This paper examines whether domestic and foreign productivity and fiscal policy changes can account for the wide swings in U.S. 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 U.S. trade balance fairly closely, provided permanent country-specific productivity shifts are assumed. The simulations suggest that U.S. productivity changes were the main source of fluctuations in U.S. net exports.

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1. Introduction

This paper examines whether domestic and foreign productivity and fiscal policy changes can account for the wide swings in U.S. net exports during the period 1975–1991. A two-country Real Business Cycle (RBC) model with a government 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 U.S. 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 U.S. trade balance rather closely, provided permanent country-specific productivity shifts are assumed (statistical tests presented in the paper support the assumption of permanent idiosyncratic U.S. and G6 productivity shocks). ¹

The simulations of the structural model suggest that U.S. productivity changes were the major source of fluctuations in U.S. net exports during the period 1975–91; 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 U.S. during the first half of the 1980s were important forces behind the sharp drop in U.S. 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., DeIlas (1986), Baxter and Crucini (1993), Backus et al. (1995)), fails to explain the observed behavior of the U.S. trade balance--predicted trade balance series generated by that version of the model are negatively correlated with the actual U.S. 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, U.S. 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 sharing between the U.S. and the G6 countries. However, asset market incompleteness alone is not sufficient to explain the observed behavior of U.S. 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 U.S. 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 U.S. 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: U.S. and G6 data

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

The net exports variable is exports minus imports of goods and services. Figure 1 also shows net exports of the G6 countries. While G6 net exports are not an exact mirror image of U.S. 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 Figure 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:

$$\ln(\theta^i_t) = \ln(Y^i_t) - (1-\eta) \ln(K^i_t) - \eta \ln(N^i_t),$$

where $Y^i_t$, $K^i_t$ and $N^i_t$ are real GDP, physical capital and labor input (total hours worked) in country i, respectively. $\eta$ is a parameter that represents the wage share; Figure 1 uses $\eta=0.75$. The productivity and government consumption series in Figure 1 are presented in (log) levels, as well as in linearly detrended form. Further information about the data is provided in the Appendix.

The most striking aspect of the net exports series is the strong increase in the U.S. 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 U.S. trade balance, the following features of the other time series plotted in Figure 1 seem noteworthy:

(i) The average U.S. tax rate dropped sharply in 1982 and stayed below its pre-1982 level during the next four years; during the sample period as a whole, the U.S. tax rate showed no pronounced trend, in contrast to the G6 tax rate that increased steadily (from about 17% in the mid-1970s to 22% in 1991).

(ii) U.S. net exports co-move negatively with (detrended) U.S. productivity and government consumption; note, in particular, that during the first half of the 1980s (i.e., during the sharp drop in U.S. net exports), U.S. productivity and government consumption grew much more rapidly than during the sample period as a whole. Note also that detrended productivity and government consumption show more variation in the U.S.
than in the G6.

This paper investigates whether the behavior of U.S. net exports can be explained by the changes in productivity, government consumption and tax rates in the U.S. and the G6 that are documented in Figure 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

\[ E_t \sum_{j=0}^{\infty} \beta^j u(C_{t+j}^i), \]  

where \( E_t \) denotes the mathematical expectation conditional on information available at date t. \( \beta \) is the country's subjective discount factor and \( C_{t+j}^i \) denotes country i's aggregate consumption. A CRRA period utility function is assumed:

\[ u(C) = \frac{1}{1-\sigma} C^{1-\sigma}, \text{ with } \sigma > 0. \]  

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

\[ Y_t^i = \theta_t^i (K_t^i)^{1-\eta} (N_t^i)^{\eta}, \]

where \( K_t^i \) is country i's aggregate capital stock, while \( N_t^i \) is the country's
labor force. Labor is immobile internationally. The labor force grows at a constant rate: \( N_t^i = N_{t-1}^i \). Total factor productivity \( \theta_t^i \) is given by

\[
\theta_t^i = (Z_t^i)^{\eta} \exp(\nu_t^i),
\]

where \( \nu_t^i \) is an exogenous random variable with mean zero, while \( Z_t^i \) is a deterministic geometric trend. \( Z_t^i \) grows at a constant rate: \( Z_{t+1}^i = qZ_t^i \). Let \( X_t^i = Z_t^i N_t^i \) 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: \( q_X = X_{t+1}^1 / X_{t+1}^2 = X_t^2 / X_t^1 \) (thus, \( q_X = q_{Z_1}^1 = q_{Z_2}^2 \); this makes balanced growth possible).

