International Business Cycles and the Dynamics of the Current Account

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Abstract This paper analyzes the transmission of productivity shocks across countries and how the responses of investment and the current account differ depending on the degree of propagation of shocks. We explore both issues by estimating a structural model for Japan, the US and Europe. We postulate, as an identifying assumption, that the propagation of shocks is proportional to trade. We find that there is a strong asymmetry in that shocks to the US propagate quickly to the other two economies while European and Japanese shocks have little impact in other countries' productivity. When we explore the responses of investment and the current account we find that productivity increases lead to domestic investment booms and current account deficits. Investment in other countries tends to react positively to productivity shocks, even when the shock is purely national. This second result contradicts the predictions of a standard open-economy model with perfect capital mobility where, in response to country-specific shocks, domestic and foreign investment should move in opposite directions. We also find quantitative differences among the three countries in the response of the current account. These differences are not related to the global or idiosyncratic nature of the shocks.

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1.- Introduction

In the last two decades, there has been a growing interest in testing the intertemporal implications of open economy models. The distinctive feature of an open economy is the ability to borrow and lend in international capital markets in response to cyclical disturbances. As a result, domestic income and spending can be different as countries run current account surpluses and deficits. This behavior is the result of consumption smoothing and capital flows to those countries where investment opportunities exist. These two forces shape the dynamics of saving and investment rates and, thus, the response of the current account.

Most of the recent research in this area has focused on two issues: the correlation of investment and saving rates and the characteristics of open economy business cycles (such as cross-country correlations of productivity, output, consumption or investment). In most cases, the results of a calibrated model are compared to some set of stylized facts derived from correlation coefficients and the analysis is an informal joint test of a specific model and the degree of openness and international capital mobility.

One of the main stylized facts in this literature is the high correlation of national saving and investment rates using both cross-section and time-series data.[1] This high correlation was initially seen as evidence against the importance of the intertemporal dimension of the current account. The conclusion was that a high correlation between domestic saving and investment was caused by a low degree of capital mobility. This conclusion was challenged in two different fronts. First, from an empirical point of view, alternative evidence showed that the current account is countercyclical and that increases in investment are associated with current account deficits.[2] Second, from a theoretical perspective, perfect capital mobility does not necessarily imply a zero correlation between saving and investment. The correlation depends on the type of shocks that drive economic fluctuations.[3] This correlation can indeed be quite high depending on two main characteristics: the origin and persistence of shocks and whether shocks are global or country-specific. Indeed, these two characteristics also affect many other related stylized facts of the international business cycle such as cross-country comovements of consumption, investment, productivity or output. For example, the extent to which a shock is shared by different countries is a major determinant of the comovements

[1] The literature started with the findings of Feldstein and Horioka (1980). Tesar (1991) presents a survey of this literature.

[2] Sachs (1981) shows that investment has a larger explanatory power than saving for movements in the current account.

[3] Obstfeld (1985), Backus, Kehoe and Kydland (1992) and Baxter and Crucini (1993), among others, explore this idea.

in output, consumption and investment. If all shocks are global we expect all these correlations to be very high and, at the same time, we expect a high correlation of national saving and investment. In fact, this is what we find empirically, large cross-country correlations in output, productivity or investment which can only be explained by the presence of common shocks or when country-specific shocks are quickly transmitted across countries. Most calibrations of models of the international business cycle take this evidence into account and estimate parameters that measure both the correlation and diffusion of innovations. The sensitivity of the calibration results to these parameters is very large. In this sense, the first step to assess the importance of the intertemporal dimension of the current account is to establish the source and propagation of the shocks responsible for business cycles.

The goal of this paper is to empirically examine the predictions of intertemporal real business cycles models with regard to the different effects of productivity shocks which are local (or idiosyncratic) and those which spill over to other economies. We propose a model where all shocks are country specific and are potentially spread to other countries. For this purpose, we fit an econometric spatial model using data from Japan, the US and Europe.[4] The model allows us to establish the origin of the shocks and their contribution to output fluctuations in each of the three countries. We identify the model by postulating that the contemporaneous propagation of shocks is proportional to the trade linkages between countries. We use bilateral trade weights to identify structural shocks and then look at the dynamic responses of productivity, investment and the current account.

