The US "Twin Deficits": A Reappraisal

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1 Introduction

In the mid-1980s, the US fiscal and trade deficits reached unprecedented levels. Between 1979 and 1985, the federal government deficit grew from 0.5% of GDP to over 3%, while the trade deficit increased from 1% to 2.3%[1]. This episode lead many economists to believe in a one-to-one relationship between the US trade and fiscal deficits, the so called "twin deficit" behavior.

This "twin deficit" hypothesis is supported by the traditional Mundell Fleming model. Budget deficits financed through bonds raise home interest rate, which causes inflows of foreign capital. Increased home interest rate results in an appreciation of the currency, thus harming competitiveness and leading to a current account deficit. The trade balance also deteriorates because of an income effect: through the multiplier effect, the expansionary budget policy raises home demand for foreign goods.

An extensive empirical literature has investigated the relationship between the US fiscal and trade deficits. However, no consensus has yet emerged. Abell [1990] considers a VAR system that describes the joint behavior of money supply, prices, interest rate, output, exchange rate as well as the budget and trade deficits. Except for money and prices that are second-differenced stationary, data are first-differenced stationary. Abell [1990]'s paper endorses the conventional view that suggests that deficits have a causal relationship through the interest rate. Diboolu [1994] estimates an error correction representation of budget deficit, government spending, output, real interest rate, productivity and terms of trade. The short run dynamics of these US variables seems to conform

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[1] Those real data are taken from the Federal Reserve Bank of St Louis.

to the twin deficit hypothesis where budget deficits are associated with high interest rates and current account deficits. Similarly, after calculating ratios to nominal GNP, Rosenweig and Tallman [1993] examine the behavior of trade balance, federal budget deficit, real interest rate and exchange rate. With a level specification, Rosenweig and Tallman [1993] uncover a causality that runs from the government deficit to the trade balance. In contrast, by using per capita consumption, per capita government purchases, net exports and real exchange rate, Enders and Lee [1990] find little evidence of the twin deficit behavior. After considering raw data, Dewald and Ulan [1990] do not discover any impact of fiscal deficits on trade deficits. Darrat [1988] reports mixed results by uncovering a bi-directional causality between budget and trade deficits.

Rather than resorting to an econometric technique, this paper examines the relationship between the US net exports and government balance by using a standard Real Business Cycle (RBC) model. As pointed out by Baxter [1995], the intertemporal model provides some insight about the "twin deficit" relationship: the government spending shock, when financed on impact by an increase in debt, leads to an instantaneous rise in the fiscal deficit and in the real interest rate. Through intertemporal substitution effects, the higher interest rate lowers consumption, favors saving (thus investment) and enhances the supply of labor. These movements generates a trade deficit(2) on impact. As a consequence, the intertemporal model lends support to the view that government budget deficits lead to trade deficits.

Baxter [1995]'s mechanism seems relevant in the 1980s. Indeed, as shown by Figure 1, under the Reagan presidency, the US experienced an expansionary fiscal policy and twin deficits appeared. However, fiscal and trade deficits move in opposite directions in the 1970s and the 1990s.

Figure 1 actually provides two intuitions. First, the correlation between the US net exports and government balance seems unsteady, which may account for the conflicting result in the empirical literature. Furthermore, the sign of the correlation may stem from the nature of the dominant shock in the economy: demand shocks such as government spending shocks, generate twin deficits. In contrast, when supply shocks dominate the fluctuations in the US economy, trade and government balances may move in opposite directions.

The paper is organized as followed. In section 2, I uncover the unsteadiness of the relationship between the US net exports and government balance: the correlation of both series, whether stationarized

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(2) In this kind of model as well as in the paper, the balance of trade is defined as output minus absorption (the sum of consumption, investment and government spending).

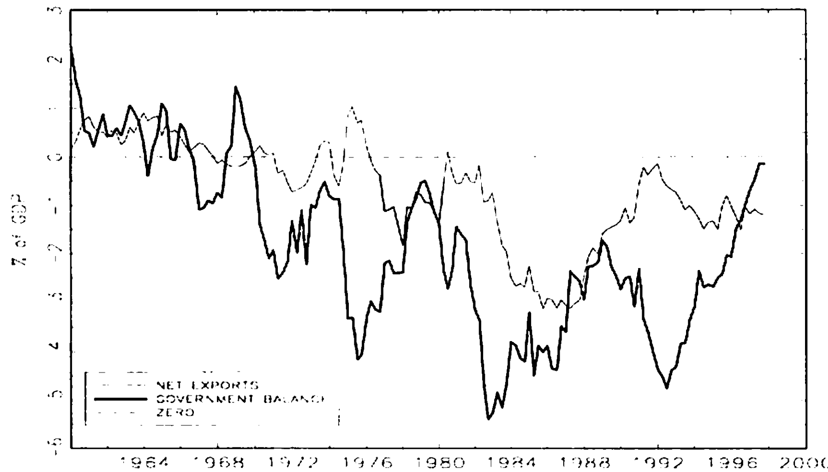

Figure 1: The US Net Exports and Government Balance.

or not, is not stable over each sub-period. Switches in the relative contribution of supply and demand shocks in the US economy may account for this unstable relationship. In order to gauge the empirical relevance of this proposition, I consider a standard RBC model in section 3. The theoretical model does not depart much from Baxter [1995]'s. However, in contrast to Baxter [1995], I measure the pertinence of the model by estimating standard deviations of supply and demand shocks over each sub-sample (section 4). Government spending shocks indeed become dominant in the 1960s and the 1980s while technological disturbances exhibit a higher volatility in the 1970s. After making sure that the model constitutes a good proxy for the US economy, I feed the model with the estimated changes in volatility ratios of supply and demand shocks. The switches in the standard deviation of the US disturbances account for the unstable correlation between the US net exports and government balance over each sub-sample except the 1990s. Finally, I measure the robustness of the results by carrying out a sensitiveness analysis on key parameters of the model (section 4.4).

2 An unsteady relationship

I examine US quarterly series from the Federal Reserve Bank of St. Louis database. The 136-point sample ranges from 1964:1 to 1997:1. All variables are in real terms.

The sample is divided into 4 sub-periods. Each breaking point is a peak or a trough as defined by the NBER. The first sub-sample (1964:1-1973:4) ends before the first oil shock. The second period (1974:1-1980:3) is marked by the oil shocks whereas the third one (1980:4-1990:2) mainly covers the Reagan presidency. Finally, the last period (1990:3-1997:4) spans the 1990s.

2.1 Raw data

I use real net exports as a proxy for the trade balance. Table 1 reports the contemporaneous correlation of net exports to GDP (NX) and federal budget balance to GDP (NG)[(3)].

Table 1: Raw data

1964:1-1997:4	1964:1-1973:4	1974:1-1980:3	1980:4-1990:2	1990:3-1997:4
0.54	0.50	−0.64	0.26	−0.57

Over the whole period, the positive correlation (0.54) seems to give some support to the twin deficit behavior. However, this correlation is unstable: in the 1960s as well as in the 1980s, the budget deficit is positively linked to net exports, while, in the 1970s and the 1990s, the correlation becomes negative.

After performing ADF tests, NX and NG have a unit root. So, the correlation calculated above gives some hints about the long run behavior of the US government deficit and net exports[(4)]. It is interesting to know whether this unsteady relationship is still obvious when I look at the short run behavior of the series.

2.2 Cyclical Properties

There is no consensus yet over the appropriate way of identifying the cyclical component of economic data. In the RBC literature, the trend of raw data is identified by using the Hodrick and Prescott [1997] filter (hereafter, HP filter). Since I use a RBC model to study the behavior of the US net exports and government balance, raw data are HP filtered. Table 2 reports the contemporaneous correlations between the cyclical components of the US net exports to GDP and government balance to GDP.

The correlation between trade and budget balances is slightly negative (−0.20), which does not give support to the twin deficit hypothesis

[(3)] $NG < 0$ corresponds to a budget deficit and $NG > 0$ indicates a budget surplus. Similarly, $NX < 0$ denotes a trade deficit.

[(4)] ADF statistics are reported in the Appendix A. After performing Johansen and Juselius [1990]'s procedure, both series turn out to be cointegrated. In the long run, the US net exports are positively related to the fiscal deficit, thus giving some support to the twin deficit view.

Table 2: HP filtered data

1964:1-1997:4	1964:1-1973:4	1974:1-1980:3	1980:4-1990:2	1990:3-1997:4
−0.20	−0.03	−0.49	−0.04	−0.35

over the whole sample. In contrast, the contemporaneous correlation of raw data over the whole period is positive (0.54). So, as mentioned by Rosenweig and Tallman [1993], in empirical papers about the twin deficit behavior, the use of stationarized data versus data in level has a major impact on results, which is likely to account for the lack of consensus in the existing literature.

I add another explanation for conflicting results about the twin deficit relationship. The contemporaneous link between both series has been quite unsteady since the mid-1960s. In the 1970s and the 1990s, the correlation hovers around −0.40. Following a Mundell-Fleming approach, one would expect a positive correlation during periods of expansionary budget policies. However, in the 1960s and the 1980s, trade and budget balances are hardly linked, with a correlation of about −0.03.

In an nutshell, the US correlation between trade and government balances, whether in level or stationarized, exhibits an unsteady pattern, which may account for the disagreement in the empirical literature. Moreover, in raw data, the twin deficit behavior appears during decades of expansionary budget policies while, in 1970s and the 1990s, marked by supply shocks, the correlation turns negative. Thus, in my view, the switching sign of the correlation may be due to the nature of the dominant shock in the economy. I check the empirical relevance of this intuition by using a standard RBC model that must account for the unsteady correlation of table 2.

3 A two-country model

The model hardly departs from the standard two-country one-good RBC framework as described by Baxter [1995]. In addition to its simplicity, the model replicates most of the domestic as well as cross-country stylized facts (See section 4.2). The specification of the complete markets draws heavily on Bec and Hairault [1997].

The model consists of two countries. Their sizes, preferences and technologies are similar. In contrast to capital, labor cannot move freely from one country to the other.

3.1 Set of hypothesis

Each country is inhabited by many identical, infinitely living agents. I thus adopt the representative household approach. The economy in each country consists of the firm, the government and the representative agent.

