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Fiscal Policy, Productivity Shocks, and the U.S. Trade Balance Deficit

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ABSTRACT

A two-country Real Business Cycle (RBC) model is used to study the behavior of the United States trade balance. In this model, economic fluctuations are driven by productivity shocks and by variations in government purchases and in distorting taxes. The model is simulated using quarterly data on total factor productivity, government purchases, and the average tax rate in the seven major industrial countries during the period 1975–91. A version of the model that postulates complete international asset markets—as frequently assumed in the International RBC literature (see, e.g., Backus, Kehoe, and Kydland 1992)—fails to explain the observed behavior of the U.S. trade balance. In contrast, a version with incomplete asset markets, in which only debt contracts can be used for international capital flows, tracks the behavior of the U.S. trade balance fairly closely.

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1. Introduction

This paper uses a two-country International Real Business Cycle (RBC) model to study the behavior of the US trade balance during the period 1975-91. In this model, economic fluctuations are driven by productivity shocks and by variations in government purchases and in distorting taxes.[1]

Particular attention is devoted to the way in which the effects of productivity and fiscal policy shocks depend on the structure of international asset markets. Two asset market structures are compared. In the first, complete international markets exist (as typically assumed in the International RBC literature--see, e.g., Backus et al. [1992]), while in the second setup, only debt contracts can be used for international financial transactions.

The paper computes the response of the two-country model to observed quarterly series on total factor productivity, government consumption and average tax rates in the United States and in the remaining G7 countries during the period 1975-91. It appears that the version of the model with incomplete asset markets tracks the observed behavior of the US trade balance rather closely. In contrast, the version with complete markets fails to do so, mainly because that version predicts that private consumption co-moves too closely across countries.

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[1] Most papers in the International RBC literature focus on variations in productivity as the central source of business cycles (see e.g. Dellas [1986], Cantor and Mark [1988], Baxter and Crucini [1992, 1993], Crucini [1989], Costello [1989], Finn [1990], Stockman and Tesar [1990], Reynolds [1991], Backus, Kehoe and Kydland [1992], Backus and Smith [1992], Boileau [1992], Costello and Prashnik [1992], Devereux et al. [1992], Ravn [1992], Head [1992], Canova [1993] and Eudy [1994]). Authors such as Yi (1990, 1993), McCurdy and Ricketts (1991) and Bec (1994) consider International RBC models with fiscal policy shocks, but in contrast to the present paper, they assume lump-sum taxes. The research described in this paper was conducted independently of Baxter (1992) and of Ishikawa (1994) who discuss two-country RBC models with distorting taxes.

The simulations of the version of the model with incomplete markets suggest that the relatively rapid productivity growth, the strong increase in government purchases and the low average tax rate in the US during the first half of the 1980s explain the sharp drop in that country's net exports during that period.

The model presented here postulates infinitely lived optimizing agents. It allows for physical capital accumulation and endogenous labor supplies. The use of distorting taxes in a framework with infinitely lived agents distinguishes this study from recent empirical work in open economy macroeconomics that has broken Ricardian Equivalence by postulating an overlapping generations structure while assuming lump-sum taxes (see, e.g., Leiderman and Razin [1990] and Cardia [1991]). In the OLG setup considered in that work, a tax cut leads to a reduction in net exports as, holding constant government purchases, it increases the wealth of the current generation, at the expense of future generations, thereby increasing the demand for consumption goods by the present generation. In contrast, in this paper, tax changes affect economic decisions because of their impact on the after-tax marginal product of labor and capital. Numerical simulation results are presented which show that, on impact, a tax cut leads to an increase in investment and a decline in net exports.

Section 2 discusses the model and describes the method used to solve and simulate the model. Simulation results are then presented in Section 3. Section 4 concludes.

2. The Model

2.1 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 can also be used as an investment good. Private sector preferences and technologies are similar to those assumed in previous two-country RBC models (see, e.g., Kollmann [1991], Backus et al. [1992] and Baxter and Crucini [1993]).

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

$$E_t \sum_{j=0}^{j=\infty} \beta^j \cdot u(C^i_{t+j}, \ell^i_{t+j}), \tag{1}$$

where E_t denotes the mathematical expectation conditional on information available at date t; $0<\beta<1$ is the country's subjective discount factor; and C^i_t and ℓ^i_t denote Country i's aggregate consumption and the fraction of their time that the residents of Country i devote to work in period t. A standard RBC specification is adopted for the period utility function (see, for example, Rotemberg and Woodford [1989]):

$$u(C^i_t, \ell^i_t) = (1/(1-\sigma)) \cdot (C^i_t \cdot e^{-\psi(\ell^i_t)})^{1-\sigma}, \tag{2}$$

where $\sigma>0$, $\sigma\neq1$. ψ is an increasing function. Concavity of u requires that $\psi''-(1-\sigma)\cdot(\psi')^2>0$ and that $\sigma\cdot\psi''-(1-\sigma)\cdot(\psi')^2>0$.

Labor is immobile internationally. Each country produces the single good using capital and labor. Country i's output in period t is given by a Cobb-Douglas production function:

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

where K_t^i is Country i's aggregate capital stock in period t. N_t^i is the population of Country i in period t and, hence, $N_t^i \cdot \ell_t^i$ measures the total number of hours worked in Country i during that period. The population growth rate is constant and identical in both countries: $N_t^i = g_N \cdot N_{t-1}^i$. Total factor productivity (θ_t^i) is given by

$$\theta_t^i = (Z_t^i)^{1-\eta} \cdot \exp(\nu_t^i), \tag{4}$$

where ν_t^i is an exogenous random variable, while Z_t^i is a deterministic geometric trend. Z_t^i grows at a rate that is constant and common in both countries: $Z_t^i = g_Z \cdot Z_{t-1}^i$ for i=1,2.

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

$$K_{t+1}^i + \phi(K_{t+1}^i, K_t^i) = (1-d) \cdot K_t^i + I_t^i, \tag{5}$$

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

$$\phi(K_{t+1}^i, K_t^i) = 0.5 \cdot \Phi \cdot \left\{K_{t+1}^i - \vartheta \cdot K_t^i\right\}^2 / K_t^i, \quad \Phi>0, \ \vartheta>0. \tag{6}$$

2.2 Government Behavior

Governments purchase units of the homogeneous good and finance these purchases by taxing the private agents. In addition, governments trade in real one-period bonds.[2] The budget constraint of the government of Country i is

$$G_t^i + D_t^i \cdot (1+r_t) = T_t^i + D_{t+1}^i, \tag{7 a}$$

[2]Even in a setting where complete asset markets exist (as considered in Section 2.3.2), governments are assumed to engage in unconditional borrowing and lending only. This seems largely consistent with the observed financial behavior of governments.

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 on that debt. The only tax available to governments is a flat-rate tax on net output (output net of capital depreciation and of adjustment costs).[3] Government tax revenues are hence given by

$$T^i_t = s^i_t \cdot [Y^i_t - d \cdot K^i_t - \phi(K^i_{t+1},K^i_t)], \tag{7 b}$$

where s^i_t is the rate of the flat-rate tax.[4]

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

$$G^i_t = \mu_G \cdot D^i_t + \gamma^i_t, \tag{8 a}$$

$$s^i_t = \mu^i_T \cdot D^i_t / [Y^i_t - d \cdot K^i_t - \phi(K^i_{t+1},K^i_t)] + \sigma^i_t. \tag{8 b}$$

Here, γ^i_t and σ^i_t are exogenous random variables. Equations (8 a) and (8 b) 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 (see, e.g., Buiter [1990, pp.265-66]).

Per capita autonomous fiscal spending is given by

$$\gamma^i_t/N^i_t=Z^i_t\cdot\bar{\gamma}^i\exp(\varepsilon^i_t), \tag{9}$$

where Z^i_t is the deterministic trend that appears in the process for total

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[3]Recently, Braun (1989), McGrattan (1990) and Greenwood and Huffman (1991) have presented RBC analyses of the effects of distorting taxes in a closed economy setting. The theoretical literature on the effects of tax policy in open economy settings is surveyed by Dixit (1985). Recent theoretical studies on the effects of distorting taxes in open economies include: Bianconi and Turnovsky (1992), Bianconi (1992), Cassou (1992), Correia (1992), Frenkel and Razin (1987) and Frenkel, Razin and Sadka (1991).

[4]Given the complexity of the model, a highly stylized tax system is assumed. Notice that, in the tax system considered here, private agents do not pay taxes on their (foreign and domestic) interest income. Such a set-up can be justified by the fact that, according to Frenkel et al. (1991, p.185) "...there is now substantial evidence that governments encounter severe enforcement difficulties in attempting to tax foreign-source income".

factor productivity (4).[5] $\bar{\gamma}^i$ is a constant and ε_t^i is a random variable with mean zero.

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

2.3 Asset Markets

Two asset market structures are considered. In the first (incomplete asset markets), private agents have to use real risk-free one-period debt contracts in their international financial transactions. Hence, agents are unable to buy foreign assets with state-contingent pay-offs (such as equity).[6] In contrast, the second framework assumes complete international markets for date- and state-contingent claims.

2.3.1 Incomplete asset markets

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

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

where T_t^i denotes the period t tax liability of the private sector, A_t^i

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[5]The fact that the same deterministic trend appears in equations (4) and (9) allows balanced growth.

[6]Cole (1988), Kollmann (1991) and Baxter and Crucini (1992) study two-country models with this asset market structure. 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., Ahmed [1986], Johnson [1986], Ghosh [1990], Leiderman and Razin [1990], Sheffrin and Woo [1990 a,b], Cardia [1991], Mendoza [1991, 1992], Otto [1992], Glick and Rogoff [1992], Bruno and Portier [1993], Macklem [1993], Schmitt-Grohé [1993], van Wincoop and Marrinan [1993], and Senhadji [1994]). In that work, the small open economy can trade risk-free bonds in the international capital market at an exogenous interest rate. In contrast, the present paper treats the world interest rate as an endogenous variable.

denotes the (net) stock of one-period bonds held by the private sector that mature in t and r_t is the real risk-free interest rate on these bonds. Note that the interest rate that appears in equations (7 a) and (10) is the same: private agents and the government both face the same interest rate. $A^i_t>0$ holds when the private sector is a net lender and $A^i_t<0$ holds when it is a net borrower.