We find that positive cross-country comovements in productivity are mainly due to the transmission of shocks originated in the US economy. US shocks are quickly transmitted to both Europe and Japan. On the other hand, European and Japanese shocks are mostly country specific in nature and do not have a significant effect on other countries' productivity. When we analyze the response of the domestic current account and investment to productivity shocks we find that the current account is generally countercyclical in response to shocks that affect domestic productivity. The reason for this behavior is that a domestic investment boom follows a positive shock to productivity. In this sense, we confirm early findings by Sachs (1981) which support the importance of the intertemporal approach to the current account. We also obtain some evidence of the S-shaped pattern of the current account found by Backus, Kehoe and Kydland (1994). We find, however, that the response of investment flows from other countries in response

[4] Europe is an aggregate of the European G-7 countries: France, Italy, Germany and Great Britain.

to these shocks is at odds with some of the predictions of open-economy models. The response of investment to foreign productivity shocks tends to be positive, even if the shock is not propagated internationally. This stands in contrast with the theoretical prediction that, for this type of shocks, investment rates should be negatively correlated across countries. Lastly, although the direction of the responses of the current account and domestic investment are always the predicted ones, there are significant differences regarding their magnitudes.

Our paper relates to previous work which characterizes business cycle in open economies such as Backus, Kehoe and Kydland (1992 and 1994), Baxter and Crucini (1992) Stockman (1990), Ahmed, Ickes, Wang and Yoo (1993) or Razin and Rose (1992). The work of Glick and Rogoff (1995) is also very close to our paper as they analyze differences in the response of investment and the current account to country-specific shocks and global shocks. We differ from their analysis as we impose some additional structure to the transmission of the shocks and we are able to obtain information on the relative importance of different shocks.

Section 2 reviews the literature on the international business cycle and develops our framework of analysis. Section 3 presents the econometric specification and methods. Section 4 shows and interprets the results of the structural decomposition. Section 5 uses the results of our decomposition to look at the dynamic response of the current account and investment to structural shocks. Section 6 concludes.

2.- Open Economy Business Cycles

There are significant differences between open and closed economies regarding business cycles. First, open economies can run current account imbalances as domestic spending and income differ and countries borrow or lend in international financial markets. This behavior is reflected in the different responses to output fluctuations of national saving and investment rates. For example, in the presence of a positive domestic productivity shock, we expect increases in both consumption and investment leading to changes in the current account. Second, in open economies there exists the possibility of the transmission of shocks between countries. Tastes, technology or policy shocks abroad are additional sources of domestic business cycles.

Regarding the current account, there are two related factors that determine the nature of its dynamics. First, the degree of openness of trade and capital markets influences saving and investment decisions. Second, the type of shocks that cause output fluctuations determines the possibilities of borrowing from other countries. Only shocks with a large country-specific component have a significant effect on the current account as they will induce capital flows from abroad. This second factor is closely related to the possibility of cross-country transmission of shocks; a country-specific shock which is quickly transmitted to other countries has a similar effect to a global shock.

We have two distinct scenarios where international comovements of investment, consumption and the current account can be markedly different. When shocks are either global (shared by all countries), or they are country specific but quickly spread to other countries, we expect a small response of the current account, high correlations between investment and saving and high cross-country correlations in output, productivity or investment. On the other hand, country-specific shocks which are not spread to neighboring countries, should produce large swings in the current account and low cross-country correlations of output, investment or productivity. In fact, under very general circumstances, we expect negative cross-country correlations of output and investment in response to country-specific shocks.

Empirically, we observe large positive cross-country correlations in investment, output and productivity. We, thus, require either a large number of global shocks or a significant and quick transmission of country-specific shocks.