3.1.1 Firms

The unique good is produced in both countries with a Cobb-Douglas technology

$$y_{i,t} = z_{i,t} n_{i,t}^{1-\theta} k_{i,t}^{\theta} \tag{1}$$

with $\theta \in]0,1[$. $y_{i,t}$, $n_{i,t}$, $k_{i,t}$ and $z_{i,t}$ denotes country i production, labor, capital and total factor productivity. The joint behavior of $z_{1,t}$ and $z_{2,t}$, interpreted as supply shocks, is governed by

$$\begin{aligned} \begin{pmatrix} \ln(z_{1,t}) \\ \ln(z_{2,t}) \end{pmatrix} &= \begin{pmatrix} \rho_{Z,1} & \rho_{12} \\ \rho_{12} & \rho_{Z,1} \end{pmatrix} \begin{pmatrix} \ln(z_{1,t-1}) \\ \ln(z_{2,t-1}) \end{pmatrix} \\ &+ \begin{pmatrix} 1-\rho_{Z,1} & -\rho_{12} \\ -\rho_{12} & 1-\rho_{Z,1} \end{pmatrix} \begin{pmatrix} \ln(z_1) \\ \ln(z_2) \end{pmatrix} \\ &+ \begin{pmatrix} 1 & \psi \\ \psi & 1 \end{pmatrix} \begin{pmatrix} \varepsilon_{1,t}^Z \\ \varepsilon_{2,t}^Z \end{pmatrix} \end{aligned} \tag{2}$$

where $\ln(z_i)$ is the mean of the stochastic process. I assume that technological shocks are stationary and $|\rho_{Z,i}| < 1$, $|\rho_{12}| < 1$. Let ε_t^Z be the vector of serially independent, contemporaneously correlated innovations of $\ln(z_t)$. The standard deviation of supply shocks are σ_i^Z. The symmetric calibration implies $z_1 = z_2 = z$, $\rho_{Z,1} = \rho_{Z,2} = \rho_Z$ and $\sigma_1^Z = \sigma_2^Z = \sigma^Z$. Finally, $E[\varepsilon_{1,t}^Z] = E[\varepsilon_{2,t}^Z] = 0$ and $E[\varepsilon_{1,t}^Z \varepsilon_{2,t}^{Z'}] = 0$. $\psi > 0$ governs the cross-country correlation of technological innovations.

3.1.2 Governments

The behavior of each government draws heavily on Kollman's [1995] and Bec and Hairault's [1996] papers. Governments purchase units of the good and finance spending by taxing private agents and by issuing one-period bonds. The government budget constraint is

$$d_{i,t+1} + t_{i,t} + tr_{i,t} = (1+r_t)d_{i,t} + g_{i,t} + T_i \qquad i = 1,2 \text{ and } \forall t \tag{3}$$

where $g_{i,t}$, $t_{i,t}$, T_i and $tr_{i,t}$ are respectively government purchases, transfers to households and tax revenues. In contrast to $tr_{i,t}$, T_i is a lump-sum transfer. $d_{i,t}$ is the government debt[5]. $d_{i,t+1} > 0$ means that country i government is net borrower while it is net lender with $d_{i,t+1} < 0$. r_t is the real risk-free rate on public debt.

Mendoza, Razin and Tesar [1994] observe that tax revenues are procyclical in industrial countries. In order to capture this feature, the government imposes a flat tax rate on production

$$t_{i,t} = \tau_i y_{i,t} \tag{4}$$

where τ_i a constant tax rate.

Government spending, interpreted as demand shocks, follow a stochastic exogenous process

$$\ln(g_{i,t}) = (1 - \rho_G) \ln g_i + \rho_G \ln(g_{i,t-1}) + \varepsilon_{i,t}^G \tag{5}$$

with $\ln(g_{i,t})$ the mean of government spending and $|\rho_G| < 1$ its degree of persistence. $\varepsilon_{i,t}^G$ denotes the innovation of $ln(g_{i,t})$. It is not serially correlated. Its standard deviation is σ_i^G. $E[\varepsilon_{2,t}^G\ ] = E[\varepsilon_{1,t}^G] = 0$ and $E[\varepsilon_{1,t}^G \varepsilon_{2,t}^{G'}] = 0$[6]. The calibration being symmetric, $\rho_{G1} = \rho_{G2}$ and $\sigma_1^G = \sigma_2^G = \sigma^G$.

Finally, some appropriate condition should be imposed in order to ensure the government solvency. The transfer $tr_{i,t}$ is paid by private households and guarantees that government debt does not grow endlessly.

$$tr_{i,t} = \mu_i d_{i,t} \tag{6}$$

Equation (6) does not depart from the solvency condition chosen by Kollman [1995] and Bec and Hairault [1996].

3.1.3 Households

Representative households have similar preferences.

$$u\left(c_{i,t},\, g_{it},\, l_{i,t}\right) = \log\left(c_{i,t} + \alpha g_{it}\right) + \gamma \log\left(1 - n_{i,t}\right) \tag{7}$$

[5] Even in a complete market framework, governements are assumed to engage in unconditonal lending and borrowing. To this purpose, governements trade one-period bonds. $d_{i,t+1}$ is issued at period t and paid back at period $t+1$.

[6] The assumption of no international correlation across spending shocks is quite sensible. The following table reports correlations between government spending as calculated by Bec [1994].

	Japon	Germany	France	Italie	UK	Canada
$\rho_{G,G_{US}}$	-0.07	-0.17	-0.04	-0.16	0.6	0.16

Quarterly series, taken in logarithm, comes from IMF *IFS* database. After Hodrick and Prescott [1997] filtering, Bec calculates the correlation over 1960:1-1992:2, except for France (1965:1-1992:1) and Italy (1970:1-1992:1).

with $\gamma > 0$ and $\alpha \in [0,1]$. $c_{i,t}$ denotes the quantity of units of goods consumed by country i household. As underlined by Barro [1981], country i government expenditures (g_{it}) affect households' utility. With $\alpha = 0$, the marginal utility of private consumption remains unchanged after a government spending shock. In contrast, with $\alpha = 1$, private and government expenditures are perfect substitutes. An increase in g_{it} then implies a complete crowding out on private consumption.

As in Bec and Hairault [1997], the representative household owns the domestic capital stock and takes all the decisions related to capital accumulation.

Country i household's earnings stem from his labor ($w_{i,t}n_{i,t}$) and the capital that he rents to the firm ($\xi_{i,t}k_{i,t}$). Besides, he receives the lump-sum transfer T_i from the government. The household's expenditures include consumption $c_{i,t}$, taxes $t_{i,t}$ and transfers $tr_{i,t}$, current investment $i_{i,t}$ and adjustment costs linked to capital accumulation $\frac{\varphi}{2}(i_{i,t} - \delta k_{i,t})^2$ with $\varphi > 0$.

At period t, household i purchases the quantity $b_i(J_{t+1})$ of state-contingent claims at price $\chi(J_{t+1})$. At date $t+1$, the claim allows for the payment of one unit of good providing that the realized state of nature is $J_{t+1} = (z_{1,t+1}, z_{2,t+1}, g_{1,t+1}, g_{2,t+1})$. I assume the existence of a complete set of Arrow-Debreu securities. Therefore, if the domestic household suffers from a bad state of nature, he receives a transfer from its foreign counterpart. As a consequence of this international risk pooling, responses of consumption depends on world wealth.

Let $f(J_{t+1}, J_t)$ be the function that describes the evolution of the state of nature. The household's budget constraint in country i is

$$\begin{aligned} w_{i,t}n_{i,t} + \xi_{i,t}k_{i,t} + b_i(J_t) + T_i & \\ \geqslant \quad & c_{i,t} + i_{i,t} + t_{i,t} + tr_{i,t} + \frac{\varphi}{2}(i_{i,t} - \delta k_{i,t})^2 \\ & + \int \chi(J_{t+1}) b_i(J_{t+1}) dJ_{t+1} \end{aligned} \tag{8}$$

The following equation

$$k_{i,t+1} = (1-\delta)k_{i,t} + i_{i,t} \tag{9}$$

describes the evolution of capital whose rate of depreciation is $\delta \in [0,1]$.

3.1.4 Equilibrium

Good market clears so that

$$\sum_{i=1}^{2} y_{i,t} = \sum_{i=1}^{2} (c_{i,t} + i_{i,t} + g_{i,t} + \frac{\varphi}{2}(i_{i,t} - \delta k_{i,t})^2) \tag{10}$$

As labor market clears, Walras law ensures that bond market clears as well. Since the household owns all the stock of domestic capital, the maximization program of the firm becomes completely static. Thus, marginal productivities of labor and capital respectively equal the wage and rental rate of capital.

The representative household's maximization problem can be written as

$$V(k_{i,t}, b_i(J_t)) = \text{Max}\left\{ \begin{array}{l} \log(c_{i,t}) + \gamma \log(1 - n_{i,t}) + \\ \beta \int V(k_{i,t+1}, b_i(J_{t+1})) f(J_t, J_{t+1}) dJ_{t+1} \end{array} \right\} \quad (11)$$

with respect to $c_{i,t}, n_{i,t}, i_{i,t}, k_{i,t+1}$ and $b_i(J_{t+1})$ subject to (8) and (9)[7].

The behavior of the model is described by the set of first-order conditions, equation (10) as well as laws of motion of capital (equation (9)) and public debt (equation (3)). This system of non-linear equations is solved as in King, Plosser and Rebelo [1988]. After a log-linearization, the system is given by

$$M_1 \widehat{C}_t = M_2 \widehat{S}_t \quad (12)$$

$$M_{3,0} \widehat{S}_{t+1} + M_{3,1} \widehat{S}_t = M_{4,0} \widehat{C}_{t+1} + M_{4,1} \widehat{C}_t + M_5 \varepsilon_{t+1} \quad (13)$$

where the matrices in equations (12) and (13) consist of parameters of the model. $\widehat{C}_t$, $\widehat{S}_t$ and ε_t refer to vectors of control variables, state variables and innovations, expressed as a percentage deviation from their steady states.

3.2 Calibration

As in the RBC literature, I look at the long run behavior of the US economy. In the post-war era, government spending to GDP ratio is 20% on average while debt to GDP ratio amounts to 25%. According to Mendoza and Tesar [1995], the US tax revenues-to-GDP ratio is 28%. Since countries are symmetric, flat tax rate are identical, that is to say $\tau_1 = \tau_2 = 0.28$. Finally, $\mu_1 = \mu_2 = \mu = 6\%$, a value that is greater than the stationary interest rate[8]. T_i adjusts so that (3) written at the stationary equilibrium is compatible with the calibration choice for g/y, d/y, τ and μ.

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(7) First order conditions are presented in Appendix B.

(8) As pointed out by Cardia [1991], stability of the model requires $\mu_i > r$ where r is the steady state value of the real interest rate. This condition ensures the long run solvency of the government without modelling the intertemporal behavior of the government.

The value of γ is such that working time is 20%. The discount rate β is set at 0.988. This value corresponds to a rate of time preference of 1.2% per quarter. According to Aschauer [1985]'s estimations, α amounts to 0.2.

As for the technology, the labor income share is set at 0.58 which means that $\theta = 0.42$. The annual rate of capital depreciation is 10% per year, or 2.5% per quarter. As in Bec [1994]'s paper, φ equals 0.05.

In the last section, I try to measure the impact of varying weight of supply and demand shocks on the correlations between trade and fiscal deficits. Therefore, σ^G and σ^Z will constitute parameters that I will modify in the simulations. In order to draw impulse response function, I use Christiano and Eichenbaum [1992]'s estimate of the persistence of government shocks ($\rho_G = 0.97$). Besides, according to Hairault and Portier [1995], $\rho_Z = 0.95$. Finally, I imitate Bec [1994] by setting $\rho_{12} = 0.04$ and $\psi = 0.5$.

A sensitiveness analysis on parameters α, ρ_{12}, ψ and μ is performed in section 4.4.

3.3 Impulse response functions

Impulse response functions describe the behavior of the economy after a 1 increase in total factor productivity or government spending. Country 1 is considered as the domestic country whereas country 2 is the foreign country.