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

$$u^i_{1,t} = (1+r_{t+1}) \cdot \beta \cdot E_t[\, u^i_{1,t+1}] \qquad \text{for } i=1,2 \tag{11 a}$$

and
$$u^i_{1,t} = \beta \cdot E_t[\, MPK^i_{t+1} \cdot u^i_{1,t+1}] \qquad \text{for } i=1,2. \tag{11 b}$$

Here, $u^i_{1,t}$ is Country i's marginal utility of consumption at date t, while MPK^i_{t+1} is its intertemporal marginal rate of transformation between periods t and t+1.[7]

In addition, Country i equates the marginal rate of substitution between labor effort and consumption to the after-tax marginal product of effort:

$$u^i_{2,t} + [\, (1-s^i_t)\cdot\theta^i_t\cdot(K^i_t)^{\eta}\cdot(1-\eta)\cdot(\ell^i_t)^{-\eta}\cdot(N^i_t)^{1-\eta}\,] \cdot u^i_{1,t} = 0, \tag{11 c}$$

where $u^i_{2,t}$ is Country i's marginal (dis-) utility of labor.

Given exogenous processes $\{\theta^i_t,\gamma^i_t,\sigma^i_t\}$ i=1,2, an *equilibrium* in the

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[7] $MPK^i_{t+1}\equiv\{(1-s^i_{t+1})\cdot[\theta^i_{t+1}\cdot\eta\cdot(K^i_{t+1})^{\eta-1}\cdot(N^i_{t+1}\cdot\ell^i_{t+1})^{1-\eta}-\phi^i_{2,t+1}-d]+1\}$ / $\{1+(1-s^i_t)\cdot\ \phi^i_{1,t}\}$, where $\phi^i_{s,t}$ is the derivative of the adjustment cost function $\phi(K^i_{t+1},K^i_t)$ with respect to the s^{th} argument of that function.

economy with incomplete asset markets is a set of stochastic processes for the endogenous variables $\{Y_t^i, K_t^i, \ell_t^i, C_t^i, I_t^i, D_t^i, G_t^i, T_t^i, s_t^i, A_t^i, r_t\}$ (for i=1,2) that satisfies equations (3), (5), (7 a-b), (8 a-b), (10) and (11a-c) as well as the condition that the goods market clears:

$$C_t^1 + C_t^2 + I_t^1 + I_t^2 + G_t^1 + G_t^2 = Y_t^1 + Y_t^2. \tag{12}$$

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

2.3.2 Complete asset markets

Most International RBC models assume that asset markets are complete (see, e.g., Backus et al. [1992]). The existence of complete asset markets implies that in equilibrium, (weighted) marginal instantaneous utilities of consumption are equated in the two countries, and that for all states of the world:

$$u_{1,t}^1 = \Lambda \cdot u_{1,t}^2, \tag{13}$$

where Λ is a time-invariant term reflecting the distribution of private sector wealth between the two countries (see Appendix A for a derivation of equation (13)). Equivalently, one can note that, with complete markets, intertemporal marginal rates of substitution are equated between the countries, in other words, $\beta \cdot u_{1,t+1}^1 / u_{1,t}^1 = \beta \cdot u_{1,t+1}^2 / u_{1,t}^2$ holds (see, e.g., Obstfeld [1993]). The key difference when compared with the version of the model with incomplete asset markets is that, in the latter, marginal rates of substitution between consumption at dates t and t+1 are, in general, not equated across the two countries on a state-by-state basis. However, they are equated in expected value: the Euler condition (11 a) implies that $\beta \cdot E_t u_{1,t+1}^1 / u_{1,t}^1 = \beta \cdot E_t u_{1,t+1}^2 / u_{1,t}^2$ holds in equilibrium. As a result, one might expect that consumption is more closely correlated across countries when markets are complete than when they are incomplete.

Obviously, the first-order conditions (11 a-c) and the market clearing condition (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 $\{Y_t^i,\ K_t^i,\ \ell_t^i,\ C_t^i,\ I_t^i,\ D_t^i,\ G_t^i,\ T_t^i,\ s_t^i,\ r_t\}$ for i=1,2 that satisfies equations (3), (5), (7 a-b), (8 a-b), (11 a-c), (12) and (13).

2.4 Solving the Model

A solution of the model is obtained by considering the "detrended" variables $\hat{Y}_t^i \equiv Y_t^i/X_t^i$, $\hat{K}_t^i \equiv K_t^i/X_t^i$, $\hat{C}_t^i \equiv C_t^i/X_t^i$, $\hat{I}_t^i \equiv I_t^i/X_t^i$, $\hat{D}_t^i \equiv D_t^i/X_t^i$, $\hat{G}_t^i \equiv G_t^i/X_t^i$, $\hat{T}_t^i \equiv T_t^i/X_t^i$, $\hat{A}_t^i \equiv A_t^i/X_t^i$, $\hat{\theta}_t \equiv \theta_t^i/Z_t^i$ and $\hat{\gamma}_t^i \equiv \gamma_t^i/X_t^i$, where $X_t^i \equiv Z_t^i \cdot N_t^i$. Under the assumptions about preferences and technologies stated above, the model can be written as a system of equations in the variables $\hat{\theta}_t^i$, $\hat{\gamma}_t^i$, σ_t^i, $\hat{Y}_t^i$, $\hat{K}_t^i$, ℓ_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).[8]

An approximate solution of the model can be computed by deriving a linear approximation of the equilibrium conditions (expressed in terms of this set of variables) near a deterministic steady state--i.e., near an equilibrium in which the (detrended) endogenous and exogenous variables are constant.[9] Keeping the linear terms of Taylor expansions of the incomplete

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[8] Note: The variable $\hat{A}_t^i$ is relevant only when asset markets are incomplete.

[9] This solution method is standard in the RBC literature (see, e.g., King et al. [1988]).

markets version of the model yields a system of equations that can be written as

$$E_t h_{t+1} = G \cdot h_t + H \cdot q_t + J \cdot E_t q_{t+1} \ , \tag{14 a}$$

where $h_t \equiv (\nabla r_{t-1}, \nabla \hat{D}_t^1, \nabla \hat{D}_t^2, \nabla \hat{A}_t^1, \nabla \hat{K}_t^1, \nabla \hat{K}_t^2, \nabla \hat{C}_t^1, \nabla \hat{C}_t^2, \nabla \hat{K}_{t+1}^1)'$, $q_t \equiv (\nabla \hat{\theta}_t^1, \nabla \hat{\theta}_t^2, \nabla \hat{\gamma}_t^1, \nabla \hat{\gamma}_t^2, \nabla \sigma_t^1, \nabla \sigma_t^2)'$. Here, ∇x_t denotes the relative deviation of variable x_t from its value in the deterministic steady state around which the linearization is taken.[10]

The linearized version of the model with complete markets can be expressed as

$$E_t w_{t+1} = S \cdot w_t + Q \cdot q_t + R \cdot E_t q_{t+1} \ , \tag{14 b}$$

where $w_t \equiv (\nabla \hat{D}_t^1, \nabla \hat{D}_t^2, \nabla \hat{K}_t^1, \nabla \hat{K}_t^2, \nabla \hat{C}_t^1, \nabla \hat{C}_t^2, \nabla K_{t+1}^1)'$.

In equations (14 a-b), G, H, J, S, Q and R are matrices of dimensions (9x9), (9x6), (9x6), (7x7), (7x6) and (7x6), respectively. 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. As shown by Blanchard and Kahn (1980), a system of expectational difference equations of the form given in equations (14 a) and (14 b) has a unique stable solution if the number of non-predetermined variables in the system equals the number of eigenvalues of the matrices G and S that lie strictly outside the unit circle. This condition is satisfied for the parameter values assumed in the simulations.

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[10] $\nabla x_t = (x_t - x)/x$, where x is the value of the variable x_t in the deterministic steady state. One exception to this notation is made: in order to allow for cases where steady state net asset holdings of the private sector and of the government are zero, $\nabla \hat{D}_t^i$ and $\nabla \hat{A}_t^i$ (i=1,2) denote the differences between $\hat{D}_t^i$ and $\hat{A}_t^i$ and the steady state values of these variables.

The simulations assume that the exogenous variables are random walks. Under this assumption, the solutions of (14 a) and (14 b) are of the following form:

$$Q_t=H_0\cdot Q_{t-1}+H_1\cdot q_{t-1},\ P_t=F_0\cdot Q_t+F_1\cdot q_t, \tag{15}$$

where Q_t is the vector of variables that are predetermined at date t, while P_t is the vector of non-predetermined variables (H_0, H_1, F_0 and F_1 are matrices).

Output, the trade balance and other variables of interest are functions of Q_t and P_t and, hence, they can be computed easily once one has solved for Q_t and P_t.

2.5 Parameters

A detailed description of the parameter values used for the simulations is given in Appendix B. The model is linearized around a symmetric deterministic steady state in which all variables have the same values in both countries. The steady state share of government purchases in output and the steady state tax rate are set to 15 % and 18 % respectively. The fiscal policy parameters μ_G and μ_T are set to $\mu_G=-0.002$ and $\mu_T=0.002$. The simulations are based on the assumption that the exogenous shocks $\nabla\hat{\theta}^i_t$, $\nabla\hat{\gamma}^i_t$, and $\nabla\sigma^i_t$ for (i=1,2) are random walks.[11]

[11]The next section describes how empirical counterparts to the variables $\nabla\hat{\theta}^i_t$, $\nabla\hat{\gamma}^i_t$ and $\nabla\sigma^i_t$ are constructed. Augmented Dickey Fuller tests fail to reject the hypothesis (at the 10% level) that these variables follow unit root processes and Phillips and Ouliaris (1990) tests strongly suggest that they are not cointegrated. This allows us to model the first differences of these variables as a vector autoregressive process. Fitting VARs of various orders to first differences of the variables and using the estimated coefficients of these VARs to simulate the model yields results that are very similar to those that obtain when one simply assumes that the variables are random walks.