The theoretical importance of the origin and transmission of business cycles has been recognized in calibration exercises of intertemporal real business cycles models such as Backus, Kehoe and Kydland (1992) or Baxter and Crucini (1993). In both cases, a model is calibrated to explain the comovements of key macroeconomic variables. The starting point is a stochastic process for productivity shocks which assumes that shocks are correlated between countries and spread across borders through some sort of technology diffusion process. Formally, suppose that we have two countries: the home country and the foreign country and we represent the percentage deviations of productivity from their steady state values as $\hat{A}$ and $\hat{A}^*$ respectively. Then, the stochastic process followed by productivity is represented by

$$\begin{pmatrix} \hat{A}_t \\ \hat{A}_t^* \end{pmatrix} = \begin{pmatrix} \rho & \nu \\ \nu & \rho \end{pmatrix} \begin{pmatrix} \hat{A}_{t-1} \\ \hat{A}_{t-1}^* \end{pmatrix} + \begin{pmatrix} \epsilon_t \\ \epsilon_t^* \end{pmatrix}$$

where it is assumed that the productivity innovations have zero mean, $E(\epsilon_t) = E(\epsilon_t^*) = 0$, and that they are possibly correlated, so that the variance-covariance matrix is equal to

$$E(\epsilon_t, \epsilon_t^*)(\epsilon_t, \epsilon_t^*)' = \begin{pmatrix} \sigma_\epsilon^2 & \psi \\ \psi & \sigma_{\epsilon^*}^2 \end{pmatrix}$$

In the previous specification there are two ways in which home and foreign productivity can be correlated. First, as long as $\psi \neq 0$, shocks are contemporaneously correlated. Second, as long as $\nu \neq 0$, innovations to foreign productivity are diffused (with a lag) to home productivity.[5] The calibrations of Baxter and Crucini (1993) show that the model is very sensitive to different values of these parameters. As an example, when shocks are purely country specific, the case $\psi = 0$, the predicted cross-country correlation of output and investment is negative.

The approach of the real business cycles literature has generally been to calibrate a model to replicate the first and second order moments of the relevant variables. Our goal is to test these theoretical predictions using a different approach. We make explicit the nature of the shocks and measure the dynamic responses of investment and the current account. By doing so, we are able to trace the dynamic response of each of these variables (both domestic and foreign) to identified structural shocks and therefore to provide an additional source of tests to the implications of intertemporal models. We restrict ourselves to the analysis of productivity shocks to make the comparison as close as possible to the RBC intertemporal open economy models.

Our approach starts by interpreting the ϵ shocks of the previous expression as being the net result of different productivity shocks that are transmitted across countries and lead to a positive correlation between foreign and home productivity. In other words, the previous variance covariance matrix corresponds to the reduced-form solution of a model that is driven by structural shocks. Once structural shocks are identified, we can uncover the dynamic responses of investment and the current account.

The identification that we propose is based on two assumptions. First, we assume that shocks always originate in one country. Productivity is contemporaneously correlated only as the result of the immediate transmission of country-specific shocks. Second, we identify the country of origin of shocks by fitting a spatial model that leads to the variance covariance matrix of our reduced form estimations. Our basic assumption is that shocks will be spread to a larger extent among those countries that are 'closer' to each other. To define the notion of 'distance' we use bilateral trade weights as a proxy and we postulate that the transmission of shocks is proportional to these trade weights.

There are several reasons why trade weights are a good measure of 'distance' to identify country-specific shocks.

1.- Even if countries are fully specialized and they produce different goods, as long as they trade intermediate inputs, a shock to the production function of a foreign supplier of intermediate inputs has an effect in the productivity of the

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[5] Baxter and Crucini (1993) calibrate the model so that $\nu = 0.05$ and ψ lies between 0.4 and 0.8. The values of ψ are in fact equal to the correlation between shocks as they normalize variances to 1.

domestic value-added production function.

2.- The existence of increasing returns to scale can create market-size effects. When there is an expansion abroad, domestic productivity increases as the country moves along a downward marginal cost curve.

3.- Technological productivity gains in one country are spread to other countries through trade in technology or, indirectly, through technological spillovers that could be possibly linked to trade in capital goods.

Therefore, our specification assumes that all shocks are country specific and that the contemporaneous correlation of productivity is proportional to trade flows.[6] Using these assumptions, we map the variance covariance matrix of a reduced-form VAR into a variance covariance matrix of a structural model where the orthogonal country-specific shocks are identified. We then use these identified shocks to examine the dynamic response of the current account, investment and consumption to the productivity shocks.