3.3.1 Technological shocks

The behavior of production, labor, investment and consumption: As shown by Figure 2, the behavior of production, labor, investment and consumption does not differ from the standard two-country unique-good RBC model. The positive supply shock makes domestic capital more productive so that country 1 benefits from a financial capital inflows whose counterpart is the home trade deficit. Both labor and investment increase instantaneously which implies that capital remains above its steady state value along the adjustment path. Gradual accumulation of capital makes labor more productive so that the supply of labor, thus production increase[9] after the first period. Home consumption is under the influence of wealth and intertemporal substitution effects. The increase in income entices the home household to raise its consumption on impact. However, because of consumption smoothing behavior, the private consumption profile mirrors the path of interest rate.

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[9] Due to the specifications of our model, intertemporal substitution effects dominate wealth effects.

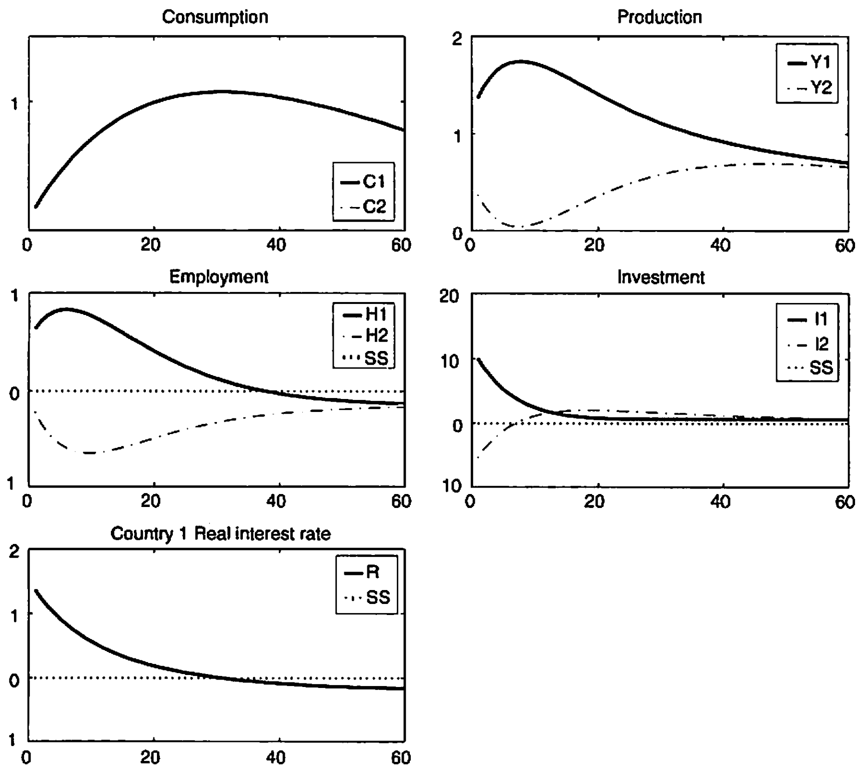

Figure 2
Responses to the domestic technological shock on consumption, production, employment, investment and country 1 interest rate (SS denotes the Steady State).

Thanks to the trading of Arrow securities, the foreign household receives a transfer paid by its domestic counterpart so that foreign private consumption immediately increases after the shock. Afterwards, responses of consumption are completely similar across countries. This stems from the international risk pooling.

With no international transmission of the productivity shock ($\psi = 0$), the instantaneous behavior of foreign variables after the domestic supply shock is the mirror image of responses in the domestic economy: capital outflows lowers marginal productivity of labor, thus employment and production. With $\psi = 0.5$ (Figure 2), the increase in productivity occurs in country 2 as well. Therefore, the foreign production jumps above its stationary value in the first period.

Owing to the international propagation of supply shocks, the foreign representative household takes advantage of the home supply shock. The intertemporal trade-off entices him to reduce his labor supply today. After a few periods, the home transmission of country 1 supply shock is enhanced (through ρ_{12}), foreign labor and capital then go up, thus boosting foreign production. Financial capital movements gradually reduces capital productivity differential so that foreign and domestic capital stocks converge toward their steady state value, which brings all the variables down to the stationary equilibrium.

Trade and fiscal balances: As in standard open-economy RBC models, the trade balance is defined as the excess of production over absorption (the sum of consumption, investment and government expenditures). The consumption smoothing behavior reduces the volatility of private consumption. Consequently, output net of consumption is procyclical. However, the response of investment is strongly procyclical and volatile, which makes absorption more variable than output. Net exports are thus countercyclical (Figure 3).

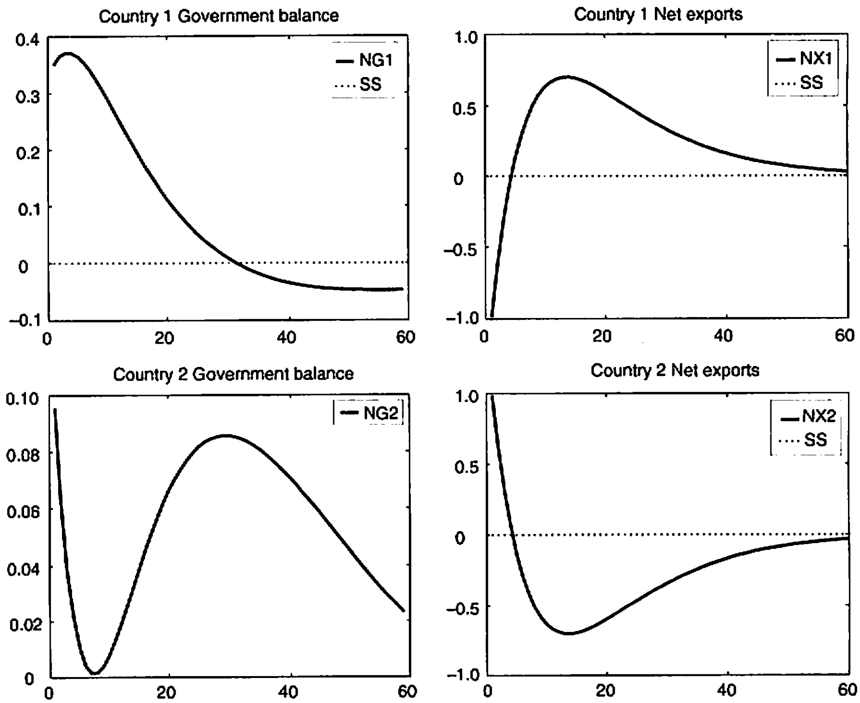

Figure 3

Responses to the domestic technological shock on government balance and net exports of countries 1 and 2 (SS denotes the Steady State).

As underlined by Backus, Kehoe and Kydland [1994], investment movements are essential in generating countercyclical fluctuations in the trade balance. Baxter [1995] notices that the response of net exports is consistent with the empirical investigations by Sachs [1981] and Glick and Rogoff [1994] who notice that fluctuations in investment are the dominant short-run influence on the current account. Investment booms tend to be associated with current account deficits.

Government balance consists of tax revenues minus the sum of government spending, transfers to households and interest payment. In the domestic country, the positive supply shock implies, on the one hand, an increase in interest rate so that interest payments go up. On the other hand, the instantaneous jump of production raises tax revenues. The latter effect dominates so that, in the short run, the government runs a budget surplus and accumulates assets. Within twenty quarters, the response of tax revenues explains the shape of the trajectory of budget balance. In the long run, stability of the model requires that the public debt converges to its stationary level. This is made possible through the subsequent budget deficit. In a nutshell, the positive supply shock creates instantaneous trade deficit and budget surplus, which implies a negative correlation contemporaneous between domestic trade and budget balances.

In the foreign country, the effects mentioned above generate an opposite behavior of country 2 variables. The immediate shrinkage in investment results in a trade balance surplus. With no international propagation of the productivity shock ($\psi = 0$), the government runs a budget deficit because of the drop in production. In contrast, when ψ is high (Figure 3), country 2 fiscal authorities collect more taxes as country 2 output benefits from the home positive shock.

3.3.2 Government spending shock

A negative wealth effect: The response of home private consumption stems from two elements. First, the negative wealth effect induces a fall in consumption. Furthermore, the expansionary government expenditure reduces the marginal utility of private consumption, thus amplying the drop in consumption, as can be seen from Figure 4.

The increase in government spending is financed by issuing more bonds, which pushes up home interest rate. Because of intertemporal substitution, the rise in home interest rate entices country 1 household to lower her consumption and increase her supply of labor. This latter effect favors domestic production. The marginal productivity of capital is also enhanced by the upsurge in employment so that country 1 investment goes up. As the shock steadily declines, the variables go back to their stationary levels. Since financial markets are complete, country 2 economy shares the negative wealth effect.

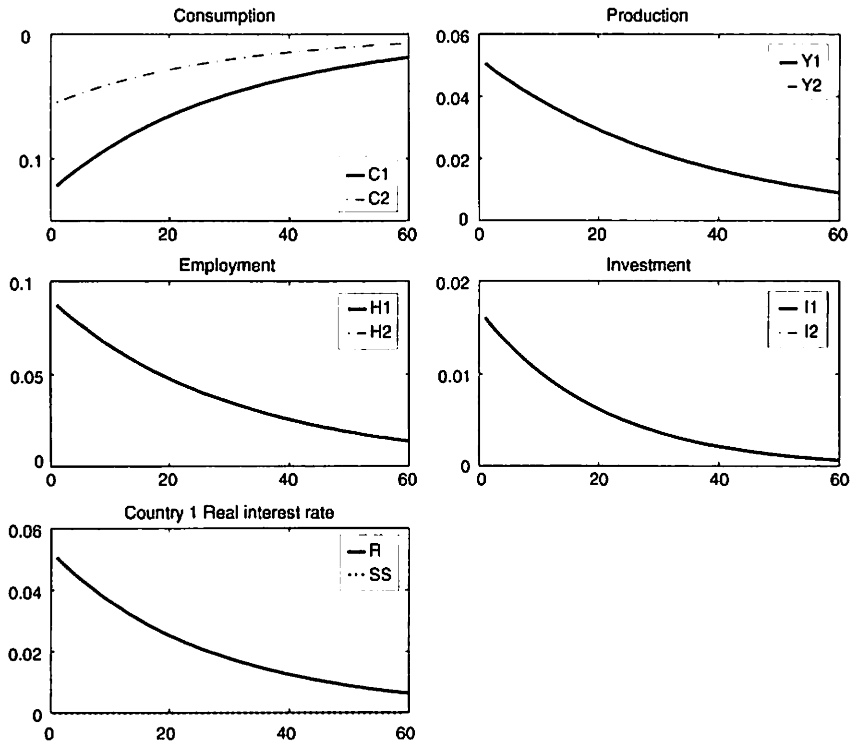

Figure 4
Responses to the domestic government shock on consumption, production, employment, investment and country 1 interest rate (SS denotes the Steady State)

Twin deficits and twin surplus: In spite of the jump in production and the reduced private consumption, the increase in domestic government spending and investment results in an immediate trade deficit (Figure 5). Besides, the expansion in domestic labor supply favors the marginal productivity of capital. As in the Mundell Fleming framework, the government spending shock implies a rise in the real interest rate as well as a disequilibrium of the trade balance. Furthermore, due to the expansionary fiscal shock and despite the higher tax revenue, budget balance deteriorates. In order to satisfy the government long run solvency, the government then runs a surplus. This is made possible thanks to increased taxes paid by households.