2.6 Empirical Implementation of the Model

Below, empirical measures of the series $\nabla\hat{\theta}^i_t$, $\nabla\hat{\gamma}^i_t$, and $\nabla\sigma^i_t$ for the US and an aggregate of the remaining G7 countries (Japan, Germany, France, the UK, Italy and Canada) are fed into the model (henceforth, this set of countries will be referred to as the G6 countries). The sample period considered in this simulation exercise is 1975:1-1991:3. All series are quarterly. Appendix C provides definitions and sources of all the data used in this paper (Appendix C also explains how aggregate time series for the G6 countries are constructed).

The index of total factor productivity, θ^i_t, is estimated using the formula

$$\ln(\theta^i_t) = \ln(Y^i_t) - \eta \cdot \ln(K^i_t) - (1-\eta) \cdot \ln(N^i_t \cdot \ell^i_t), \tag{16}$$

with η=0.25.[12] The empirical measures used for Y^i_t, K^i_t and $N^i_t \cdot \ell^i_t$ are real GDP, physical capital and total hours worked, respectively.

The tax rate, s^i_t, is estimated using the ratio of total tax revenues and social security contributions received by governments (minus transfer payments made by governments) and the net domestic product (GDP minus consumption of fixed capital).

The measure of government purchases used in the simulations is government consumption (as recorded in national income and product accounts). According to the model, government purchases and the tax rate are endogenous (see equations (8 a-b)). In spite of this, actual government consumption and the average tax rate are used as empirical counterparts of autonomous government purchases (γ^i_t) and the exogenous component of the tax rate (σ^i_t), as no direct observations of these exogenous variables are

[12]In the US, the ratio of labor income to capital income fluctuates around 2.5, which suggests a value of η in the range of 0.25.

available. It appears that for low absolute values of the fiscal policy parameters μ_G and μ_T (as used in the simulations), G_t^i is very closely correlated with γ_t^i (s_t^i and σ_t^i are also highly correlated).

Empirical counterparts of $\nabla\hat{\theta}_t^i$ and $\nabla\hat{G}_t^i$ are obtained by linearly detrending the productivity index $\ln(\theta_t^i)$ and logged government consumption. The empirical counterpart for $\nabla\sigma_t^i$ used in the simulations is the relative deviation of the period t tax rate in Country i from the average tax rate observed during the sample period in that country.

2.7 The Data

Figure 1 plots quarterly net exports (as a share of GDP) as well as the productivity index, government consumption and the tax rate for the US and the G6 during the period 1975:1-1991:3. The net exports variable is exports minus imports of goods and services. Figure 1 also shows net imports of the G6 countries. While US net exports and G6 net imports are not identical (as they would be if--as assumed in the model--the G7 did not trade with other countries), the two series are closely correlated.

The most striking feature 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 data plotted in Figure 1 seem noteworthy: (i) the average US tax rate dropped sharply in 1982 and stayed below its pre-1982 level during the next 4 years; (ii) during the first half of the 1980s, US government consumption and US productivity grew much more rapidly than during the rest of the sample period.

3. Simulations[13]

3.1 *Impulse Responses*

Figures 2 and 5 show impulse responses 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, a permanent 1% increase in Country 1 autonomous government purchases and a permanent 1 percentage point reduction in the autonomous component of the Country 1 tax rate.[14]

Under both asset market structures, the productivity shock increases worldwide (private) consumption. It induces a rise in Country 1 investment and output, while it has only a relatively small impact on output and investment in Country 2.

With complete markets, consumption in both countries rises by approximately the same amount. In contrast, when asset markets are incomplete, consumption rises strongly in Country 1 and falls in Country 2.[15] This difference in the responses of consumption explains why the productivity shock induces a fall in Country 1 net exports when asset markets are incomplete and a rise when markets are complete (Note that Country i net exports are $Y^i_t-C^i_t-I^i_t-G^i_t$).

A permanent increase in autonomous government purchases in Country 1 reduces that country's net exports. It has only a relatively weak effect on output and investment and, hence, is accompanied by a reduction in world

[13] Appendix D discusses in detail how the simulations are carried out.

[14] All impulse responses shown in Figures 2 and 5 are expressed as percentages of the value of output in the steady state around which the model is linearized.

[15] The world interest rate (not shown in Figure 2) rises as a result of the productivity shock, which induces Country 2 to lower its current consumption.

consumption. With complete markets, consumption in both countries falls by roughly the same amount. In contrast, when asset markets are incomplete, consumption in Country 1 drops much more strongly than consumption in Country 2. As a result, Country 1 net exports fall more strongly when asset markets are complete than when they are incomplete.

A reduction in Country 1's tax rate increases the after-tax marginal product of capital and the after-tax real wage rate in that country. This increases Country 1's gross investment, labor supply and output and it induces a fall in Country 1's net exports. The tax cut has only a relatively weak effect on Country 2's output and investment. With incomplete markets, consumption in Country 1 rises strongly, while consumption in Country 2 falls (this, again, reflects the fact that, as a result of the tax cut, the world interest rate rises). With complete markets, Country 1 consumption rises much less than in the presence of incomplete markets and, hence, the cut in the tax rate induces a much smaller fall in Country 1's net exports.[16]

We conclude from this discussion that the key difference between the two asset market structures is that consumption co-moves much more closely across the two countries when asset markets are complete than when they are incomplete.

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[16]The tax cut increases government debt in Country 1. According to the fiscal policy rule specified in equation (8 a), this leads to a reduction in government purchases, as can be seen in panel (e) of Figures 2 and 5 (recall that $\mu_G<0$ is assumed).

3.2 Simulations Based on Observed Productivity, Government Purchases and Tax Rate Series

Figures 3 and 6 show the predicted US net exports series that obtain when the model is subjected to the empirical counterparts of the $\nabla\hat{\theta}_t^i$, $\nabla\hat{g}_t^i$ and $\nabla\sigma_t^i$ variables constructed for the US and the G6 countries. The predicted and the actual net export series are expressed as shares of output. Consider first the predicted trade balance behavior that results when the model is subjected to each of the three types of shocks separately.

Subjecting the version of the model with incomplete markets to the observed productivity series (see Figure 3, panel (b)) yields a simulated trade balance series that captures the major swings in observed US net exports during the sample period. The strong growth in US productivity during the first half of the 1980s induces a strong decline in simulated net exports during that period, but productivity shocks fail to fully account for the low level of US net exports during the second half of that decade.

As discussed earlier, when complete asset markets are assumed, a permanent positive productivity shock increases net exports in the country in which the shocks occur. As a result, the simulated net export series that obtains when the complete markets model is subjected to the actual productivity series is clearly inconsistent with the observed behavior of the US trade balance (see panel (b) of Figure 6).

Simulations of the incomplete markets model that use actual tax rate data as the only source of shocks (Figure 3, panel (c)), suggest that tax changes had a strong impact on US net exports (in contrast, when markets are complete, the predicted response to the variations in the tax rates is very weak). According to that model, the drop in the US average tax rate by approximately 2.5 percentage points that occurred in 1982 led to a drop in

US net exports by more than 0.5% of GDP. It appears, however, that changes in US and G6 tax rates do not explain the persistence of low US net exports during the second half of the 1980s: the strong rise in the US tax rate in 1986 induces a sharp rise in the predicted US net export series.

Feeding the observed government purchases series into the model generates a trade balance series that is highly correlated with the observed US trade balance series, but the variability of the predicted series is too small compared to the data (see panel (d) of Figures 3 and 6).

Simultaneously feeding the empirical $\nabla\hat{\theta}_t^i$, $\nabla\hat{g}_t^i$ and $\nabla\sigma_t^i$ series into the incomplete markets model generates a predicted net export series that tracks the actual behavior of US net exports fairly closely (see panel (a) of Figure 3). The main shortcoming of the incomplete markets model is that it fails to fully account for the persistence of the US trade balance deficit--after reaching a trough in the mid-1980s, the simulated US net exports series rises sharply in 1986, whereas actual US net exports start to rise only in 1988.[17]

Figures 4 and 7 plot actual (linearly detrended) output, consumption and investment series for the US and the G6 as well as the predicted series that obtain when the two-country model is simultaneously subjected to the observed productivity, government consumption and tax rate series. The complete and the incomplete asset market versions of the model both capture well the behavior of actual US and G6 output during the sample period. However, they match less closely the observed investment series--although

[17]The discrepancy between the simulated trade balance series and the G6 trade surplus is less pronounced: panel (a) of Figure 1 shows that after reaching a peak in mid-1986, the G6 net surplus starts to fall strongly in late 1987, which is closer to the predicted series in panel (a) of Figure 3.

they capture most of the major swings in that variable.

The incomplete markets framework explains much better the actual US and G6 consumption series than the complete markets model (see panels (d) and (e) in Figures 4 and 7). The predicted consumption series for Countries 1 and 2 generated by the complete markets model are much more closely correlated with each other than the actual US and G6 consumption series. The complete markets model does not capture well the strong growth in US consumption during the 1982-88 period, and this appears to be one of the main reasons why that model fails to explain the strong drop in US net exports during the first half of the 1980s.

4. Conclusions

This paper uses a two-country RBC model to quantitatively study the dynamics of the US trade balance. The model postulates infinitely lived optimizing agents and fully integrated international capital markets. Governments use a flat-rate tax on output to finance their expenditures. The study shows that the behavior of the trade balance depends strongly on the structure of international asset markets. This conclusion is reached by comparing two asset market structures: a framework with complete markets and one where financial transactions are restricted to unconditional debt contracts. Versions of the two-country model with these alternative asset market structures are simulated by feeding actual series on productivity, government consumption and the average tax rate for the US and an aggregate of the remaining G7 countries into the model.

The version of the model with incomplete markets tracks rather closely the observed behavior of the US trade balance, while the version with complete markets fails to do so--mainly because in that version, private consumption is predicted to co-move more closely across countries than the data indicate.

The simulations of the model with incomplete markets suggest that the relatively rapid productivity growth, the strong increase in government purchases and the drop in the US average tax rate during the first half of the 1980s explain the sharp drop in US net exports during that period.