Our approach is very close to Glick and Rogoff (1995). They identify country-specific shocks and global shocks and then measure the response of the current account and investment. We differ from their work in three aspects. First, we construct country-specific shocks that are orthogonal to each other. Glick and Rogoff (1995) start by constructing a series for world productivity as a GNP-weighted average of individual countries' productivity which they use as a measure of global shocks. Country-specific shocks are defined as the differences between domestic and world productivity. One reason we may not want wish to approximate global shocks in this way is that any idiosyncratic shock will raise average productivity and thus be counted partly as a global shock. This could be important as some of the countries (e.g. the US) are large relative to the aggregate. A second reason is that such idiosyncratic shocks are most likely correlated with each other even though in the analysis they are given a structural interpretation, thus the experiment of 'what is the effect of an idiosyncratic shock to country A?' is asked but could lack any meaning if these correlations are significant; in this case orthogonal shocks are required. Second, we are able to trace the full dynamic response of investment and the current account. Third, by identifying orthogonal country-specific shocks, we can measure the response of both domestic and foreign

[6] One could also imagine situations in which productivity is correlated across countries which do not trade with each other. This would be true if productivity shocks hit industries that are shared by a group of countries. Productivity will raise in all these countries regardless of the amount of trade that they do. In the extreme case, when trade is caused by comparative advantage and countries fully specialize in the production of certain goods, then the absence of trade could imply that two countries share a similar set of industries which could lead to large correlations in productivity. Empirically, this argument is relatively weak as trade is larger among countries with similar degree of development and, moreover, intra-industry trade is a major part of total trade.

variables. This allow us to test additional predictions of open-economy models regarding cross-country correlations of investment, output and consumption.

There is a second identification issue which we leave aside as we concentrate on productivity shocks: the persistence of shocks and the possibility of having aggregate demand shocks. Backus, Kehoe and Kydland (1994) show that the response of the current account to shocks to government purchases and productivity could be quite different. Also, the responses of investment and the current account strongly depend on whether productivity shocks are transitory or permanent; the incentives to invest in a country which receives a positive productivity shock are an increasing function of the persistence of the shock. In our analysis, we only consider one source of shocks, productivity. The work of Ahmed, Ickes, Wang and Yoo (1993) partly deals with some aspects of this identification issue. However, they do not examine productivity data directly and they do not test the specific predictions of the intertemporal approach to the current account. They do find that most of the business cycle variation is due to what they call supply shocks, indicating that our examination of productivity is the empirically relevant direction in which to focus.

3.- Method to Decompose Shocks

The productivity data for the n countries is given by the vector y_t, and the vector of the various macroeconomic variables to be examined is given by z_t, where z_t is nkx1 where we have k macroeconomic variables for each country to examine. These can be collected into the $n(k+1)$ vector x_t, which following Sims (1980) can be modelled without further restriction (except for the selection of lag length) by the reduced form model

$$A(L)\,x_t = \omega_t \tag{1}$$

or with some further restrictions by the structural form

$$A(L)\,x_t = R^{*}e_t \tag{2}$$

where e_t are defined to be structural shocks to the system (i.e. uncorrelated with other shocks contemporaneously) and the ω_t are potentially contemporaneously correlated shocks.[7]

The unrestricted reduced form cannot be sensibly estimated here without further restriction, as for a VAR with one lag and $n = 3$, $k = 4$ (as we have) we

[7] See Watson (1994) for a review of VAR's and structural forms

would need to estimate in excess of 220 parameters with only 33 years of data. Typically, RBC models take productivity shocks to be exogenous with respect to other variables which here means that R^* is lower block diagonal where the partition separates the productivity variables y_t from z_t, and $A(L)$ is similarly block diagonal. This means that the empirical procedure can proceed in two separate steps; first examining the subsystem for productivity and secondly the vector of variables in z_t. Further restrictions on $A(L)$ are undertaken to reduce the parameter space; we have cross country effects only through productivity, so past and present variables in z_t for one country do not affect those in another.