The table 3 sums up the short run behavior of trade balance and budget balance in the home country.

The supply shock implies opposite responses of both balances. The correlation between public balance and trade balance should then be

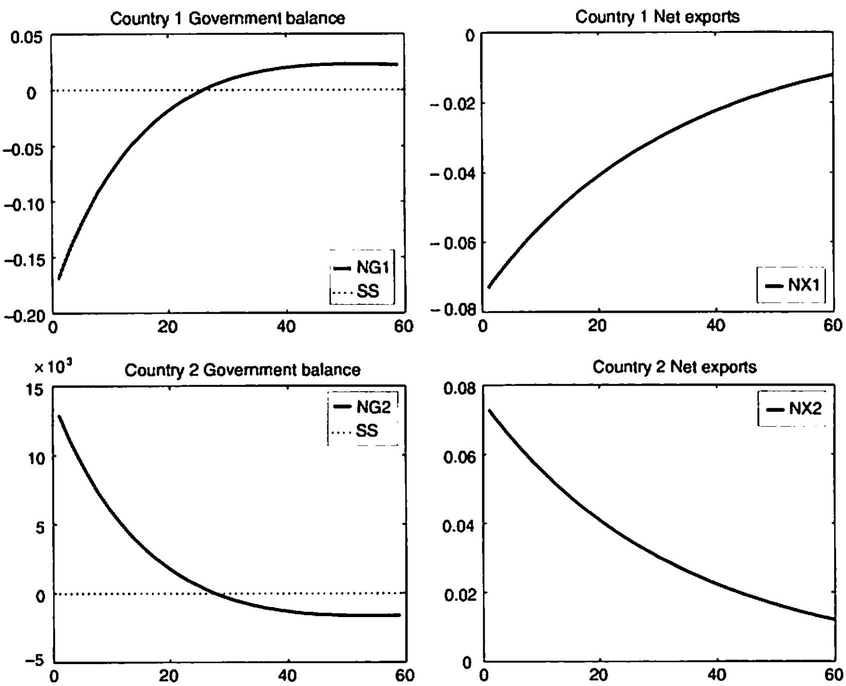

Figure 5
Responses to the domestic government shock on government balance and net exports of countries 1 and 2 (SS denotes the Steady State)

Table 3: Short run responses of trade and government balances

	Home supply shock	Home demand shock
Balance of trade	Deficit	Deficit
Budget balance	Surplus	Deficit

negative in the home country. In contrast to technological shocks, government spending disturbances generate "Twin deficits" in country 1.

4 The twin deficit hypothesis revisited

The analysis of the impulse response function supports the initial intuition that dominant supply shocks in the economy produce a negative correlation between home net exports and government balance while the correlation turns positive as a consequence of strong demand shocks in the home country. In this section, I check the empirical relevance of this proposition by estimating supply and demand shocks over the whole period as well as over each sub-period (section 4.1). Indeed, supply and demand shocks exhibit unsteady volatilities that may account for the lack of a robust relationship between net exports and government balance.

In section 4.2, I verify that, over the whole sample, the model is a good proxy for the US economy by making sure that the model is consistent with the standard RBC stylized facts such as relative volatilities of private aggregates, cross-country correlation, and so on. Finally, the model is simulated with the estimated volatility ratios of supply and demand shocks for each sub-period (section 4.3). It is thus possible to measure to which extent the change in the variance of supply and demand shocks accounts for the unsteady correlation between net exports and government balance. In section 4.4, I measure the robustness of the results by performing a sensitiveness analysis on key parameters of the model.

4.1 Methodology: calibration of shocks and simulations

In order to construct Solow residuals as a proxy for technological shocks, I use Backus, Kehoe and Kydland [1992]'s formula:

$$\ln(z_t) = ln(y_t) - (1-\theta)\ln(n_t) \tag{14}$$

with $\theta = 0.42$. The output series (y) is the real output used in section 2. The labor variable (n) is total civilian employment from the US Bureau of Labor Statistics. The quarterly sample ranges from 1964:1 to 1997:4. After rescaling each estimate of z to give it a sample mean of 1, the cyclical component of the Solow residuals is identified by considering a deterministic trend

$$\ln(z_t) = \chi_0 + \chi_1 t + \ln(\widehat{z}_t).$$

The AR(1) process of $\ln(\widehat{z}_t)$ is the following

$$\ln(\widehat{z}_t) = \rho_Z \ln(\widehat{z}_{t-1}) + \varepsilon_t^z.$$

In order to calibrate the variance of technological shocks, the standard deviation of ε_t^z over the whole period as well as for each sub-sample is calculated.

I use a similar procedure to estimate the AR(1) process followed by the cyclical component of the logarithm of real government expenditures taken from the Federal Reserve Bank of St. Louis database. The AR(1) coefficients ($\rho_Z = 0.95$ and $\rho_G = 0.97$) are similar to those estimated respectively by Hairault and Portier [1995] and Christiano

Table 4: Volatilities of shocks

Sample	σ_Z	σ_G	σ_G/σ_Z
1964:1-1997:4	0.00749	0.010410	1.38
1964:1-1973:4	0.00823	0.001274	1.55
1974:1-1980:3	0.00942	0.008610	0.91
1980:4-1990:2	0.00652	0.009870	1.51
1990:3-1997:4	0.00437	0.007740	1.77

and Eichenbaum [1992]. Table 4 reports the properties of innovations of Solow residuals and government spending shocks.

The changes in the volatilities seem quite consistent with the switches in the correlation between net exports and government balance. Indeed, in the 1960s as well as in the 1980s, government spending shocks turn out to be dominant whereas, in the 1970s, the relative standard deviation drops to 0.91. However, in the 1990s, the volatility ratio is not consistent with Baxter [1995]'s view: the true correlation between cyclical components of the US net exports and government balance in the 1990s (-0.35) does not stem from dominant technological shocks.

In the next section, I use the *estimated* volatilities to check whether they are able to account for the standard RBC stylized facts and the unsteady correlation between net exports and the budget balance. For each simulation, four vectors of innovations $\{\varepsilon^Z_{1,t}\}_{1\leqslant t\leqslant T}$, $\{\varepsilon^Z_{2,t}\}_{1\leqslant t\leqslant T}$, $\{\varepsilon^G_{1,t}\}_{1\leqslant t\leqslant T}$, $\{\varepsilon^G_{2,t}\}_{1\leqslant t\leqslant T}$ are drawn from a normal distribution whose mean is zero and whose standard deviations are taken from Table 4. T equals the length of the sub sample I examine. Table 5 reports the values of T corresponding to each sub-period.

Table 5: Values of T

Sub-period	1964:1-1997:4	1964:1-1973:4	1974:1-1980:3	1980:4-1990:2	1990:3-1997:4
T	136	40	27	39	30

For instance, when I consider 1964:1-1973:4, I draw for each simulation, four vectors $\{\varepsilon^Z_{1,t}\}_{1\leqslant t\leqslant 40}$, $\{\varepsilon^Z_{2,t}\}_{1\leqslant t\leqslant 40}$, $\{\varepsilon^G_{1,t}\}_{1\leqslant t\leqslant 40}$, $\{\varepsilon^G_{2,t}\}_{1\leqslant t\leqslant 40}$ from a normal distribution whose standard deviations are such that $\sigma^Z_1 = 0.00823, \sigma^G_1 = 0.001274, \sigma^Z_2 = 0.00749$ and $\sigma^G_2 = 0.01041$. Whatever the sub-sample, $\sigma^Z_2 = 0.00749$ and $\sigma^G_2 = 0.01041$ since I attribute the switching correlation between net exports and government balance to the varying volatilities of *home* shocks.

Thanks to equations (12) and (13), I construct series of net exports and budget balance. The cyclical component is identified through the Hodrick Prescott filter. Then, the correlation between net exports and government balance is calculated. Correlations over 100 simulations are averaged out.

4.2 The theoretical model does match most of the standard RBC stylized facts

Before using the model to examine the twin deficit hypothesis, it is necessary to make sure that the predictions of the model replicate the cyclical properties of the US economy.

4.2.1 Stylized facts

Backus, Kehoe and Kydland [1995] review the salient properties of business cycle in and across countries. Tables 17 to 19 (Appendix C) report the features that serve as a basis of comparison with the theoretical model.

To the standard stylized facts, I add the cyclical properties of net exports to GDP, federal budget deficit to GDP and logarithm of GDP (y). Data in real terms are taken from the database of the Federal Reserve Bank of St. Louis.

Table 6: Values of T

Standard Deviation			**Correlation**		
Output	Relative to Output		with Outpout		Net Exports
σ_y %	Net Exports	Budget Balance	Net Exports	Budget Balance	Budget Balance
1.32	0.24	0.54	−0.37	0.65	−0.20

Net exports are about one-fourth as volatile as output and slightly countercyclical, with a contemporaneous correlation with output of −0.37 over the whole sample. The countercyclical movement of the balance of trade has also been documented by Backus, Kehoe and Kydland [1992] and Dantine and Donaldson [1993] for other OECD countries. This may stem from the strong income term in the home demand for foreign goods.

The budget balance is about half as volatile as output and strongly procyclical. As a consequence, we do not observe some Keynesian pattern that would endorse expansionary budget policy, thus government deficit, in periods of recession. As mentioned in section , over the whole sample, HP filtered data do not support the twin deficit view since the contemporaneous correlations between both series is negative (−0.20).

4.2.2 Simulations over the whole sample

Simulations were performed according to the procedure described in section 4.1 ($T = 136$, $\sigma_1^Z/\sigma_1^G = \sigma_{\bar{e}}^Z/\sigma_2^G = 1.38$ and $\sigma_1^Z = \sigma_2^Z = 0.00749$). Statistics that are in line with the US stylized facts are indicated in bold figures. Statistics in italic are consistent with those calculated for other industrial countries. Standard deviations are between parenthesis.

Table 7: Standard Stylized Facts

	Relative volatility $\sigma_{.}/\sigma_Y$	Correlation with ouput	Cross-country Correlation
Output	-	-	0.32 (0.20)
Consumption	*0.61* (0.07)	**0.70** (0.11)	0.99 (0)
Investment	5.21 (0.75)	*0.61* (0.18)	-0.73 (0.10)
Employment	**0.59** (0.06)	**0.81** (0.10)	-0.83 (0.05)
Saving-Investment	-	-	**0.65** (0.07)

The model accounts for most of the cyclical properties of the US economy. However, in spite of adjustment costs on capital, the model fails to replicate the standard deviation of investment. Moreover, the cross-country correlations of investment and employment differ from post-war data. Indeed, since the model predicts that capital shifts to the most productive location, responses of investment after a productivity shock are asymmetric. Labor follows a similar pattern. Because of the inclusion of government spending in the utility function, cross-country correlation of consumption is not equal to one. Yet, due to the international risk sharing, the international comovement of consumption is too high compared to output interdependance.