APPENDIX A. Derivation of the risk-sharing condition (13)

Equation (13) holds in the version of the two-country model that assumes complete asset markets. Let $p_t(s_{t+1})$ be the date t price (in terms of date t output) of an asset that pays one unit of the consumption good if and only if the state of the world in t+1 is $s_{t+1} \in S_{t+1}$, where S_{t+1} is the set of possible states in t+1. Optimal consumption behavior by Country i implies that

$$\pi_t(s_{t+1}) \cdot \beta \cdot u_1(C^i_{t+1}(s_{t+1}), \ell^i_{t+1}(s_{t+1}))/u_1(C^i_t, \ell^i_t) = p_t(s_{t+1})$$

holds for all $s_{t+1} \in S_{t+1}$ where $C^i_{t+1}(s_{t+1})$ and $\ell^i_{t+1}(s_{t+1})$ denote Country i's consumption and work effort in period t+1 if s_{t+1} obtains, while $\pi_t(s_{t+1})$ is the probability density of s_{t+1} conditional on date t information (see Sargent [1987] and Kollmann [1995], for example). This implies that, in equilibrium, the following condition holds for all t and q (and for all possible states of the world):

$$\beta^q \cdot u_1(C^1_{t+q}, \ell^1_{t+q})/u_1(C^1_t, \ell^1_t) = \beta^q \cdot u_1(C^2_{t+q}, \ell^2_{t+q})/u_1(C^2_t, \ell^2_t).$$

This shows that, when complete markets exist, intertemporal marginal rates of substitution in consumption are equated between the countries, for all dates and states. This condition implies that the risk-sharing condition (13) has to hold for some time-invariant term Λ.

Previous International RBC models have largely assumed economies without distortions. In these models, competitive equilibria are Pareto optimal (provided asset markets are complete). Competitive equilibria in these models can therefore be computed by solving a social planning problem that consists in maximizing a weighted sum of the expected life-time utilities of the representative agents of all countries subject to a world resource constraint (for example, this approach has been used by Backus et al. [1992], Lewis [1993], Canova and Ravn [1993] and by Brennan and Solnik [1989] in studies on international risk-sharing; see also Cochrane [1991], Mace [1991] and Townsend [1994] who use the same idea to study risk-sharing among individual households within the same country or village). It is easy to see that one of the first-order conditions of this planning problem is that weighted marginal utilities of consumption are equated between countries. This first-order condition has the same form as equation (13).

In the presence of distorting taxes, competitive equilibria are not Pareto optimal. It is thus not possible to solve for an equilibrium by solving for a Pareto optimum. Despite this, the risk-sharing condition (13) holds in the complete markets version of the model considered in this study (the key assumption underlying (13) is that residents of all countries can trade in complete markets for date- and state-contingent claims to future consumption, and that they face the same prices in these markets).

APPENDIX B. Parameter values

Preference parameters

Eichenbaum et al. (1988) present estimates of coefficients of relative risk aversion that lie roughly in the 0 to 1 range, and the simulations assume $\sigma=0.5$.

The utility function assumed in this paper implies that the Frisch labor supply elasticity (i.e., the labor supply elasticity that is computed holding the marginal utility of consumption constant) is $els\equiv\sigma/(\sigma\cdot\nu_2(\ell_t)+(\sigma-1)\cdot\nu_1(\ell_t))$, where $\nu_2(\ell_t) \equiv \psi''(\ell_t)\cdot\ell_t/\psi'(\ell_t)$ and $\nu_1(\ell_t)\equiv\psi'(\ell_t)\cdot\ell_t$. The first-order condition (11c) implies $(1-\eta)\cdot(1-s_t^i)\cdot\hat{Y}_t^i/\hat{C}_t^i = \nu_1(\ell_t^i)$. The steady state value of ν_1 is thus pinned down by the steady state tax rate and by the steady state ratio of output to consumption. To solve the model, one has to specify the elasticities (evaluated at the steady state) of the period utility function and of its first derivatives (with respect to consumption and effort). Once values for ν_1, σ and els are given, the values of all these elasticities are determined. For males, many studies find labor supply elasticities close to zero (see Pencavel [1986] and Card [1991]) and recent research gets similar results for females (see Mroz [1987]). The simulations assume that els=0.1 holds at the steady state (the finding that the incomplete markets model explains better the behavior of the US trade than the complete markets is not sensitive to the values of els and σ).

Steady state interest rate and technology parameters

The following values for the steady state interest rate and the depreciation rate are selected: r=0.01, d=0.025. The model is calibrated to quarterly data. Hence, the implied annual real interest rate and annual depreciation rate are 4% and 10% respectively.

The elasticity of output with respect to capital is set to $\eta=0.25$ (as discussed above, this corresponds roughly to the factor share of capital in the US economy).

The adjustment cost parameter Φ is set to Φ=8 (for lower values of Φ, the simulated trade balance series is excessively volatile, compared to the data). 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 $\vartheta = g_Z \cdot g_N$, where $g_Z = Z_t^i / Z_{t-1}^i$ and $g_N = N_t^i / N_{t-1}^i$). For this specification of the adjustment cost function, the average capital adjustment cost in the simulations reported in Figures 3, 4, 6 and 7 amounts to less than 0.07% of output.

Fiscal policy parameters

The simulations assume μ_G=-0.002 and μ_T=0.002 (the aim in setting the fiscal policy parameters μ_G and μ_T is to use values that ensure government debt is non-explosive in equilibrium, and that are numerically "small").

Growth rates

In the model, the steady state growth factor of output is $g_Z \cdot g_N$. It is assumed that $g_Z \cdot g_N$= 1.0061 and g_N=1.0016 (which implies of g_Z=1.0045), as 1.0061 and 1.0016 are, respectively, the average quarterly growth factors of total G7 output and of the total G7 population during the period 1975:1-1991:3.

Time series properties of exogenous variables

All exogenous variables are assumed to be random walks.

Steady state asset positions, tax rates and government purchases

The model is linearized around a symmetric deterministic steady state in which all variables have the same value in each country. Hence, net exports and net foreign asset positions are zero in this steady state. It is also assumed that, in steady state, government net asset positions are 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 the steady state government net asset position).

In steady state, 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. Given these values, the government budget constraint implies that the steady state tax rate equals 18% (which is not far from the mean value of the US and G6 average tax rates during the sample period: 19%).

APPENDIX C. The data

Output: Nominal GDP (for Germany: nominal GNP) deflated using Consumer Price Indexes (CPI). Source--International Financial Statistics (IFS).

(Private) Consumption: Private consumption expenditures from IFS (deflated using domestic CPIs).

The **government purchases** series used in the simulations is the government consumption series provided by IFS (deflated using domestic CPIs).

Investment: Gross fixed capital formation from IFS, deflated using CPIs. The investment series includes government investment.

Capital stocks: US--private plus government-owned fixed capital (at constant costs). Source for 1974-1990: Musgrave (1992, Table 4). The Capital stock for 1991 was estimated by assuming that the growth rate of capital between 1990 and 1991 equals the growth rate between 1989 and 1990.
Japan, Germany, France, UK, Canada--1975-89 total net stock of capital in constant prices is taken from Flows and Stocks of Fixed Capital (OECD). Capital stocks for 1990 and 1991 were estimated by linear extrapolation (using OLS) from 1975-89 capital stocks.
Italy--1974-85 capital stock series taken from Intersectoral Database (OECD). 1986-91 capital stock for Italy is estimated by assuming that the share of Italian capital stock in total G6 capital stock in 1986-91 equals the 1985 share.
The capital stock series from these sources are annual. Quarterly capital stock series are constructed by linear interpolation of the annual series.

Hours worked: US--total number of hours worked in non-agricultural sector (series LPHMU from Citibase).
Japan, Germany--total employment in the non-agricultural sector multiplied by average weekly hours worked (from Bulletin of Labour Statistics, International Labour Office, ILO).

France--total employment in the non-agricultural sector multiplied by average weekly hours worked (from Bulletin of Labour Statistics, published by ILO, and Bulletin Mensuel des Statistiques du Travail, published by INSEE).

UK--total employment multiplied by average weekly hours worked (from Employment Gazette, Supplement with Historical Statistics [1992]). This source provides only annual series for average hours worked. A quarterly hours series is obtained by linear interpolation.

Italy--total employment in the non-agricultural sector (from Bulletin of Labour Statistics, ILO).

Canada--Total hours worked, all jobs (from Historical Labor Force Statistics [1991], Statistics Canada).

ILO series for Italy and France pertain to the first month of a given quarter. Japanese employment and hours series are provided at a monthly frequency. Observations for the second month of a each quarter are used to construct quarterly series.

Hours/employment series for the US, the UK and Canada are provided in seasonally adjusted form by the data sources. ILO series seem to be presented in seasonally unadjusted form, but inspection of the ILO series for Japan and France suggests that these series do not exhibit seasonality. The ILO employment series for Italy, however, exhibits seasonality, and it was seasonally adjusted using the Hodrick-Prescott (1980) filter (with the smoothing parameter λ set to $\lambda=2$).

The **net exports** variable considered in this paper is exports minus imports of goods and services as provided by national accounts statistics (source: IFS).

Tax rates: The tax rate in a given fiscal year is estimated by subtracting transfer payments made by governments from total tax revenues and by dividing the difference by the net domestic product (GDP minus consumption of fixed capital) in that fiscal year. The tax revenue data include social security contributions received by governments. The calculations use annual data on total tax revenues (all levels of government) taken from the OECD publication "Revenue Statistics of OECD Member Countries" and annual data on transfer payments made by governments (from IMF Government Finance Statistics). For the US, Japan, France, Italy and Canada, data on transfer payments by central governments are used; for Germany and the UK, transfer payments by all levels of government are used. Construction of net domestic product series: GDP minus consumption of fixed capital (from OECD National Accounts). Quarterly tax rate series are constructed by assuming that tax rates are constant during all quarters of a given fiscal year.

Construction of aggregate time series for G6 countries

Aggregate output, (private) consumption, government consumption, investment, capital stock and trade balance series for the G6 countries are constructed by expressing national series in domestic currencies at constant 1980 prices, converting these series into US dollars using 1980 exchange rates, and summing over the G6 countries. The aggregate series on hours worked for the G6 countries is constructed by normalizing the national series to unity in 1980:1 and taking a weighted sum of the normalized series, using as weights national shares in total 1980 G6 GDP. (The hours series for several G6 countries are available in index form only; hence, it is not possible to add up the national hours series to obtain total G6 hours.)

To obtain an aggregate tax rate for the G6 countries, a weighted average of the tax rates for each G6 country is computed, using as weights the 1980 shares of these countries in G6 GDP.