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

\[
K_{t+1}^i = (1-d) K_t^i + I_t^i + \phi(K_{t+1}^i, K_t^i),
\]

where \( I_t^i \) denotes how much output is required to change the capital stock from \( K_t^i \) to \( K_{t+1}^i \). \( 0 < d < 1 \) is the depreciation rate of the capital stock and \( \phi(K_{t+1}^i, K_t^i) \) is a convex adjustment cost function that is homogeneous of degree 1 in \( K_{t+1}^i \) and \( K_t^i \):

\[
\phi(K_{t+1}^i, K_t^i) = 0.5 \phi \left( \frac{K_{t+1}^i - \phi K_t^i}{K_t^i} \right)^2 / K_t^i, \quad \phi > 0, \quad \phi > 0.
\]

### 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

\[
G_t^i + D_t^i (1 + r_t^i) = T_t^i + D_{t+1}^i,
\]

where \( G_t^i \) and \( T_t^i \) are, respectively, government purchases and tax revenues, while \( D_t^i \) is government debt that matures in period t, and \( r_t^i \) 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
\[ T_t^1 = s_t^1 [Y_t^1 - d K_t^1 - \phi(K_{t+1}^1, K_t^1)], \]
(7b)
where \( s_t^1 \) 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:
\[ G_t^1 = -\mu_G D_t^1 + \gamma_t^1, \]
(8a)
\[ s_t^1 = \mu_T D_t^1 / [Y_t^1 - d K_t^1 - \phi(K_{t+1}^1, K_t^1)] + \sigma_t^1. \]
(8b)
Here, \( \gamma_t^1 \) and \( \sigma_t^1 \) are exogenous random variables. Equations (8a) and (8b)
are assumed because, by selecting appropriate values for \( \mu_G \) and \( \mu_T \) (in
particular, \( \mu_G > 0 \) and/or \( \mu_T > 0 \)), one can guarantee that government solvency
conditions are satisfied (fiscal policy rules similar to (8a), (8b) have
frequently been used in the public finance literature and in
macroeconometric models; see, e.g., Buiter (1990, pp.265-66) and Masson et
al. (1990)).

Autonomous fiscal spending \( (\gamma_t^1) \) is given by
\[ \gamma_t^1 = X_t^1 \exp(\epsilon_t^1), \]
(9)
where \( \gamma_t^1 \) is a constant and \( \epsilon_t^1 \) is an exogenous random variable with mean
zero \((X_t^1 \) is defined after equation (4); the fact that \( X_t^1 \) appears in
equation (9) makes balanced growth possible).

In contrast to productivity and autonomous government spending, the
exogenous tax rate shock, \( \sigma_t^1 \), 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 market 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:

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

where $T_t^i$ denotes the period $t$ tax liability of the private sector, $A_t^i$ denotes the (net) stock of one-period bonds held by the private sector that mature in $t$ ($r_t^i$ 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 (1) subject to the restriction that the budget constraint (10) holds in all periods. The solution to this decision problem satisfies the following Euler equations (assuming that Ponzi games are ruled out):

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

and

$$u_t^i = \beta E_t^i [ MPK_{t+1}^i u_{t+1}^i ].$$

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 $t+1$ ($MPK_{t+1}^i=\{(1-s_{t+1}^i)\phi_{t+1}^i (1-\eta)(K_{t+1}^i)^{-\eta}(N_{t+1}^i)^{-\eta}-\phi_{t}^i 2_{t+1} - d_{t+1})/((1-s_{t}^i)\phi_{t}^i, t)\}$, where $\phi_{s,t}$ is the derivative of the adjustment cost function $\phi(K_{t+1}^i,K_t^i)$ with respect to the $s$th argument of that function).
Given exogenous processes \( \{y_{t}^{i}, \sigma_{t}^{i}\} \) \( i=1,2 \), 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 equations (3), (5), (7 a-b), (8 a-b), (10) and (11 a-b) as well as the condition that the goods market clears:

\[
C_{t}^{1} + C_{t}^{2} + I_{t}^{1} + I_{t}^{2} + G_{t}^{1} + G_{t}^{2} = Y_{t}^{1} + Y_{t}^{2}.
\]  
(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., Backus et al. (1995) and Baxter and Crucini (1993)). 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:

\[
u_{t}^{1} = A \cdot u_{t}^{2},
\]

