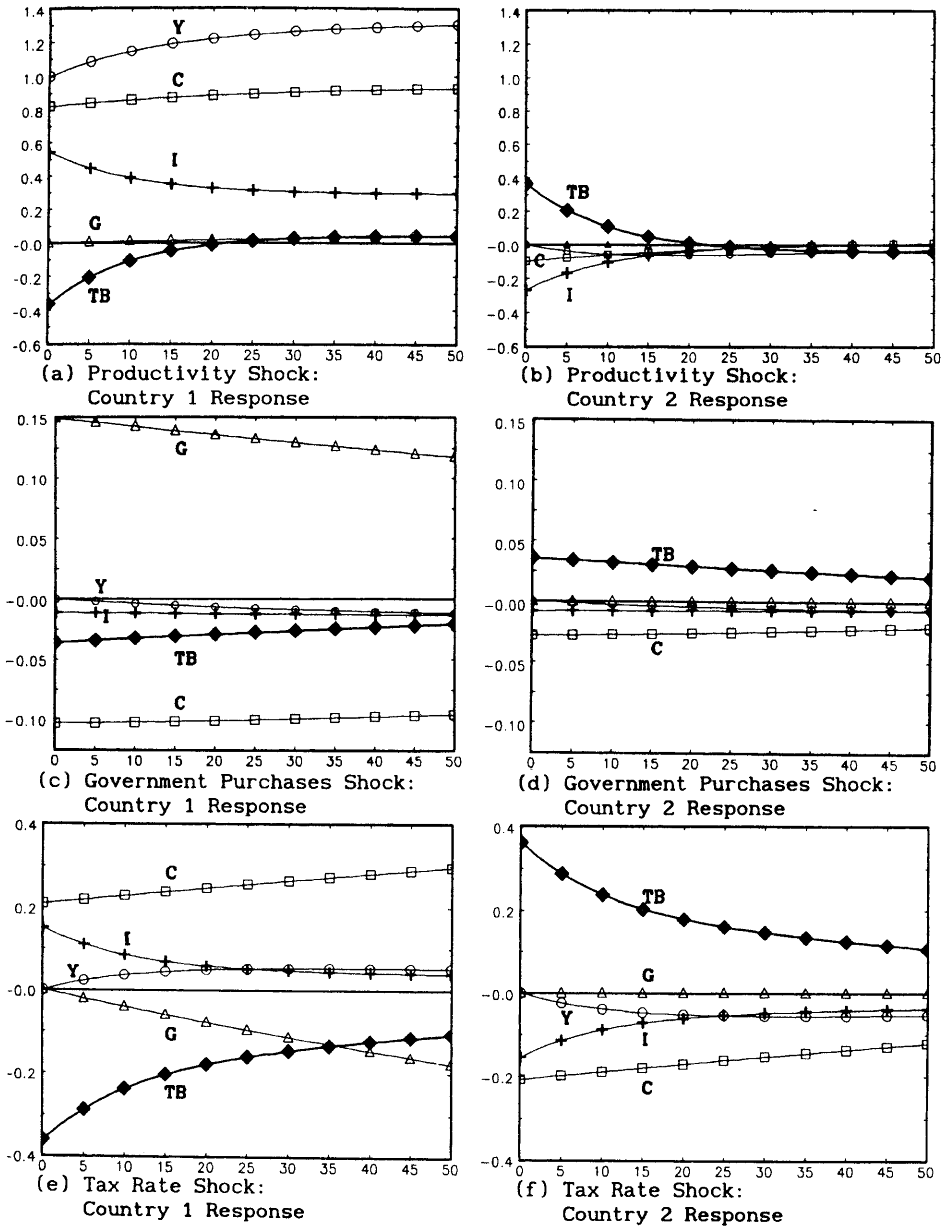

Fig. 2. Incomplete asset markets: effects of permanent shocks.
Responses to permanent 1% rise in country 1 productivity and in country 1 autonomous government purchases, and to permanent one percentage point drop in autonomous component of country 1 tax rate. Responses are expressed as percentage of steady state output. Abscissa: quarters after shock. ○: output (Y); □: private consumption (C); △: government purchases (G); +: gross investment (I); ◆: net exports (TB).