The productivity index, $\ln(\theta_t^i)$, for the G6 countries is constructed according to equation (16), using aggregate G6 output, capital and labor series.

APPENDIX D. The Simulations (Figures 2-7)

For given values of the vector of predetermined variables Q_0 in some "initial" period t=0, and given values for the exogenous shocks q_t in periods t=0,1,2,3,..., the system of equations (15) allows computation of the values of the endogenous variables in periods $t\geq 0$.

The simulation results are insensitive with respect to initial conditions selected for predetermined variables other than physical capital. The outcome of the simulations is somewhat more sensitive to the choice of the initial capital stock. To obtain initial conditions for capital, one could linearly detrend US and G6 physical capital (in logs) during the period 1975:1-1991:3 and use the values of the detrended capital series in the first period of the sample as estimates of $\nabla\hat{K}_0^1$ and $\nabla\hat{K}_0^2$. This procedure yields $\nabla\hat{K}_0^1$=-0.0018 and $\nabla\hat{K}_0^2$=-0.0115 (where i=1 and 2 denote the US and the G6, respectively). These initial conditions have only a rather weak effect on the predicted path of the endogenous variables. For simplicity, the values of all predetermined variables (expressed in deviation form relative to the steady state around which the model is linearized) in the first period of the sample are therefore set to zero, i.e., $Q_0=0$ is used for all simulations.

Construction of impulse response functions (Figures 2 and 5)

The impulse responses to the permanent productivity shocks shown in Figures 2 and 5 are the predicted series that obtain when one sets $\nabla\hat{\theta}_t^1=0.01$ for $t\geq0$, and $\nabla\hat{\theta}_t^2=\nabla\hat{\gamma}_t^i=\nabla\sigma_t^i=0$ for i=1,2 and $t\geq0$. Similarly, the impulse responses for the permanent government purchases shocks are computed by setting $\nabla\hat{\gamma}_t^1=0.01$ for $t\geq0$, and $\nabla\hat{\theta}_t^i=\nabla\hat{\gamma}_t^2=\nabla\sigma_t^i=0$ for i=1,2 and $t\geq0$. The impulse responses for the permanent tax rate shock are computed by setting $\nabla\sigma_t^1=-0.01/0.18$ for $t\geq0$, and $\nabla\hat{\theta}_t^i=\nabla\hat{\gamma}_t^i=\nabla\hat{\sigma}_t^2=0$ for i=1,2 and $t\geq0$. (Note: $\nabla\sigma_t^1\equiv(\sigma_t^1-\sigma)/\sigma$, where σ is the steady state tax rate; $\sigma=0.18$ is assumed. The third set of impulse response functions in Figures 2 and 5 (panels (e) and (f)) considers the case of a permanent 1 percentage point reduction in σ_t^1. Hence $\nabla\sigma_t^1=-0.01/0.18$ in that experiment.)

To make it easier to compare the responses of different variables, all impulse responses shown in Figures 2 and 5 are expressed as percentages of steady state output. For example, the consumption response shown in Figures 2 and 5 is measured as $\nabla\hat{C}_t^i\cdot\hat{C}/\hat{Y}\cdot100$, where $\hat{C}$ and $\hat{Y}$ are the values of the transformed variables $\hat{C}_t^i$ and $\hat{Y}_t^i$ in the deterministic steady state around which the model is linearized.

Simulations based on actual productivity, government purchases and tax rate series (Figures 3,4,6 and 7)

The model predictions reported in Figures 3,4,6 and 7 are obtained by feeding the empirical measures of $\nabla\hat{\theta}_t^i$, $\nabla\hat{g}_t^i$ and $\nabla\sigma_t^i$ for the US and the G6 into the model (Section 2.6 explains how these empirical measures are constructed).

The simulated output, consumption and investment series shown in

Figures 4 and 7 correspond to the series $\nabla\hat{Y}^i_t$, $\nabla\hat{C}^i_t$ and $\nabla\hat{I}^i_t$ generated by the model.

Country i's net exports (expressed as a share of output) are $tb^i_t \equiv (Y^i_t-C^i_t-I^i_t-G^i_t)/Y^i_t = (\hat{Y}^i_t-\hat{C}^i_t-\hat{I}^i_t-\hat{G}^i_t)/\hat{Y}^i_t$. The simulations focus on a symmetric deterministic steady state. Hence, net exports are zero in that steady state. Taking a first-order Taylor expansion of tb^i_t around the steady state, it can be seen that (approximately): $tb^i_t = \nabla\hat{Y}^i_t-\nabla\hat{C}^i_t\cdot(\hat{C}/\hat{Y})-\nabla\hat{I}^i_t\cdot(\hat{I}/\hat{Y})-$ $-\nabla\hat{G}^i_t\cdot(\hat{G}/\hat{Y})$ (where $\hat{C}$, $\hat{Y}$, $\hat{I}$ and $\hat{G}$ are the values of $\hat{C}^i_t$, $\hat{Y}^i_t$, $\hat{I}^i_t$ and $\hat{G}^i_t$ in the deterministic steady state, while $\nabla\hat{Y}^i_t= (\hat{Y}^i_t-\hat{Y})/\hat{Y}$, etc.). The net export series shown in Figures 2-7 are computed according to this formula.

Since, by construction, the linearly detrended productivity, government purchases and tax rate series used as driving forces in the simulations reported in Figures 3, 4, 6 and 7 have a sample mean of zero, the predicted trade balance series have a sample mean that is close to zero. In contrast, the sample average of the US trade balance surplus (expressed as a share of US GDP) is -1.38% during the sample period. For this reason, the simulated trade balance series and the measured net export series shown in Figures 3, 4, 6 and 7 are de-meaned. The mean of the predicted trade balance series could be set to a non-zero value (without greatly affecting the response of the trade balance to exogenous shocks) by assuming that steady state net foreign asset positions are non-zero.

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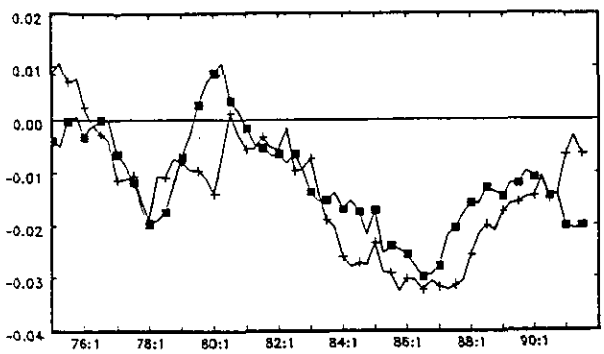
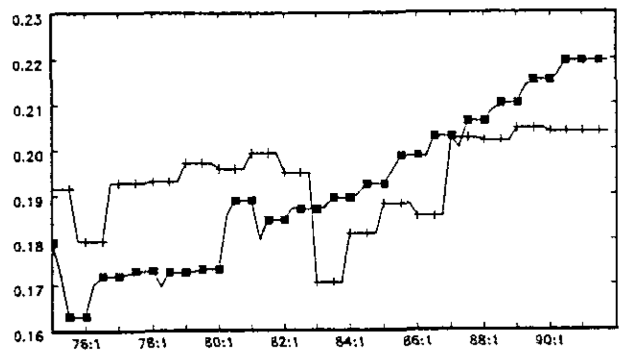
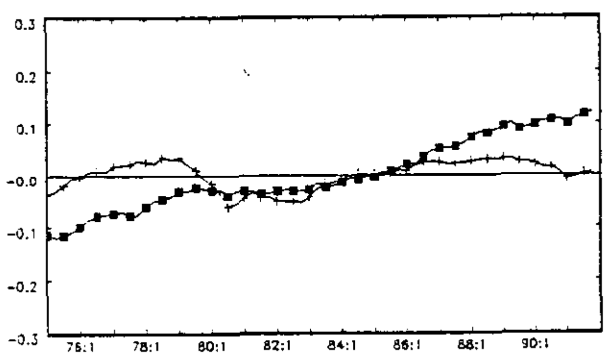


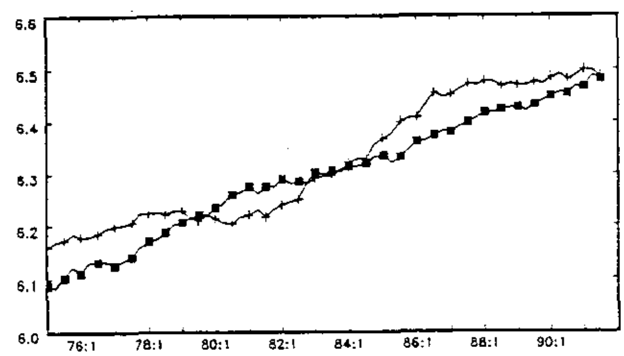
(a) ▪ : G6 Trade Balance Deficit (Relative to US GDP).
\+ : US Trade Balance Surplus (Relative to US GDP).



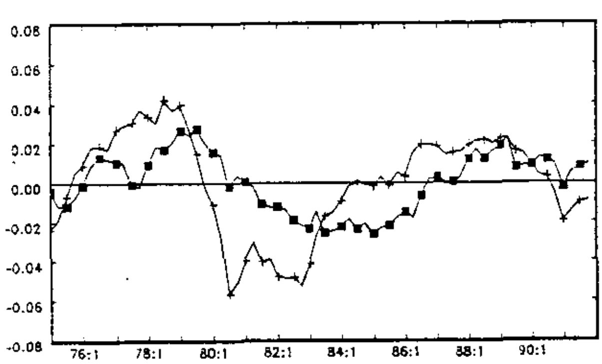
(b) Tax Rate.



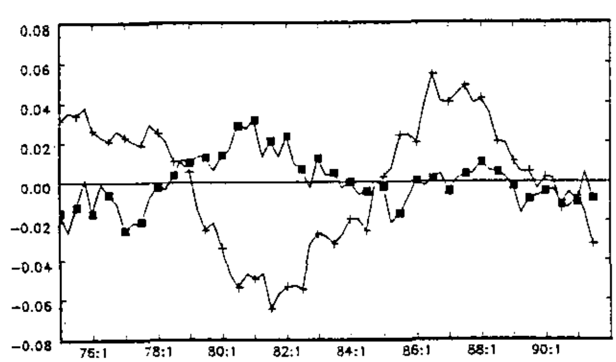
(c) Productivity Index (Ln(θ)).