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

\[
C_{t}^{1} = A \cdot C_{t}^{2}.
\]

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

Given a weight \( A \) and exogenous processes \( \{y_{t}^{i}, \sigma_{t}^{i}\} \) \( i=1,2 \), an equilibrium in the economy with complete asset markets is therefore a set of stochastic processes for the endogenous variables \( \{Y_{t}^{i}, K_{t}^{i}, C_{t}^{i}, I_{t}^{i}, D_{t}^{i}, G_{t}^{i}, T_{t}^{i}, s_{t}^{i}, A_{t}^{i}, r_{t}\} \) for \( i=1,2 \) that satisfies equations (3), (5), (7 a-b), (8 a-b),
A solution of the model is obtained by considering the "detrended" variables $\bar{Y}_t^1 = \frac{Y_t^1}{X_t^1}$, $\bar{K}_t^1 = \frac{K_t^1}{X_t^1}$, $\bar{C}_t^1 = \frac{C_t^1}{X_t^1}$, $\bar{I}_t^1 = \frac{I_t^1}{X_t^1}$, $\bar{D}_t^1 = \frac{D_t^1}{X_t^1}$, $\bar{G}_t^1 = \frac{G_t^1}{X_t^1}$, $\bar{T}_t^1 = \frac{T_t^1}{X_t^1}$, $\bar{A}_t^1 = \frac{A_t^1}{X_t^1}$, $\bar{G}_t^1 (\bar{X}_t^1)^h$ and $\bar{S}_t^1 = \frac{S_t^1}{X_t^1}$. Under the assumptions about preferences and technologies stated above, the model can be written as a system of equations in the variables $\Delta_t^1$, $\bar{Y}_t^1$, $\bar{K}_t^1$, $\bar{C}_t^1$, $\bar{I}_t^1$, $\bar{D}_t^1$, $\bar{G}_t^1$, $\bar{T}_t^1$, $\bar{A}_t^1$, $\bar{S}_t^1$, $\bar{r}_t$ and $\bar{A}_t^1$, for $i=1,2$ (the variable $\bar{A}_t^1$ 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 $A$ in the risk sharing condition (13) is, thus, set at $A=1$).

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

$$E_t h_{t+1} = G h_t + H q_t + f E_t q_{t+1}, \quad \text{and} \quad E_t v_t = f w_t + Q q_t + R E_t q_{t+1},$$

respectively, where $h_t = (\bar{V}_t^1, \bar{V}_t^2, \bar{V}_t^3, \bar{V}_t^4, \bar{V}_t^5, \bar{V}_t^6, \bar{V}_t^7, \bar{V}_t^8, \bar{V}_t^9)^T$, $w_t = (\bar{V}_t^1, \bar{V}_t^2, \bar{V}_t^3, \bar{V}_t^4, \bar{V}_t^5, \bar{V}_t^6, \bar{V}_t^7, \bar{V}_t^8, \bar{V}_t^9, \bar{V}_t^{10})^T$, $q_t = (\bar{q}_t^1, \bar{q}_t^2, \bar{q}_t^3, \bar{q}_t^4, \bar{q}_t^5, \bar{q}_t^6, \bar{q}_t^7, \bar{q}_t^8, \bar{q}_t^9, \bar{q}_t^{10})^T$. $\Delta_t^1=(x_t-x)/x$ denotes the relative deviation of variable $x_t$ from its value in the deterministic steady state around which the linearization is taken ($x$). $G$, $H$, $f$, $Q$ and $R$ 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 (14) are of the following form (see Blanchard and Kahn (1980)):

\[
Q_t = H_0 Q_{t-1} + H_1 q_{t-1}, \quad P_t = \Psi_0 Q_t + \Psi_1 q_t, \tag{15}
\]