This shortcoming is still an open issue in the business cycle research. An extensive literature attempts to solve this so-called "quantity puzzle". In order to lower the cross-country correlation of consumption, Stockman and Tesar [1995] and Devereux, Gregory and Smith [1992] consider non separable utility between consumption and leisure (Devereux, Gregory and Smith [1992]) or non-traded goods (Stockman and Tesar [1995]). The non separability introduces a specific disturbance on each consumption which is likely to reduce the international comovement of private consumption. Devereux, Gregory and Smith [1992]'s guess turns out to be quite effective in bringing down the consumption comovement. Stockman and Tesar [1995]'s model just pushes the quantity anomaly onto the traded component of consumption whose correlation is too high.

So as to increase the international comovement of production, Ambler, Cardia and Zimmermann [1998] adopt a multi-good framework. By introducing several sectors and intermediate goods in the economy, the authors hope to enhance the international linkages between home and foreign productions. The intuition is correct but the quantitative effects do not solve the quantity anomaly. Indeed, the main issue is not to focus on each international correlation in order to bring it closer to its historical level. As pointed out by Backus, Kehoe and Kydland [1995], the quantity puzzle refers to the differences in the relative sizes between cross-country correlations: international comovement of output exceeds that of consumption, investment and employment.

As mentioned by Stockman and Tesar [1995], the international cross-country correlation of Solow residuals is lower than that of output, which indicates that the monetary dimension could introduce relevant channels of international transmission of nation-specific shocks. Extensions proposed by Schlagenhauf and Wrase [1995] or Obstfled and Rogoff [1995] might help bring the quantitative implications of the theory closer to the observed properties.

As for net exports and government balance, Table 8 reports the statistics calculated after simulating the model with the estimated relative volatilities over the whole sample.

Table 8: Simulations over the whole sample

Shocks	Standard Deviation			Correlation		
	Output	Relative to Output		with Outpout		Net Exports
σ^G/σ^Z	σ_y %	Net Exports	Budget Balance	Net Exports	Budget Balance	Budget Balance
1.38	**1.60** (0.19)	*1* (0.11)	0.33 (0.02)	**−0.24** (0.14)	**0.70** (0.04)	**−0.18** (0.11)

The variability of net exports relative to output is five times larger than it is in the US data. However, a relative volatility that hovers around 1 could match stylized facts in Austria, France, Japan and the UK. The high variability of net exports is due to the volatility of investment: in spite of adjustment costs of capital, the model predicts that investment is five times more volatile than output. Besides, the relative volatility of public balance in the US economy (0.54) exceeds the volatility ratio of the simulations (0.33).

The model succeeds in matching the countercyclical behavior of the US trade balance as well as the procyclical movements of government balance. Finally, with the estimated relative variance of demand and supply shocks over the whole sample, the model accounts for the negative correlation between the US net exports and the public balance (-0.20 in the data versus -0.18 in the simulations).

Table 9: Variance Decomposition

Shocks	z_1	g_1	z_2	g_2
Horizon		**Country 1 Output**		
1 quarter	0.928	0.001	0.070	0.001
4 quarters	0.993	0.000	0.007	0.000
16 quarters	0.977	0.000	0.023	0.000
20 quarters	0.939	0.000	0.061	0.000
Horizon		**Country 1 Net exports**		
1 quarter	0.497	0.003	0.497	0.003
4 quarters	0.274	0.226	0.274	0.226
16 quarters	0.498	0.002	0.498	0.002
20 quarters	0.498	0.002	0.498	0.002
Horizon		**Country 1 Budget balance**		
1 quarter	0.761	0.187	0.051	0.001
4 quarters	0.882	0.115	0.002	0.001
16 quarters	0.905	0.040	0.055	0.000
20 quarters	0.729	0.021	0.250	0.000

Over the whole sample, the estimated ratio of demand to supply shocks is greater than one, thus indicating that government shocks have been more volatile than technological shocks since the mid-1960s. Moreover, the theoretical model predicts that demand shocks induce a positive correlation between net exports and government balance while technological disturbances generate a negative correlation. However, in spite of dominant government shocks, the model generates a negative correlation between trade and budget balances. This paradox is due to the strong internal propagation of productivity shocks. Indeed, following a supply shock, responses of consumption, output, investment, employment, net exports and government balance are larger than the ones observed after a government spending shock (Figures 2 to 5). Table 9 displays the variance decomposition of output, budget balance and net exports following the domestic and foreign shocks. At all horizon, the home supply shock accounts for more than 90% (70%) of the dynamics of output (budget balance). Since the home trade balance has the same magnitude as the foreign trade balance, net exports are as sensitive to the home productivity shock as to the foreign supply disturbance.

The dominant effects of productivity shocks is consistent with the view that the counter-cyclical behavior of prices (as shown for instance by Cooley and Ohanian [1991]) indicates that supply shocks dominate in the post-war era.(10)

4.3 The unstable relationship between net exports and government balance

After making sure that the model constitutes a rather good proxy for the US economy over the whole period, I finally measure to which extent the estimated change in the volatility ratio of supply and demand shocks accounts for the unsteady relationship between the US net exports and government balance. The model is fed with the varying volatility ratios as described in section 4.1. Table 10 reports the correlations between net exports and fiscal balance that I got from the simulations. Those predictions of the model are compared to Table 2.

Table 10: Correlation between net exports and government balance

	1964:1-1973:4	1974:1-1980:3	1980:4-1990:2	1990:3-1997:4
σ_1^G/σ_1^Z	1.55	0.91	1.51	1.77
Correlation	**−0.07** (0.15)	**−0.31** (0.13)	**−0.02** (0.12)	0.08 (0.15)

The change in the relative volatilities of shocks produces the switch in the magnitude of the correlation: in the 1970s, the variance of supply shocks exceeds the variability of government spending (with $\sigma_1^G/\sigma_1^Z = 0.91$). The corresponding volatility ratio indeed generates a negative correlation $\rho_{nx,ng}$ (-0.31) that is not so far from the one I got from historical series (-0.49). Similarly, the estimated government spending shock becomes dominant in the 1960s and the 1980s. This modified volatility ratio (σ_1^G/σ_1^Z around 1.5) lowers the correlation between net exports and government balance (around -0.07 in the 1960s and -0.02 in the 1980s) to levels that are quite close to the true statistics (-0.03 in the 1960s and -0.04 in the 1980s). However, Baxter [1995]'s view does not seem to be relevant in the current decade since the US net exports are negatively correlated to government balance (-0.35 in Table 2) in spite of more volatile government spending shocks ($\sigma_1^G/\sigma_1^Z = 1.77$).

Further research is thus needed to investigate the relationship between the US trade and fiscal deficits. Some empirical papers focused on the Ricardian Equivalence Hypothesis (REH). Indeed, in a Ricardian framework, when the government runs a deficit that is financed either by bonds or by taxes, home households, if informed about the future path

(10) I thank the anonymous referee for underlining this point.

of taxes, increase their saving. As a consequence, the government does not resort to foreign capital (current account deficit) in order to finance its deficit. Therefore, there is no causal relationship between fiscal and trade deficits.

However, investigations that examine the REH is not completely satisfactory for two reasons. First, empirical results are mixed. Evans [1988]'s estimates from Blanchard [1985]'s overlapping generation model proves that the consumer's planning horizon is long, thus indicating that the REH holds in the US. Yet, Normandin [1994] finds a significant relationship between trade and fiscal deficits although the US consumer's horizon is nearly 80 years. Secondly, the REH cannot account for the lack of a robust relationship between both deficits. Dwelling on the REH, the switching sign of the correlation would stem from the fluctuating proportion of Ricardian households in the US.

4.4 Sensitiveness Analysis

In order to test de robustness of my conclusions, I perform a sensitiveness analysis on parameters α, μ, ρ_{12} and ψ. In the first subsection, I examine whether results are sensitive to the inclusion of government spending in the utility function. Since I focus on the short-run behavior of fiscal deficit, I then measure the influence of the solvency parameter (μ) on the responses of budget balance. Finally, I study the dynamics of the model for varying values of ρ_{12} and ψ. Indeed, these parameters regulate the international transmission of productivity shocks, thus affecting investment and trade balance.

In order to grasp some intuition about the impact of α, μ, ρ_{12} and ψ, I first draw impulse response functions (IRFs) for increasing values of each parameter. I then simulate the model so as to measure the magnitude of the effects observed on IRFs. In the following subsections, I lay stress on the influence of α, μ, ρ_{12} and ψ on the specific topic of this paper: the joint behavior of home net exports and budget balance. As far as standard stylized facts are concerned, since my results confirm Bec [1994]'s observations regarding the quantitative impact of those parameters, I comment the simulations in Appendix D.

4.4.1 Substitution between private and government expenditures

$\alpha \in [0,1]$ determines the degree of substitution between private and government expenditures. If $\alpha = 0$, the marginal utility of private consumption is unchanged after a government shock, which affects the economy through a negative wealth effect. With $\alpha = 1$, since private and government are perfect substitutes, an increase in home government expenditures is completely compensated by a drop in home private consumption. As a consequence, other home and foreign variables remain unchanged. A close look at the first order conditions (equations (17) to (23) in Appendix B) reveals that the responses of the model are sensitive to the value of α only in the case of a government shock. Whatever α, the productivity shock implies a budget surplus and a trade deficit.

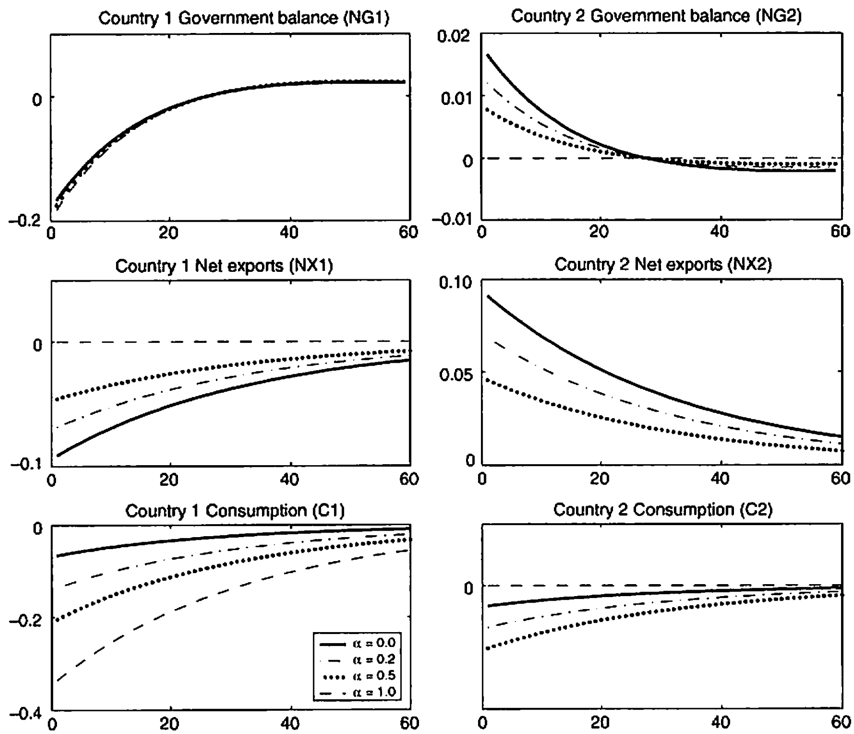

Figure 6: Responses to the domestic government shock for varying values of α

Figure 6 plots the responses of consumption, budget balance and net exports after a 1% increase in government spending. On each graph, the impulse response function is computed for varying values of α. The dynamics of home budget balance stems from the evolution the domestic government shock. As a consequence, its trajectory is hardly sensitive to the value of α. The government disturbance instantaneously creates a budget deficit. As long as α is different from 1, the other economic variables respond to the increase in government spending because of the wealth effect, thus leading to a trade deficit. Therefore, following a demand shock, the twin deficits are observed as long as private and government consumptions are not perfect substitutes. However, since productivity shocks dominate the short run dynamics of net exports and government balance (see Table 9 in section 4.2.2), the assumption about the value of α barely plays any significant role in the correlation between both balances. The simulations confirm the intuition drawn from the impulse response function (Table 11).