Having isolated the productivity data as a separate VAR, we can use the structural VAR method to decompose reduced-form shocks into estimated structural shocks where structural shocks are assumed to originate in one of the countries and influence other countries productivity contemporaneously (with annual data, this means within the year). Productivity is driven by structural shocks e_{1t}, where the structural shocks are uncorrelated with each other, and there exists a productivity shock for each country in the system. This allows us to write the model for productivity as

$$y_t = D(L)\, e_{1t} \tag{3}$$

where L is the lag operator, $D(L)$ are coefficients left unrestricted at this point and e_{1t} is the first n elements of e_t. This model is in its structural form, so that rather than having e_{1t} correlated we will write $D(0)$, not equal to the identity matrix, to take into account the cross correlated nature of the shocks (this accords with the usual form of the structural model).

The individual shocks, e_{1t}, thus represent the decomposed country specific shocks to productivity. Of course, the model is not identified - an estimated VAR using the productivity data estimates

$$y_t = C(L)\, u_t \tag{4}$$

where $C(L)\, u_t = D(L)\, R^{-1}\, R\, e_{1t}$, $C(0) = I$ and R is the upper left hand nxn block of R^*. It is well known that there still exists an infinity of models (specifications of R) such that this holds. To identify productivity part of the model, we require a minimum of $(n(n-1)/2)$ restrictions.

We obtain these restrictions through considering the contemporaneous relationship between structural shocks. The above relationship between the reduced form model and the structural model gives the result that $u_t = Re_{1t}$, thus the observed aggregated shock in each period is a linear combination of the structural shocks to each country. Row i of the previous expression will be

$$u_{it} = r_{ii} e_{1it} + r_i \, (\sum_{j \neq i} w_{ji} e_{1jt}) \tag{5}$$

where w_{ji} represents the share that country j represents of the total trade of country i. The own country shock effect is left unrestricted (the parameter r_{ii}), giving us n free parameters in R. The effect of other country shocks, however, are assumed to be in proportion to trade weights, so that rows of R equal r_i times the trade weight between the countries (with weights summing to one across rows), where r_i is a free parameter. This gives n more free parameters, yielding a total of $2n$ free parameters to be estimated. The order condition for identification allows a maximum of $(n(n+1)/2)$ free parameters, so for $n = 3$ the model has the maximum number of free parameters. For $n > 3$ the system is overidentified.

In addition to the order condition for identification, we require that the model satisfy the rank condition as well. If we define θ as the $(2n\text{x}1)$ parameter vector (r_i, r_{ii}) for $i = 1...n$, which defines R as a function of θ, then this requires that the matrix of derivatives

$$\frac{\partial\big(vech([R(\theta)][R(\theta)]')\big)}{\partial\theta'} \tag{6}$$

have full column rank, where the *vech* operator takes the upper triangular portion of the matrix, including the diagonal, and places the elements into a vector. For the model this will be true so long as all elements of θ are not zero, a result we ensure through restricting the parameter space by requiring $r_{ii} > 0$ for all i, which from an economic point of view simply means that a positive structural shock has a positive effect on the reduced-form shock to domestic productivity (this parameter has the loose interpretation, exactly when $r_i = 0$, of the standard deviation of the structural shock). This rank condition only characterizes local identification, the restriction on the parameter space also confines attention to a smaller area and thus less likely to obtain multiple solutions.

The system y_t examined in the remainder of the paper includes the 3 countries of interest: Japan, the United States and Europe, so $n = 3$. The estimates of θ were solved so that $[R(\theta)][R(\theta)]'$ equals the estimated variance covariance matrix of the reduced form model.

The remainder of the model, the last nk equations from the full VAR above, can be rearranged so that we have

$$z_t = A_{22}^{*}(L)\, z_{t-1} + G(L) e_{1t} + \omega_{2t} \tag{7}$$

where $A^*_{22}(L)$ is the lower right hand kxk block of $A^*(L)$ obtained from the transformation

$$A^*(L) = L^{-1}\left[I - A(L)\right] \tag{8}$$

Also, the results above have identified e_{1t} so this is simply a variable in the model. To further pare down the number of estimated coefficients, we have restricted $A^*_{22}(L)$ to be diagonal so only own lags appear in the regressions. These regressions can proceed using OLS.[8]

4.- Decomposition Results

We estimate a VAR with annual data from Japan, United States, and Europe, where Europe is an aggregate of the four G-7 European countries (France, Germany, Italy and Great Britain). We describe the data in an appendix.