(d) Government Consumption (in Logs), Bill. of '80 US $.

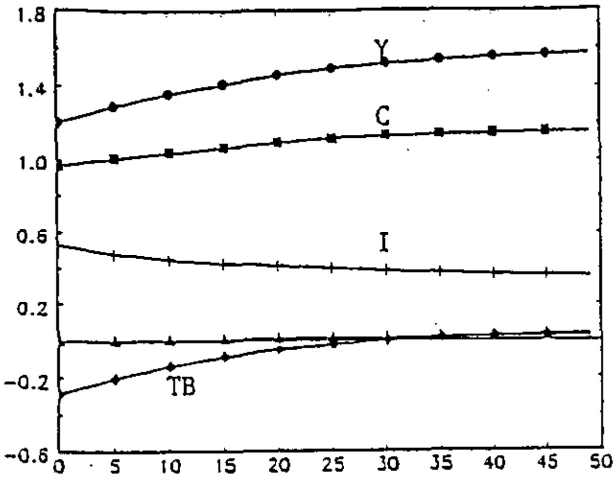


(e) Linearly Detrended Productivity Index (Ln(θ)).

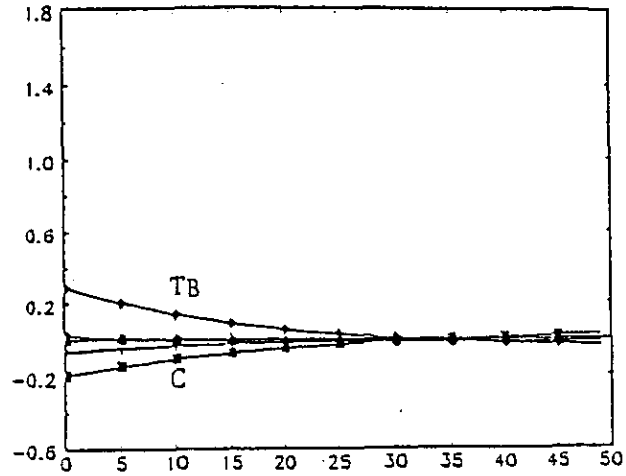


(f) Linearly Detrended Log Government Consumption.

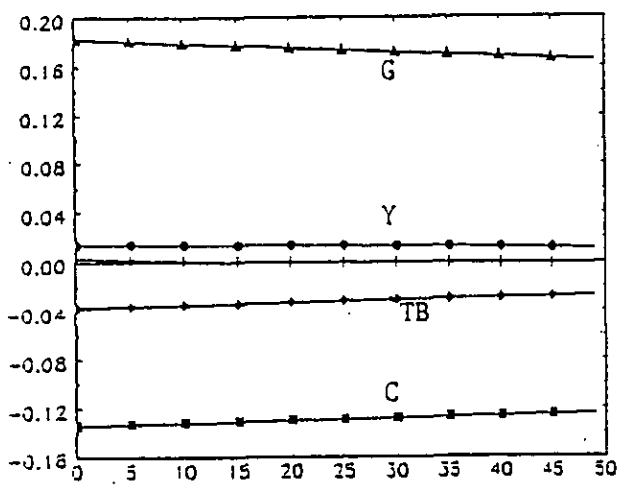
FIGURE 1 Macroeconomic Data for US (+) and G6(▪).



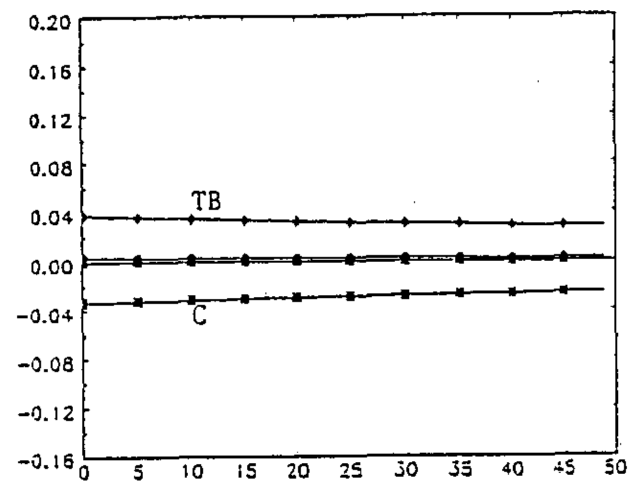
(a) Productivity Shock:
Country 1 Response.



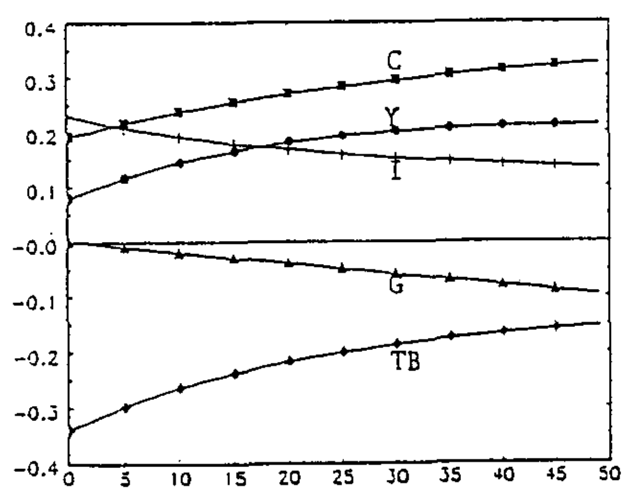
(b) Productivity Shock:
Country 2 Response.



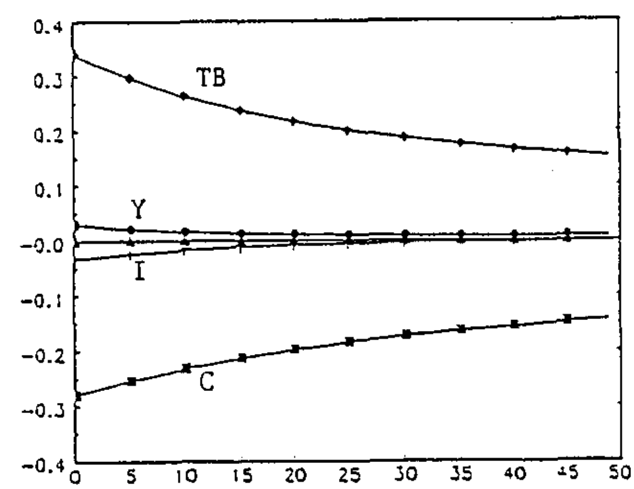
(c) Government Purchases Shock:
Country 1 Response.



(d) Government Purchases Shock:
Country 2 Response.



(e) Tax Rate Shock:
Country 1 Response.

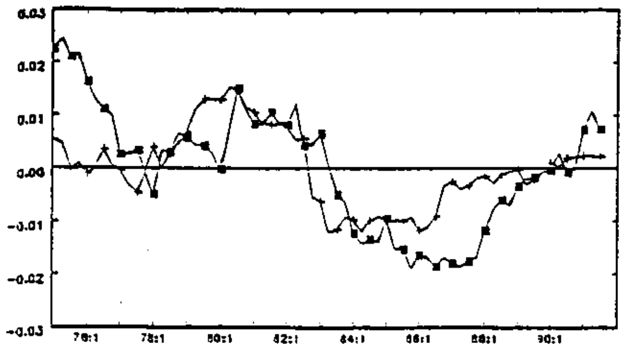


(f) Tax Rate Shock:
Country 2 Response.

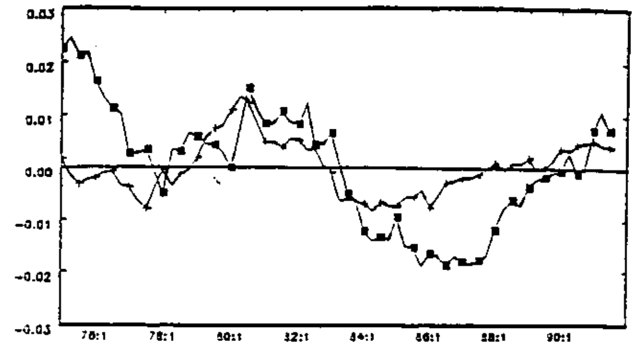
FIGURE 2 INCOMPLETE ASSET MARKETS

Responses to Permanent 1% Rise in $\hat{\theta}^1$ & $\hat{\gamma}^1$, 1 Percentage Point Drop in σ^1.

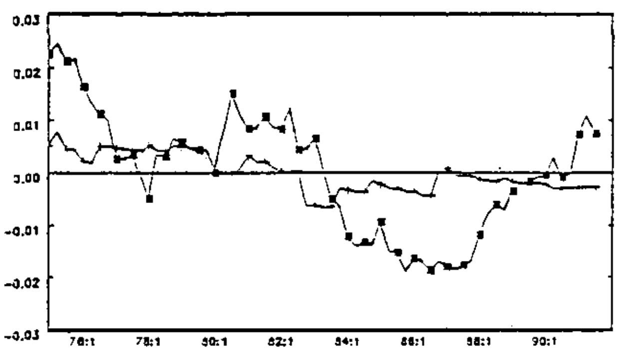
Responses Are Expressed as a Percentage of Steady State Output.
Abscissa: Quarters After Shock. •: Output (Y), ▪: Private Consumption (C), ▴: Government Purchases (G), +: Gross Investment (I), ♦: Net Exports (TB).



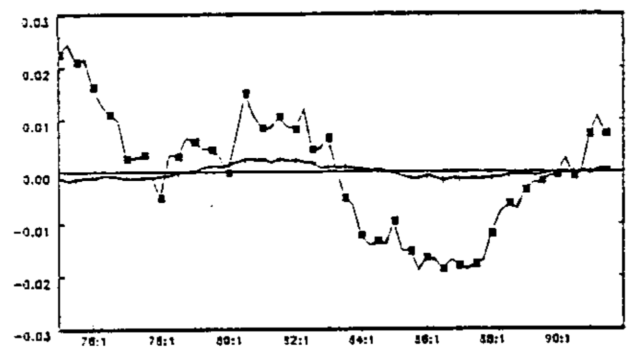
(a) Productivity, Government Purchases and Tax Rate Shocks.