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 \( \{H_0, H_1, \Psi_0, \Psi_1 \} \) 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 \( n \) is set at \( n=0.75 \) (see Section 2 for a discussion of that value). Aggregate data indicate a capital depreciation rate of approximately 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 \( n, d \) and \( r \) are generally used in RBC models. The adjustment cost parameter \( \phi \) (see equation (6)) is set at \( \phi=3 \), in order to match the variability of net exports seen in the data (for lower values of \( \phi \), the simulated net exports series are excessively volatile). The second parameter of the adjustment cost function \( \theta \) is selected in such a way that, in deterministic steady state, adjustment costs are zero; this requires \( \theta=q_X \) (recall that \( q_X=q_{t+1}/q_t \)). In the model, the steady state growth factor of output is \( q_X=1.0061 \) 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 \( \sigma \) is in
the range of 2). $\beta$ is set at $\beta=1.0022$, as $(1+r)\beta q^\varphi=1$ holds in steady state (N.E. despite $\beta>1$, the representative agents’ lifetime utility (1) is finite, as $\beta q^\varphi<1$ 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 U.S. (16%) and the G6 (14%) during the sample period. It is also assumed that, in steady state, the stock of government 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 15% (which is close to the mean value of the U.S. and G6 average tax rates during the sample period: 19%). The fiscal policy parameters $\mu_G$ and $\mu_T$ are set at $\mu_G=\mu_T=0.005$ (the aim in setting $\mu_G$ and $\mu_T$ is to use values that are numerically "small" and that ensure that the government debt to output ratio $D^t_t/Y^t_t$ 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. $q^\varphi<1+r$).

### 3.5.3 Forcing variables

The graphs in Figure 1 suggest that U.S. 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. Table 1
tests also whether the difference between U.S. and G6 productivity, as well as the U.S.-G6 differences in government consumption and in tax rates, have a unit root. For these U.S.-G6 differentials, the unit root hypothesis fails likewise to be rejected. Table 2 reports Phillips and Duliaris (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 \( q_t = (\nu_{t1}, \nu_{t2}, \nu_{t3}, \nu_{t4}, \nu_{t5}, \nu_{t6})' \) is the vector of exogenous variables in the linearized version of the model (see (14), (15)), while \( \zeta_t \) is a vector of white noises.  

4. Simulations

4.1 Impulse response functions

Figures 2 and 3 show impulse response functions for the incomplete and the complete markets versions of the model, respectively. The following shocks are considered: a permanent 1% increase in country 1 productivity \((\theta^1)\), a permanent 1% increase in country 1 autonomous government purchases \((\gamma^1)\) and a permanent 1 percentage point reduction in the autonomous component of the
country 1 tax rate ($\sigma_1$). 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; differences in the behavior of net exports across these asset structures are thus entirely due to differences in consumption behavior.

(Insert figures 2 and 3 about here)

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.\textsuperscript{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.\textsuperscript{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 (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.

\subsection*{4.1.2 Fiscal policy shocks}
A reduction in country 1's tax rate increases private sector wealth and the after-tax marginal product of capital, in that country. This raises country 1's consumption and investment (in contrast, the tax cut does not affect country 1 output, on impact). Therefore, country 1 net exports fall. This logic holds for both asset structures.

A rise in government purchases in country 1 has only a relatively weak effect on output and investment in the two countries and, hence, is accompanied by a reduction in world consumption. When markets are complete, consumption falls in both countries and, thus, country 2 net exports
rise—in other words, country 1 net exports fall. When asset markets are incomplete, consumption in country 1 drops much more strongly than when complete markets exist; as a result, country 1 net exports fall less strongly when markets are incomplete.11

4.2. Simulations based on observed productivity, government purchases and tax rate series

Figures 4-6 show simulated time series that are generated when empirical measures of the exogenous variables \( \hat{V}_{01}^t \), \( \hat{V}_{y1}^t \) and \( \hat{V}_{s1}^t \) for the U.S. and the G6 are fed into the model (see (15)). The sample period considered in this simulation exercise is 1975:Q1-1991:Q3. Actual U.S. and G6 government consumption and average tax rates are used as empirical counterparts of autonomous government purchases \( \gamma_1^t \) and of the autonomous component of the tax rate \( \sigma_1^t \), as no direct observations of these exogenous variables are available. (According to the model, government purchases and the tax rate are endogenous—see equations (8a-b); it appears, however, that for low values of the fiscal policy parameters \( \mu_G \) and \( \mu_T \), as used in the simulations, \( G_1^t \) is very closely correlated with \( \gamma_1^t \); \( s_1^t \) and \( \sigma_1^t \) are also highly correlated.)