Table 11
Correlation between net exports and government balance for increasing values of α.

α	0	0.2	0.5	1
$\rho_{nx,ng}$	−0.13 (0.11)	−0.17 (0.11)	−0.18 (0.12)	−0.15 (0.12)

4.4.2 Solvency condition

μ determines the speed of convergence of the budget balance to its stationary value. The higher μ, the faster the adjustment. Figures 7 and 8 display the responses of budget balance, net exports and production after a positive productivity (Figure 7) and government shocks (Figure 8).

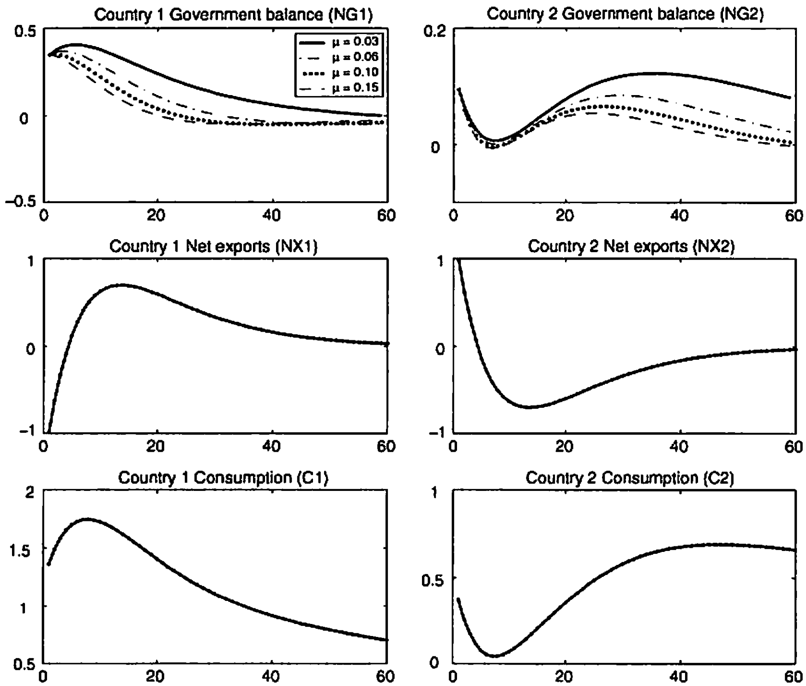

Figure 7: Responses to the technological shock for varying values of μ

As expected, whatever the shock, neither production nor net exports are sensitive to the value of μ. Moreover, since μ only affects the speed of adjustment of the budget balance, its instantaneous response is unchanged. Thus, in the first period following the shock, the main prediction of the model is not modified: the supply shock implies opposite responses of both balances while government spending disturbances generate similar responses of trade and budget balances.

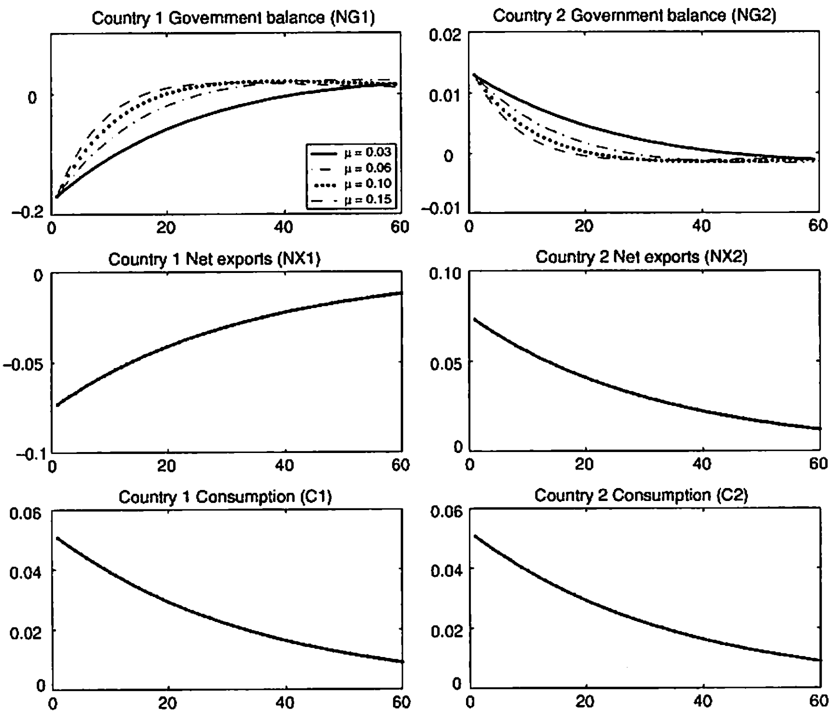

Figure 8: Responses to the domestic government shock for varying values of μ

The short-run behavior of budget balance is explained by two elements: the procyclical tax on production (τy_{it}) and the solvency condition (μd_{it}). After the productivity shock (Figure 7), when μ is low, the effect of taxation on output determines the short-run response of budget balance, hence the humpback shape of the budget surplus. The correlation between budget balance and production is expected to be high.

As μ increases, following the technological shock, the solvency condition implies a quick convergence towards the stationary value, the response of budget balance becomes the mirror image of the dynamics of net exports. This leads to more negative short-run correlation between both balances as μ increases (Table 12). However, the range of values remains close to the historical level (-0.20).

Table 12
Correlation between net exports and government balance for increasing values of μ.

μ	**0.03**	**0.06**	**0.10**	**0.15**
$\rho_{nx,ng}$	−0.09 (0.12)	−0.17 (0.13)	−0.22 (0.11)	−0.24 (0.13)

4.4.3 International propagation of technological shocks

The international propagation of productivity shocks is regulated by ρ_{12} and ψ. The latter determines the instantaneous transmission of the technological disturbance while ρ_{12} affects the speed of transmission of the supply shocks (see equation 2). As a consequence, the responses of the model following a government shocks are insensitive to the value of those parameters. In this subsection, I thus examine the effects of ρ_{12} and ψ on impulse response functions generated by a home technological shock.

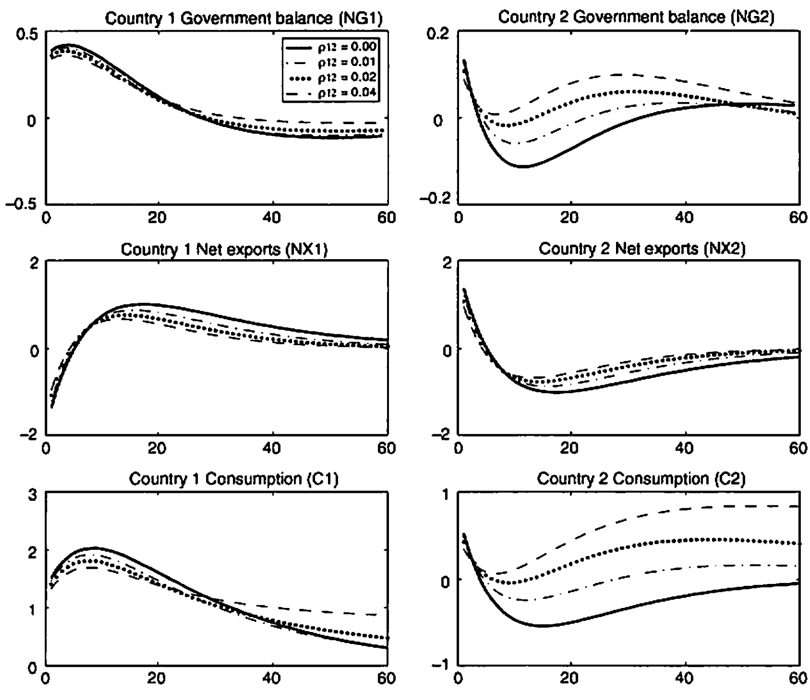

Figure 9: Responses to the technological shock for varying values of ρ_{12}

As can be seen from Figure 9, ρ_{12} hardly alters the instantaneous behavior of the variables. For high values of the parameter, country 2 benefits faster from a higher production level. As households expect a high transmission of the productivity shocks, the instantaneous productivity differential is smaller, opposite capital movements are of lower magnitude, thus leading to a trade deficit of -1.36 with $\rho_{12} = 0$ instead of -0.98 when the transmission of the productivity shock is fast ($\rho_{12} = 0.04$). However, this effect is quantitatively negligible (Table 13). As far as the contemporaneous correlation between both balances is concerned, the value of ρ_{12} is neutral.

Table 13

Correlation between net exports and government balance for increasing values of ρ_{12}.

ρ_{12}	0	0.01	0.02	0.04
$\rho_{nx,ng}$	−0.17 (0.14)	−0.16 (0.14)	−0.16 (0.12)	−0.18 (0.14)

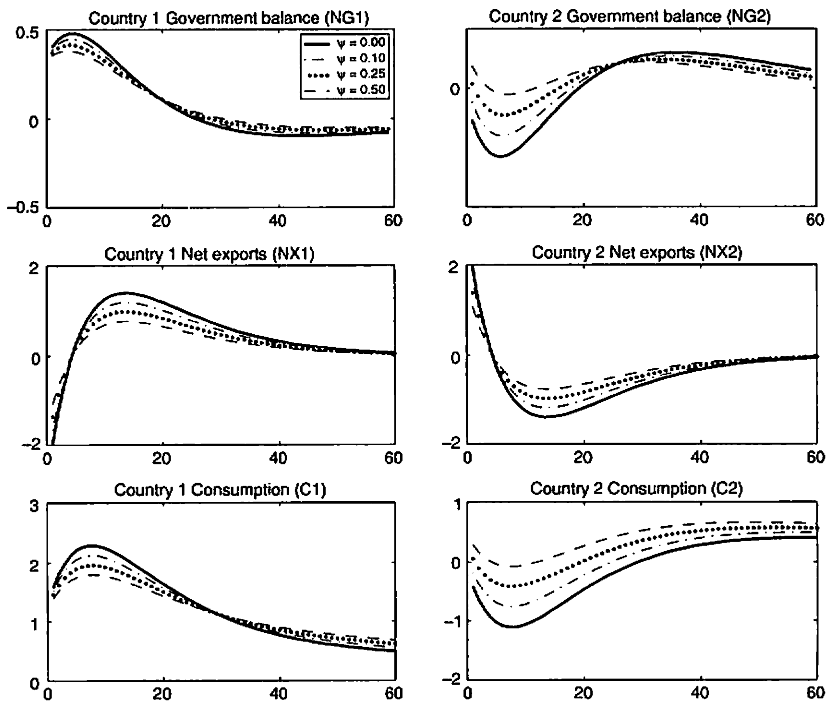

Figure 10

Responses to the domestic technological shock for varying values of ψ

The instantaneous propagation of productivity shocks is strengthened as ψ increases. This explains why the immediate responses of country 2 production and budget balance go up for rising values of ψ (Figure 10). As mentioned above, since the increase in ψ lowers the productivity differential between the two countries, instantaneous asymmetric capital movements are of lower magnitude when ψ is high. The opposite responses of investment being less important, the home (foreign) trade balance is less negative (positive) when the international propagation of the home shock is high. Moreover, the initial jump in country 1 production and budget balance are slightly affected by modifications in the value of the parameter. As a consequence, as can be seen from Table 14, the instantaneous correlation between net exports and budget balance gets less negative as ψ increases. However high ψ may be, the correlations obtained from simulations hover around the true correlation (−0.20).