(b) Productivity Shocks.

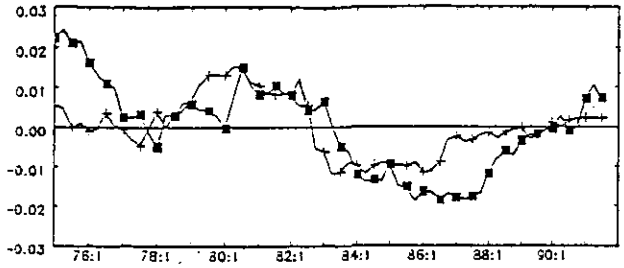


(c) Tax Rate Shocks.

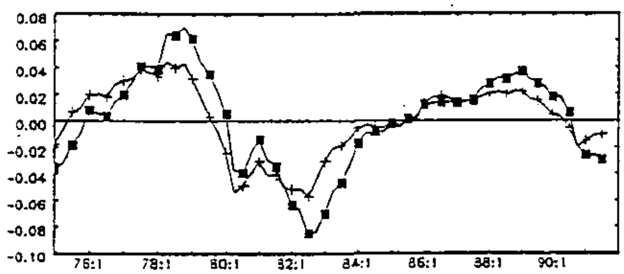


(d) Government Purchases Shocks.

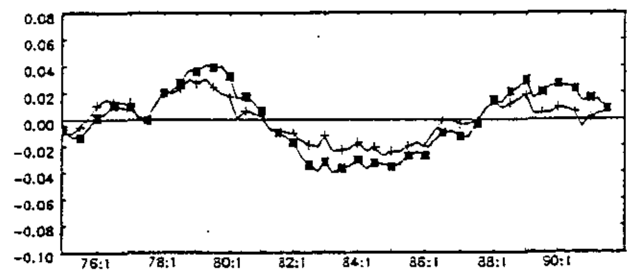
FIGURE 3 INCOMPLETE ASSET MARKETS: Simulated US Net Exports (As Share of Output). The Model Subjected to Actual US and G6 Productivity, Government Purchases and Tax Rate Series. Panel (a) Uses Three Types of Shocks Simultaneously, Panels (b)-(d) Subject Model to Each Type of Shocks Separately. Series Shown in Figure Are De-Meaned.
■ : Data, + : Simulation.



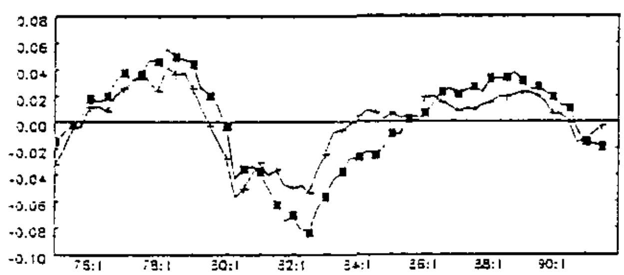
(a) US Trade Balance Surplus (As a Share of US Output).



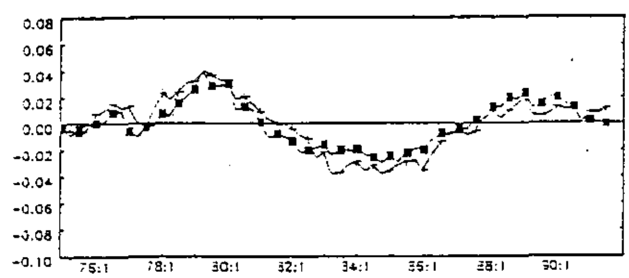
(b) US Output.



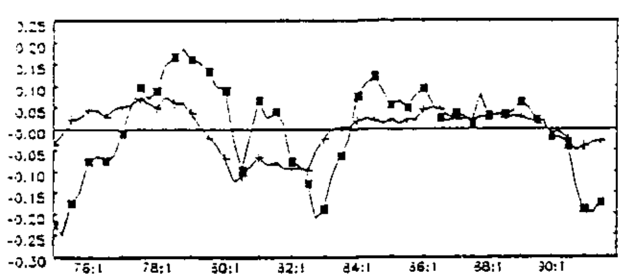
(c) G6 Output.



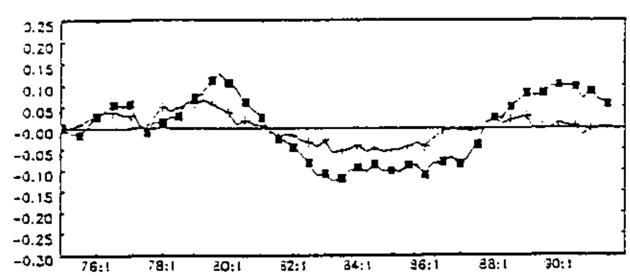
(d) US Private Consumption.



(e) G6 Private Consumption.

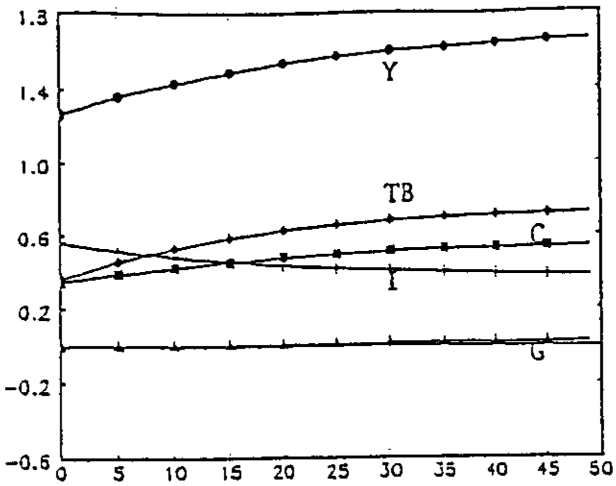


(f) US Gross Investment.

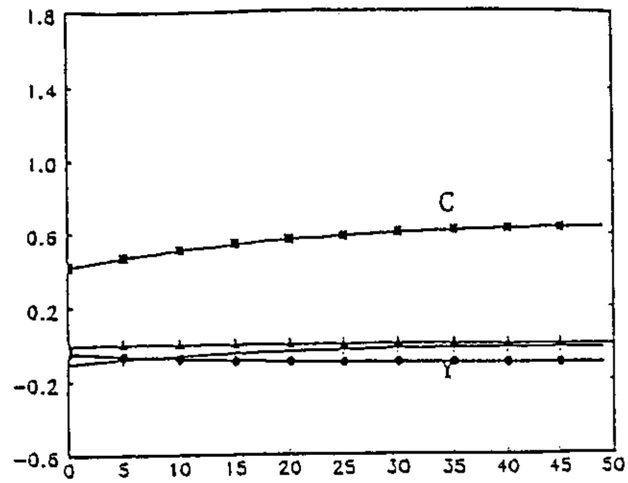


(g) G6 Gross Investment.

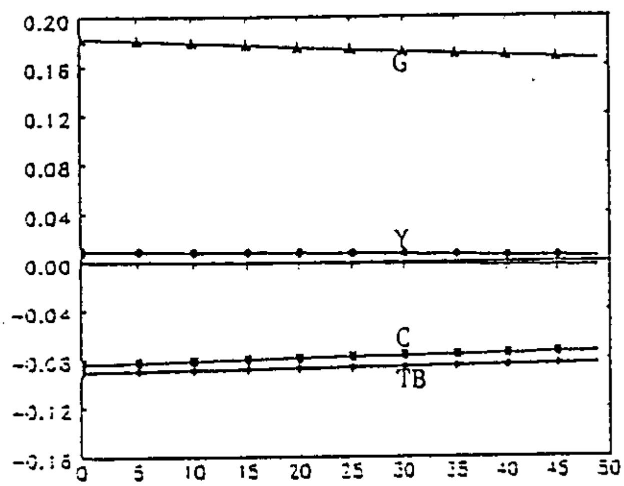
FIGURE 4 INCOMPLETE ASSET MARKETS: The Model Subjected to Actual US and G6 Productivity, Government Purchase and Tax Rate Series. Consumption, Investment and Output Data (In Logs) are Linearly Detrended. Predicted Series Are Expressed as Relative Deviations Compared to Deterministic Steady State. Series in Panel (a) Are De-Meaned.
▪ : Data,+ : Simulation.



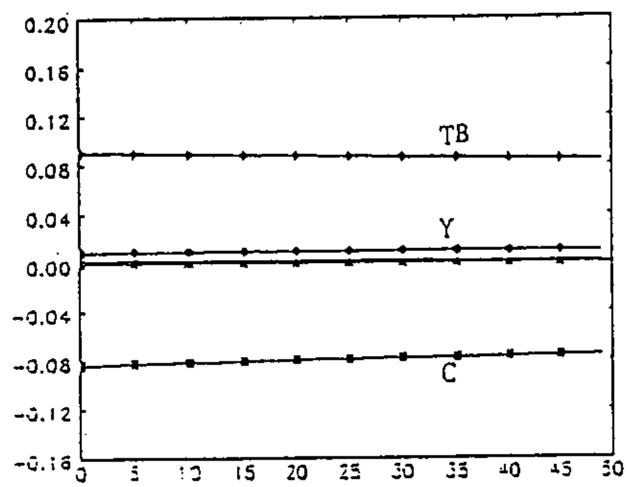
(a) Productivity Shock:
Country 1 Response.



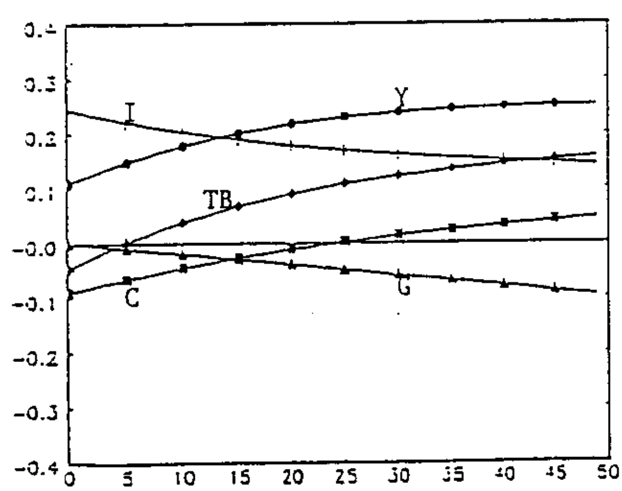
(b) Productivity Shock:
Country 2 Response.