Empirical counterparts for \( \hat{V}_{01}^t \) and \( \hat{V}_{y1}^t \) (for \( i=1,2 \)) are obtained by linearly detrending the productivity index \( \ln(\hat{V}_{11}^t) \) and logged government consumption (for the U.S. and the G6). The empirical counterpart for \( \hat{V}_{s1}^t \) used in the simulations is the relative deviation of the period \( t \) tax rate in country \( i \) (\( i=U.S., \) G6) from the average tax rate observed during the sample period in that country.

4.2.1 Net exports: simulated responses to historical shocks

Figures 4 and 5 show simulated U.S. net exports series that obtain when historical U.S. and G6 productivity, government purchases and tax rate
series are fed into the model. The predicted and the actual net export series are both expressed as shares of output. \(^{(12)}\) Panels (c)-(h) in these Figures present simulations in which the model is subjected to each of the six forcing variables separately; in Panel (b), U.S. and G6 productivity series are simultaneously fed into the model, while Panel (a) shows simulated U.S. net exports that obtain when all six forcing variables are simultaneously fed into the model.

**Simulated response to historical productivity shocks**

Feeding just the historical U.S. productivity series into the incomplete markets structure yields a simulated net exports series that captures the major changes in U.S. net exports during the sample period (see Panel (c), Figure 4). This success in matching the net exports data is due to the fact that net exports are predicted to respond negatively to permanent productivity shocks, in the bonds-only structure (see discussion in Section 4.1.1). This enables the incomplete markets structure to capture the fact that, empirically, U.S. net exports and U.S. productivity co-move negatively (see Section 2; the correlation between the simulated U.S. net exports series shown in Panel (c) of Figure 4 and the historical U.S. productivity series is \(-0.80\); for example, the strong growth in U.S. productivity during the first half of the 1980s (see Figure 1) induces a strong contemporaneous decline in simulated net exports, which is consistent with the fall in actual U.S. net exports during the early 1980s.

As discussed in Section 4.1.1, net exports respond positively to permanent productivity shocks, when asset markets are complete. Thus, the simulated net exports series that is generated when the historical U.S. productivity series is fed into the complete markets structure (Panel (c), Figure 5) bears little resemblance to actual U.S. net exports.

When just the historical G6 productivity series are fed into the
theoretical structure, then simulated net exports are negatively correlated with actual U.S. net exports—this is the case for both asset market structures (see Panel (d) in Figures 4-5). However, the simulated net exports series that is generated when U.S. and G6 productivity series are simultaneously fed into the incomplete markets structure (Panel (b), Figure 4) still matches relatively well the major fluctuations of historical U.S. net exports—the effect of U.S. productivity shocks on the U.S. trade balance dominates, thus, that of G6 productivity shocks (this is due to the fact that the (detrended) U.S. productivity series that are fed into the model fluctuate more widely than the G6 productivity series, as was noted in Section 2).

Simulated response to historical fiscal policy shocks

Figures 4 and 5 suggest that fiscal policy changes were less important sources of fluctuations in U.S. net exports than productivity shocks.

Feeding the historical government purchases series into the model generates trade balance series that are positively correlated with the observed U.S. trade balance series (for both asset market structures), but the variability of the simulated series is much too small compared to the data (see Panels (g)-(h) in Figures 4 and 5).\textsuperscript{13}

Simulations of the incomplete markets structure that use actual tax rates as the only source of shocks (Panels (e),(f) in Figure 4) suggest that tax changes had a non-negligible impact on U.S. net exports (in contrast, when markets are complete, the simulated response to historical tax changes is very weak). According to the incomplete markets structure, the drop in the U.S. average tax rate by approximately 2.5 percentage points that occurred in 1982 led to a drop in U.S. net exports by roughly 1% of GDP. However, U.S. tax changes do not explain the persistence of low U.S. net exports during the second half of the 1980s: the strong rise in
the U.S. tax rate in 1986 induces a sharp rise in the simulated U.S. net exports series. The incomplete markets structure suggests, in contrast, that the continual rise in G6 tax rates has contributed to the persistent decline in U.S. net exports during the sample period (see Panel (f), Fig. 4).