Table 14
Correlation between net exports and government balance for increasing values of ψ.

ψ	0	0.1	0.25	0.5
$\rho_{nx,ng}$	−0.29 (0.10)	−0.26 (0.10)	−0.21 (0.12)	−0.17 (0.13)

5 Conclusion

Empirical papers that focused on the twin deficit hypothesis do not reach any consensus. In this paper, I isolate two reasons for these conflicting conclusions. First, as mentioned by Rosenweig and Tallman [1993], considering data in levels versus stationarized series does have an impact on the results. While data in levels tend to lend support to the twin deficit behavior, stationarized data do not give evidence of any positive link between net exports and government balance. Moreover, the correlation between both series, whether stationarized or not, turns out to be unsteady.

This paper attempts to re-examine the relationship between trade and fiscal deficits by emphasizing the mechanism presented in Baxter [1995]'s paper: the correlation between trade and fiscal deficits is sensitive to the nature of the dominant shock in the US economy. When technological shocks are more volatile than government spending shocks, the US net exports and the budget balance move in opposite directions. In contrast, the twin deficits appears because of dominant government shocks. This intuition seems relevant over each sub-sample (from the 1960s to the 1980s) except in the 1990s. Further research is needed to identify what causes the trade and fiscal deficits to be negatively correlated in the 1990s while government spending shocks are much more volatile than supply disturbances.

APPENDIX A

Integration and cointegration

Since the series are measured as ratios to GDP, I did not include any determinist trend in the ADF equations.

Table 15: ADF tests

	ADF statistics	
	With a constant term	Without a constant term
NX	-1.90	-2.41
NG	-2.47	-2.20

With (without) a constant term, the critical value at 5% is -2.91 (-3.45). Whether with a constant or not, the ADF statistics are not significant at a 5% level of significance: the null hypothesis of a unit root is accepted.

Figure 11 plots the US net exports and government balance between 1964:1 and 1997:4. An upward sloping line could almost be drawn to fit the scattered points.

Johansen and Juselius [1990]'s procedure confirms the intuition that the long run behavior of the US data endorses the twin deficit view. Table 16 reports statistics and 95% quantiles of the λ Max and trace tests. Bold figures indicate that the null hypothesis is rejected at a 5% level significance[(11)].

Table 16: Johansen and Juselius' test.

Null hypothesis	λ Max	95%	Trace	95%
$r \leqslant 1$	4.04	9.24	4.04	9.24
$r = 0$	**21.93**	15.67	**25.95**	19.96

[(11)] The lag was chosen with AIC and BIC criteria under the null hypothesis of no cointegration. I checked for the normality of residuals by using Jarque and Bera's test. It was assumed at first that the model in level does not exhibit any deterministic trend. A specific test that compares likelihood of the model with trend versus the model without trend confirms this intuition.

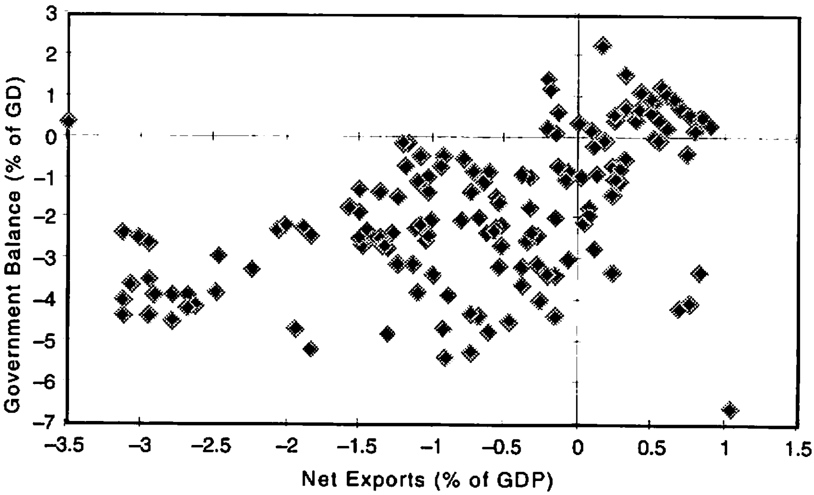

Figure 11: The US net exports and government balance (1964:1-1997:4)

Both tests point at a unique cointegration relation. The cointegration vector is such that[12]

$$NX = 0.60NG$$

Net exports are indeed positively linked to government deficit in the long run, which gives some evidence of the twin deficit behavior.

APPENDIX B

First order conditions of the theoretical model

The static program of the firm leads to

$$w_{i,t} = (1-\theta) z_{i,t} n_{i,t}^{-\theta} k_{i,t}^{\theta} \quad (15)$$

$$\xi_{i,t} = \theta z_{i,t} n_{i,t}^{1-\theta} k_{i,t}^{\theta-1} \quad (16)$$

[12] I omit the constant term.

As for country i household, vectors of control variables, state variables and innovations are:

$C_t = (c_{1,t}, y_{1,t}, n_{1,t}, i_{1,t}, p_{1,t}, c_{2,t}, y_{2,t}, n_{2,t}, i_{2,t})$,

$S_t = (k_{1,t}, k_{2,t}, d_{1,t}, d_{2,t}, z_{1,t}, z_{2,t}, g_{1,t}, g_{2,t}, q_{1,t}, q_{2,t}, p_{2,t})$ and

$S_{B,t} = (k_{1,t}, k_{2,t}, d_{1,t}, d_{2,t}, z_{1,t}, z_{2,t}, g_{1,t}, g_{2,t})$.

$p_{i,t}$ and $q_{i,t}$ denotes multipliers associated with (8) and capital (9).

Optimal conditions of (11) are[13]

$$\begin{aligned}
c_{i,t} &= \frac{1}{p_{i,t}} - \alpha g_{it} && (17)\\
n_{i,t} &= 1 - \frac{\gamma}{p_{i,t} w_{i,t}(1-\tau)} && (18)\\
q_{i,t} &= p_{i,t}(1 + \varphi(i_{i,t} - \delta k_{i,t})) && (19)\\
q_{i,t} &= \beta E_t[q_{i,t+1}(1-\delta) + p_{i,t+1}(\xi_{i,t+1}(1-\tau) \\
&\quad + \delta\varphi(i_{i,t+1} - \delta k_{i,t+1}))] && (20)\\
\chi(J_{t+1}) p_{i,t} &= \beta p_{i,t+1} f(J_{t+1}, J_t) && (21)
\end{aligned}$$

Equation (17) shows that the higher α the lower the marginal utility associated with private consumption.

As expected, according to (18), the substitution effect implies that labor supply increases subsequently to a rise in $w_{i,t}$.

Notice that (21) leads to

$$\frac{p_{1,t}}{p_{2,t}} = \omega \forall t \qquad (22)$$

where the strictly positive constant ω represents the initial relative wealth. With $\omega = 1$, wealth is equally distributed across households.

Combining (17) with (22) leads to

$$c_{1,t} + \alpha g_{1t} = c_{2,t} + \alpha g_{2t} \forall t \qquad (23)$$

As in Bec and Hairault [1997], cross-country consumption are equal when $\alpha = 0$.

Using (18) and (15), (22) lead to

$$z_{1,t} n_{1,t}^{-\theta} k_{1,t}^{\theta}(1 - n_{1,t}) = z_{2,t} n_{2,t}^{-\theta} k_{2,t}^{\theta}(1 - n_{2,t}) \qquad (24)$$

Following the domestic supply shock, the domestic household increases its labor supply. The instantaneous increase in z_1 dominates the jump of n_1 so that the left-hand side of (24) goes up. In order to preserve the equality of the equation, n_2 decreases. For, neither k_2 nor z_2 can adjust: the first variable is backward-looking and the second does not move in the first period. In a nutshell, contrary to consumptions, labor supplies immediately jump in opposite directions.

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(13) In the first-order conditions, we use the constant return to scale hypothesis so that $y_{i,t} = w_{i,t} n_{i,t} + \xi_{i,t} k_{i,t}$.

Transversality conditions are

$$\lim E_t[\beta^{t+T} q_{i,t} k_{i,t+T}] = 0$$

$$\lim E_t[\beta^{t+T} p_{i,t} b_i(J_{t+T})] = 0$$

The envelop conditions consist of

$$\frac{\partial V(k_{i,t}, b_i(J_t))}{\partial k_{i,t}} = (1-\delta) q_{i,t}$$

$$\frac{\partial V(k_{i,t}, b_i(J_t))}{\partial b_i(J_t)} = p_{i,t}$$

APPENDIX C

Stylized facts

All tables are taken from Backus, Kehoe and Kydland [1995]. Saving-Investment correlations are taken from Backus, Kehoe and Kydland [1992].

Tables 17 and 18 display the national business cycle properties of 10 OECD countries. Consumption and employment are slightly less volatile than output while investment in fixed capital has been from two to three times more volatile than output. All variables except the ratio of net exports to output are strongly procyclical. The strong income term in imports of goods and services may account for the countercyclical behavior of the trade balance.

Table 17: Business Cycles in 10 industrialized countries (1970-mid 1990)

	Standard Deviation		Ratio of standard deviation to that of output		
Country	Output	Net Exports	Consumption	Investment	Employment
Australia	1.45%	1.23%	0.66	2.78	0.34
Austria	1.28	1.15	1.14	2.92	1.23
Canada	1.50	0.78	0.85	2.80	0.86
France	0.90	0.82	0.99	2.96	0.55
Germany	1.51	0.79	0.90	2.93	0.61
Italy	1.69	1.33	0.78	1.95	0.44
Japan	1.35	0.93	1.09	2.41	0.36
Switzerland	1.92	1.32	0.74	2.30	0.71
United Kingdom	1.61	1.19	1.15	2.29	0.68
Unites States	1.92	0.52	0.75	3.27	0.61
Europe	1.01	0.50	0.83	2.09	0.85

Table 18: Correlation with output and saving-investment correlation

Country	Correlation with output				S–I
	Consumption	Investment	Net Exports	Employment	Correlation
Australia	0.46	0.68	−0.01	0.12	−0.07
Austria	0.65	0.75	−0.46	0.58	0.29
Canada	0.83	0.52	−0.26	0.69	0.06
France	0.61	0.79	−0.30	0.77	−0.04
Germany	0.66	0.84	−0.11	0.59	0.42
Italy	0.82	0.86	−0.68	0.42	0.06
Japan	0.80	0.90	−0.22	0.60	0.50
Switzerland	0.81	0.82	−0.68	0.84	0.38
United Kingdom	0.74	0.59	−0.19	0.47	0.07
Unites States	0.82	0.94	−0.37	0.88	0.68
Europe	0.81	0.89	−0.25	0.32	...