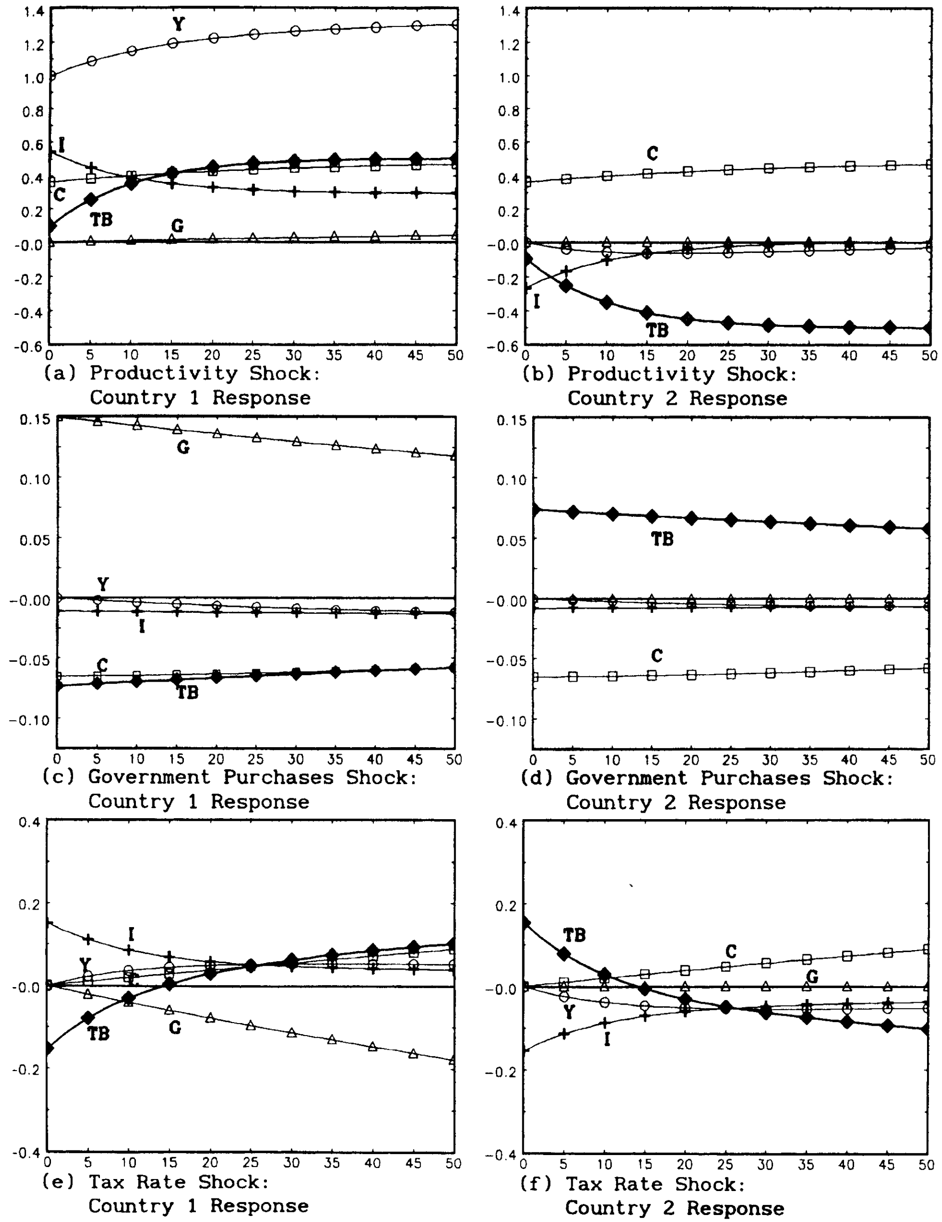

Fig. 3. Complete asset markets: effects of permanent shocks.
Responses to permanent 1% rise in country 1 productivity and in country 1 autonomous government purchases, and to permanent one percentage point drop in autonomous component of country 1 tax rate. Responses are expressed as percentage of steady state output. Abscissa: quarters after shock. ○: output (Y); □: private consumption (C); △: government purchases (G); +: gross investment (I); ◆: net exports (TB).