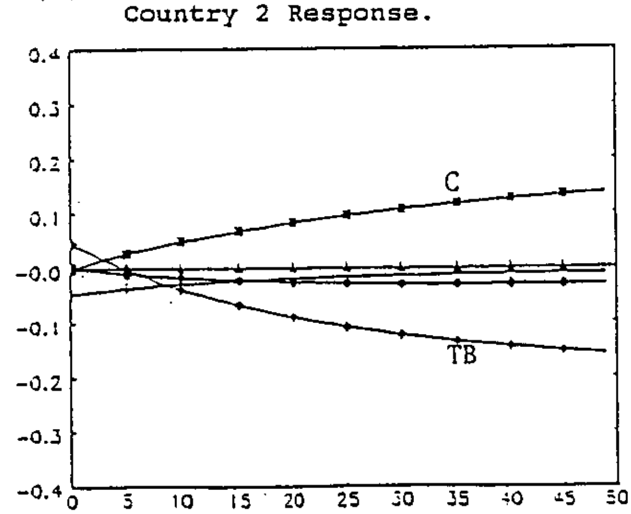
(c) Government Purchases Shock:
Country 1 Response.



(d) Government Purchases Shock:
Country 2 Response.



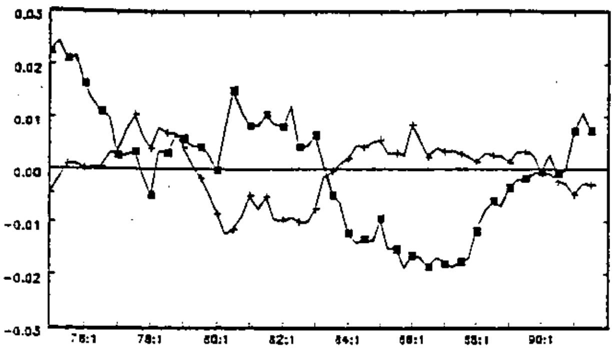
(e) Tax Rate Shock:
Country 1 Response.



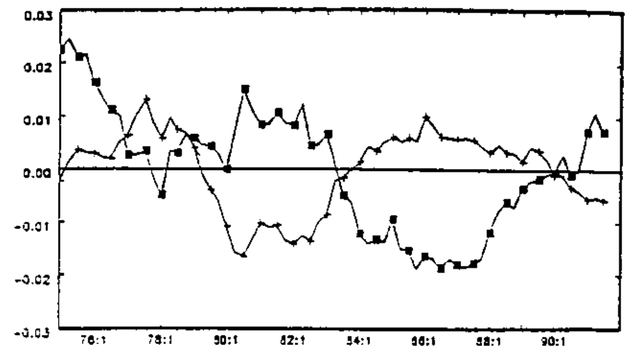
(f) Tax Rate Shock:
Country 2 Response.

FIGURE 5 COMPLETE ASSET MARKETS

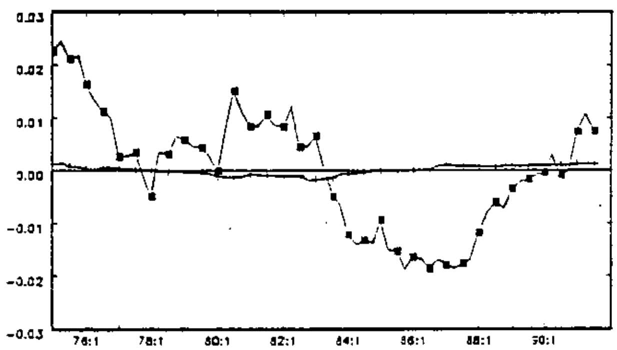
Responses to Permanent 1% Rise in $\hat{\theta}^1$ & $\hat{\gamma}^1$, 1 Percentage Point Drop in σ^1.
Responses Are Expressed as a Percentage of Steady State Output.
Abscissa: Quarters After Shock. •: Output (Y), ▪: Private Consumption (C), ▴: Government Purchases (G), +: Gross Investment (I), ♦: Net Exports (TB).



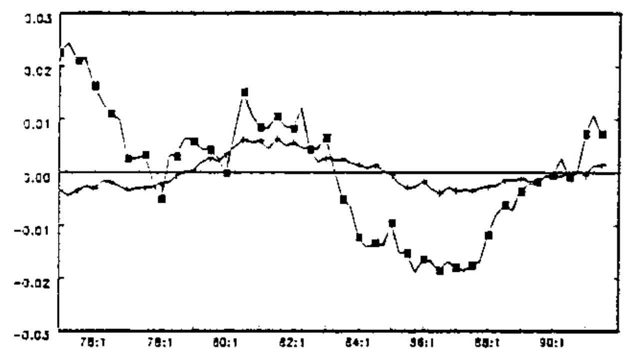
(a) **Productivity, Government Purchases and Tax Rate Shocks.**



(b) **Productivity Shocks.**

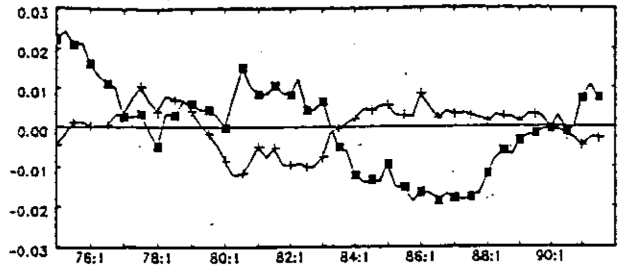


(c) Tax Rate Shocks.

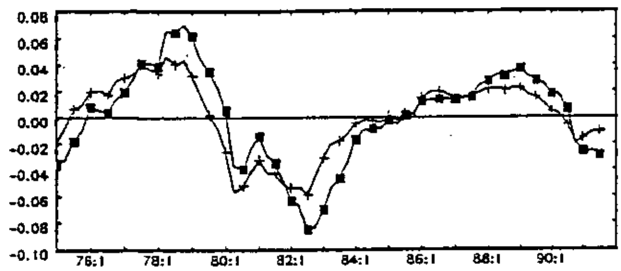


(d) Government Purchases Shocks.

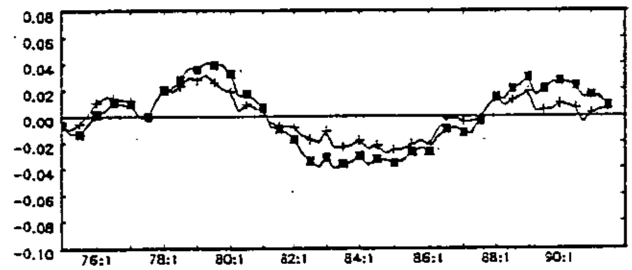
FIGURE 6 COMPLETE ASSET MARKETS: Simulated US Net Exports (As Share of Output). The Model Subjected to Actual US and G6 Productivity, Government Purchases and Tax Rate Series. Panel (a) Uses Three Types of Shocks Simultaneously, Panels (b)-(d) Subject Model to Each Type of Shocks Separately. Series Shown in Figure Are De-Meaned.
■ : Data, + : Simulation.



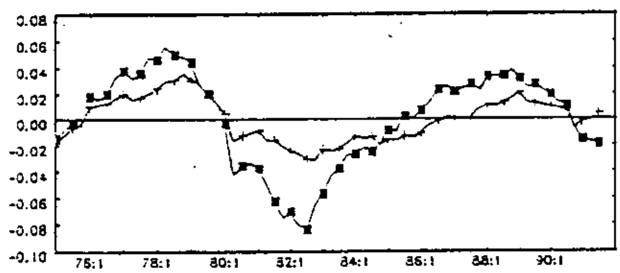
(a) US Trade Balance Surplus
(As a Share of US Output).



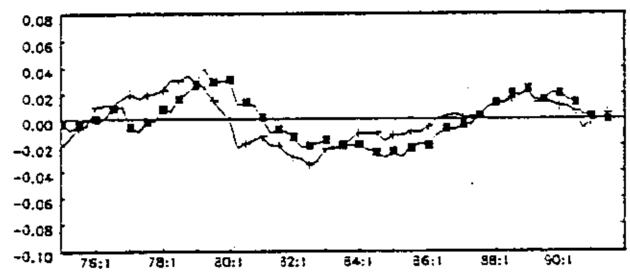
(b) US Output.



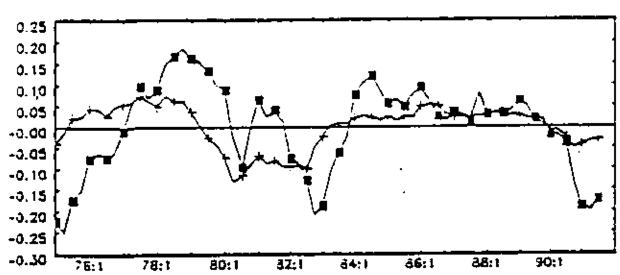
(c) G6 Output.



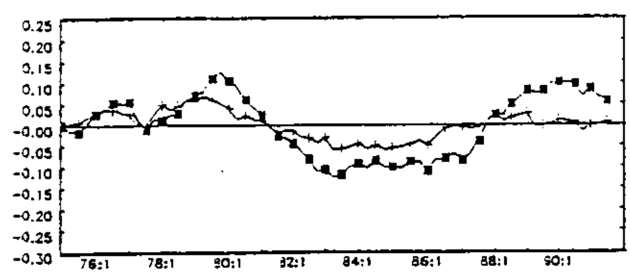
(d) US Private Consumption.



(e) G6 Private Consumption.



(f) US Gross Investment.



(g) G6 Gross Investment.

FIGURE 7 COMPLETE ASSET MARKETS: The Model Subjected to Actual US and G6 Productivity, Government Purchase and Tax Rate Series. Consumption, Investment and Output Data (In Logs) are Linearly Detrended. Predicted Series Are Expressed as Relative Deviations Compared to Deterministic Steady State. Series in Panel (a) Are De-Meaned. ▪ : Data, + : Simulation.