The US-Europe correlations of output, consumption, investment and employment are positive (Table 19). The cross-country correlation of output is larger than that of the other variables.

Table 19

International Comovements (1970-mid 1990) [correlation of each country's variable with the same US variable]

Country	Output	Consumption	Investment	Employment
Europe	0.66	0.51	0.53	0.33

APPENDIX D

Sensitiveness Analysis

In this appendix, simulations are performed over the whole sample

$$T = 136 \quad , \quad \frac{\sigma_1^Z}{\sigma_1^G} = \frac{\sigma_\varepsilon^Z}{\sigma_2^G} = 1.38 \quad , \quad \sigma_1^Z = \sigma_2^Z = 0.00749$$

with varying values of parameters α, μ, ρ_{12} and ψ. The results of this sensitiveness analysis are close to Bec [1994]'s. The only difference between her model and mine lies in government budget constraint. She does not allow the government to run any deficit. As a consequence, she studies the influence of α, ρ_{12} and ψ. In spite of this difference, business cycle properties of most of the variables are quite similar.

Sensitiveness analysis on α

The other parameters are set to their calibration value: $\mu = 0.06$, $\rho_{12} = 0.04$, $\psi = 0.5$ Equation (23) clearly shows that the inclusion of government spending in the utility function lowers the international comovement of consumption. The simulation confirms this intuition since the cross-country correlation of consumption.

Table 20: Simulations with varying values of α

	$\alpha = 0$	$\alpha = 0.2$	$\alpha = 0.5$	$\alpha = 1$
		Relative standard deviation		
y	1.55 (0.002)	1.52 (0.002)	1.59 (0.002)	1.68 (0.002)
c	0,59 (0,08)	0,61 (0,08)	0,63 (0,08)	0,65 (0,09)
n	0,60 (0,07)	0,61 (0,07)	0,60 (0,06)	0,60 (0,05)
i	5,97 (0,73)	5,09 (0,84)	5,89 (0,81)	5,47 (0,70)
nx	1,03 (0,13)	1,05 (0,16)	1,00 (0,14)	0,93 (0,12)
ng	0,33 (0,03)	0,33 (0,03)	0,33 (0,03)	0,32 (0,03)
		Correlation with output		
c	0,72 (0,09)	0,70 (0,11)	0,73 (0,08)	0,73 (0,08)
y	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)
n	0,81 (0,07)	0,84 (0,05)	0,87 (0,04)	0,92 (0,03)
i	0,57 (0,08)	0,57 (0,08)	0,59 (0,07)	0,60 (0,08)
nx	−0,20 (0,14)	−0,21 (0,13)	−0,24 (0,14)	−0,24 (0,14)
ng	0,71 (0,05)	0,72 (0,05)	0,73 (0,05)	0,75 (0,04)
		Comovement		
y	0,25 (0,20)	0,30 (0,21)	0,32 (0,18)	0,35 (0,18)
n	−0,76 (0,10)	−0,73 (0,11)	−0,65 (0,12)	−0,44 (0,16)
i	−0,84 (0,05)	−0,84 (0,05)	−0,81 (0,06)	−0,76 (0,07)
c	1,00 (0)	0,99 (0)	0,95 (0,02)	0,84 (0,05)
s, i	0,61 (0,06)	0,61 (0,07)	0,63 (0,06)	0,65 (0,65)

Sensitiveness analysis on μ

The other parameters are set to their calibration value: $\alpha = 0.2$, $\rho_{12} = 0.04$, $\psi = 0.5$ μ modifies the business cycle properties of government balance. Its relative standard deviation is not sensitive to the value of the parameter. As mentioned in section 4.4.2, with more stringent solvency condition, the hump-back response disappear, thus lessening the procyclicity of the budget balance. As far as standard stylized facts are concerned, the value of μ is neutral.

Table 21: Simulations with varying values of μ

	$\mu = 0.03$	$\mu = 0.06$	$\mu = 0.10$	$\mu = 0.15$
		Relative standard deviation		
y	1.54 (0.02)	1.54 (0.02)	1.55 (0.02	1.55 (0.02
c	0,61 (0,08)	0,61 (0,08)	0,62 (0,09)	0,61 (0,08)
n	0,60 (0,06)	0,60 (0,06)	0,60 (0,06)	0,60 (0,06)
i	5,01 (0,78)	5,85 (0,80)	5,96 (0,77)	5,03 (0,71)
nx	1,03 (0,14)	1,03 (0,14)	1,02 (0,14)	1,04 (0,13)
ng	0,33 (0,03)	0,33 (0,03)	0,33 (0,03)	0,32 (0,03)
		Correlation with output		
c	0,71 (0,10)	0,72 (0,09)	0,72 (0,09)	0,71 (0,10)
y	1,00 (0)	1,00 (0)	1,00 (0)	1,00 (0)
n	0,83 (0,06)	0,83 (0,06)	0,83 (0,06)	0,83 (0,06)
i	0,57 (0,09)	0,56 (0,08)	0,58 (0,08)	0,57 (0,09)
nx	−0,28 (0,14)	−0,25 (0,13)	−0,25 (0,14)	−0,27 (0,14)
ng	0,71 (0,05)	0,71 (0,05)	0,69 (0,05)	0,65 (0,05)
		Comovement		
y	0,32 (0.19)	0,32 (0.21)	0.30 (0.18)	0.26 (0.21)
n	−0.72 (0.09)	−0.72 (0.11)	−0.73 (0.09)	−0.74 (0.09)
i	−0,83 (0.05)	−0.82 (0.06)	−0,83 (0.05)	−0,83 (0.05)
c	0.99 (à)	0.99 (à)	0.99 (à)	0.99 (à)
s, i	0.62 (0.07)	0.62 (0.07)	0.62 (0.06)	0.61 (0.07)

Sensitiveness analysis on ρ_{12} and ψ

As mentioned in section 4.4.3, rising values of those parameters reduce the productivity differential that drives the asymmetric movements in investment. This leads to more elongated responses of production, employment, net exports and budget balance in both countries. As expected, the simulated standard deviation of those variables decreases as the transmission of the productivity shock is enhanced. Nevertheless, net exports are still too volatile.

The simulations confirm Bec [1994]'s conclusions that assuming a strengthened instantaneous propagation of technological shock imply closer comovement between home and foreign countries. Since ρ_{12} mostly affects country 2 dynamics, the cross-country correlation of output is hardly sensitive to this parameter. Yet, however ψ might be, the quantity puzzle still remains.

Table 22: Simulations with varying values of ρ_{12}

	$\rho_{12} = 0$	$\rho_{12} = 0.01$	$\rho_{12} = 0.02$	$\rho_{12} = 0.04$
		Relative standard deviation		
y	1.87 (0.002)	1.74 (0.002)	1.72 (0.002)	1.57 (0.02)
c	0,41 (0,06)	0,45 (0,07)	0,48 (0,07)	0,60 (0,08)
n	0,67 (0,05)	0,66 (0,05)	0,64 (0,06)	0,60 (0,60)
i	5,54 (0,86)	5,61 (0,95)	5,20 (0,75)	4,87 (0,70)
nx	1,16 (1,01)	1,17 (0,16)	1,07 (0,14)	1,01 (0,11)
ng	0,30 (0,02)	0,31 (0,03)	0,32 (0,03)	0,32 (0,03)
		Correlation with output		
c	0,69 (0,12)	0,68 (0,11)	0,71 (0,11)	0,72 (0,08)
y	1,00 (0)	1,00 (0)	1,00 (0)	1,00 (0)
n	0,94 (0,02)	0,92 (0,03)	0,91 (0,03)	0,84 (0,06)
i	0,56 (0.08)	0,55 (0.08)	0,58 (0.08)	0,58 (0.08)
nx	-0,22 (0,15)	-0,23 (0,15)	-0,25 (0,15)	-0,27 (0,15)
ng	0,76 (0.05)	0,75 (0.04)	0,74 (0.05)	0,72 (0,05)
		Comovement		
y	0,32 (0.22)	0,33 (0,20)	0,33 (0,19)	0,34 (0,19)
n	-0,42 (0,18)	-0,47 (0,16)	-0,52 (0,14)	-0,74 (0,09)
i	-0,76 (0,08)	-0,77 (0,07)	-0,78 (0,06)	-0,83 (0,05)
c	0,99 (0)	0,99 (0)	0,99 (0)	0,99 (0)
s, i	0,57 (0,08)	0,57 (0,08)	0,60 (0,07)	0,62 (0,06)

Table 23: Simulations with varying values of ψ

	$\psi = 0$	$\psi = 0.1$	$\psi = 0.25$	$\psi = 0.5$
		Relative standard deviation		
y	2.17 (0.003)	1.98 (0.02)	1.79 (0.0026)	1.58 (0.002)
c	0,30 (0,60)	0,36 (0,07)	0,45 (0,08)	0,60 (0,08)
n	0,79 (0,04)	0,78 (0,05)	0,73 (0,06)	0,60 (0,07)
i	8,54 (0,87)	8,29 (1,00)	8,29 (0,98)	5,93 (0,65)
nx	1,44 (0,12)	1,41 (0,14)	1,31 (0,15)	1,02 (0,12)
ng	0,29 (0,02)	0,29 (0,02)	0,31 (0,03)	0,33 (0,03)
		Correlation with output		
c	0,38 (0,15)	0,39 (0,17)	0,52 (0,15)	0,72 (0,10)
y	1,00 (0)	1,00 (0)	1,00 (0)	1,00 (0)
n	0,96 (0,01)	0,94 (0,02)	0,91 (0,03)	0,85 (0,05)
i	0,58 (0,05)	0,57 (0,07)	0,58 (0,06)	0,58 (0,08)
nx	-0,22 (0,51)	-0,21 (0,58)	-0,21 (0,58)	-0,27 (0,54)
ng	0,78 (0,04)	0,77 (0,04)	0,74 (0,06)	0,73 (0,05)
ng	0,76 (0.05)	0,75 (0.04)	0,74 (0.05)	0,72 (0,05)
		Comovement		
y	-0,21 (0,09)	-0,10 (0,14)	0,18 (0,17)	-0,33 (0,20)
n	-0,95 (0,02)	-0,94 (0,03)	-0,90 (0,02)	-0,74 (0,09)
i	-0,98 (0,01)	-0,97 (0,01)	-0,94 (0,02)	-0,83 (0,05)
c	0,98 (0,01)	0,98 (0,01)	0,99 (0)	0,99 (0)
s, i	0,59 (0,05)	0,59 (0,06)	0,60 (0,05)	0,62 (0,07)

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