**Combined effect of six forcing variables**

Simultaneously feeding all six forcing variables into the incomplete markets structure generates a simulated net exports series that tracks the actual behavior of U.S. net exports fairly closely, as can be seen in Panel (a) of Figure 4 (in contrast, the corresponding simulated series generated by the complete markets structure is negatively correlated with actual net exports; see Panel (a) in Figure 5). A shortcoming of the incomplete markets structure is that it does not fully account for the persistence of the U.S. trade balance deficit—after reaching a trough in the mid-1980s, the simulated U.S. net exports series rises sharply in 1986, whereas actual U.S. net exports start to rise only in 1988. Note also that the simulated net exports series that is generated when all six forcing variables are used simultaneously resembles rather closely the simulated series that is generated when just U.S. productivity shocks are fed into the model. This clearly suggests that U.S. productivity shocks were the major force behind the fluctuations in the U.S. trade balance during the sample period.

**(INSERT FIGURE 6 ABOUT HERE)**

**4.2.2 Other aggregates: simulated effect of historical shocks**

Figure 6 plots actual (linearly detrended) output, consumption and investment series for the U.S. and the G6, as well as the simulated series for these variables that obtain when the complete and the incomplete asset market versions of the model are simultaneously subjected to the historical productivity, government consumption and tax rate series. The model
explains relatively well the behavior of actual U.S. and G6 output; however, it matches less closely the observed investment series—although it captures most of the major swings in that variable (note that the simulated output and investment series are identical across the two asset market structures; see the discussion regarding this in Section 4.1).

The incomplete markets structure matches more closely the actual U.S. and G6 consumption series than the complete markets structure (N.B. in the latter, the simulated consumption series are perfectly correlated across countries). Note, in particular, that the incomplete markets structure explains much better the strong idiosyncratic growth in U.S. consumption during the 1982-1988 period that was associated with the rapid rise in U.S. productivity and output during that period—this explains why the incomplete markets structure succeeds in capturing the strong drop in U.S. net exports during the first half of the 1980s.

4.3 Sensitivity analysis

The key results concerning trade balance behavior that were just discussed are robust to changes in preference and technology parameters and to changes in the parameters of the fiscal policy rules (because of space constraints, no sensitivity analysis with respect to these parameters can be presented here; such an analysis is available from the author, upon request). It appears, however, that the predicted behavior of net exports is highly sensitive to changes in the assumed time-series process of productivity.

Sensitivity to assumed time-series process of productivity

The simulations so far have assumed that productivity in each country follows a random walk, which implies that the cross-country productivity difference is likewise a random walk. Section 3.5.3. showed that standard
unit root tests fail to reject the hypothesis that productivity, as well as the cross-country productivity difference, follows a unit root process. However, as is well known, unit root tests have low power against the alternative hypothesis that the variable is (trend-) stationary but highly persistent; see, e.g., Campbell and Perron (1991). It thus seems interesting to investigate whether the model predictions change when a stationary productivity process with an autocorrelation coefficient close to unity is assumed.

(intert Figue 7 about here)

Figure 7 shows impulse response functions for the case in which productivity follows an AR(1) process with an autocorrelation of 0.95:

\[ \theta^i_t = \rho \theta^i_{t-1} + \epsilon^i_t \quad \text{with} \quad \rho = 0.95, \]

where \( \epsilon^i_t \) is a white noise. A comparison with the baseline case in Figures 2 and 3 (where \( \rho = 1 \) is assumed) shows that the response of consumption in country 1 to a productivity shock experienced by that country is much weaker when \( \rho = 0.95 \) is used. In contrast, the short run response of country 1 output and investment to a productivity shock is much less affected by the change in the persistence parameter \( \rho \) (note, for example, that a 1\% productivity increase raises output by 1\%, on impact---i.e. that impact response does not depend on \( \rho \)). The explanation for the much weaker response of country 1 consumption (when \( \rho = 0.95 \)) is that exogenous shocks have a much weaker effect on private sector wealth in country 1 when these shocks are decaying at a rate of 5\% per period (\( \rho = 0.95 \)) than when the shocks are permanent (\( \rho = 1 \)). The weaker country 1 consumption response has important consequences for the response of the trade balance to productivity shocks: note, in particular, that when \( \rho = 0.95 \) is assumed, then a productivity increase in country 1 triggers a rise in that country's net