We run the reduced form VAR using productivity in growth rates.[9] Using the notation of the previous section, the VAR can be expressed as

$$y_t = A^*_{11}(L)\, y_{t-1} + u_t \tag{9}$$

where y_t is a vector that consists of productivity growth for the three countries considered and $A^*_{11}(L)$ is the upper left hand nxn block of $A^*(L)$ as defined in equation (8). The estimates of the reduced form are shown in Table 1. We use one lag for each variable.

Table 1. Estimation Results.

	y_t^{JAP}	y_t^{US}	y_t^{EUR}
Intercept	0.012	0.009	0.017
	(1.374)	(1.645)	(4.438)
y_{t-1}^{JAP}	0.673	0.107	0.317
	(3.484)	(0.896)	(3.740)
y_{t-1}^{US}	0.374	0.375	0.355
	(1.181)	(1.916)	(2.554)
y_{t-1}^{EUR}	-0.154	-0.273	-0.281
	(-0.319)	(-0.916)	(-1.323)
R^2	0.84	0.45	0.91

Sample: 1960-94
t-statistics in parentheses

[8] OLS could be inefficient as it does not take into account cross correlations in ω_{2t} but to use these correlations would require even more structure on the model.

[9] We have also run the VAR using productivity in levels and have added an extra lag. The results of the decomposition and second stage regressions results are similar. The t-statistics in the second lag are insignificant.

The variance-covariance matrix of the reduced form (where we have normalized for unity variances so that off diagonals can be interpreted as correlations) is

$$\begin{pmatrix} 1.000 & 0.237 & 0.472 \\ 0.237 & 1.000 & 0.455 \\ 0.472 & 0.455 & 1.000 \end{pmatrix}$$

Where the order of countries is: Japan, United States and Europe. The cross-country correlations are in the range 0.24-0.47. These values are close to the values estimated by Backus, Kehoe and Kydland (1992) for a VAR in levels using quarterly data for two countries (US and Europe). They are, however, below the values suggested by the calibrations of Baxter and Crucini (1993), between 0.4 and 0.8.

We use bilateral trade weights (see the appendix for a description of the data) to estimate the coefficients of the matrix R following the identification assumptions described in Section 3.[10] The last three coefficients in R estimate the contemporaneous spillover response coefficients. The very small number estimated for the effect of shocks in Japan and Europe on the US reduced form for productivity shocks of -0.004 suggests that there is little contemporaneous spillover from these countries to the US. The lack of significance and size of both the lagged Japanese and European productivity growth variables in the equation for the US in the VAR presented in Table 1 shows that this spillover does not occur with a lag either. Conversely, the larger coefficients for the effect of the other countries in the model on Japan and to a lesser extent Europe suggest that there are greater spillovers to these countries. The large weighting of the US in the foreign portion of the spillovers to Japan and Europe (through the fact that the US commands a significant trade share for each of these regions) gives the result that shocks for the US are going to be important for Japan and Europe. Had the estimate for r_2 (the parameter that measures the impact of foreign shocks on US productivity) been higher, then we would have seen contemporaneous spillovers in all general directions, however the estimates suggest that this is not the case.

From the coefficients of R we are able to recover the structural shocks. Figure 1 shows the impulse response functions for each of the three structural shocks. They are drawn for the growth rate of productivity.[11]

[10] See the appendix for the estimated values of R.

[11] The error bands are calculated using a Monte Carlo of the subsystem model as described in Hamilton (1994). Assuming structural errors are normally distributed, we generate pseudo growth of productivity data conditioning on our estimates of R and the VAR estimates. We then re-estimate these parameters from the pseudo data and calculate structural impulse responses. This was done 1000 times with the sample length set to be equal to the actual data set, and the lower and upper 5th and 95th percentiles of these pseudo structural impulse responses are reported.

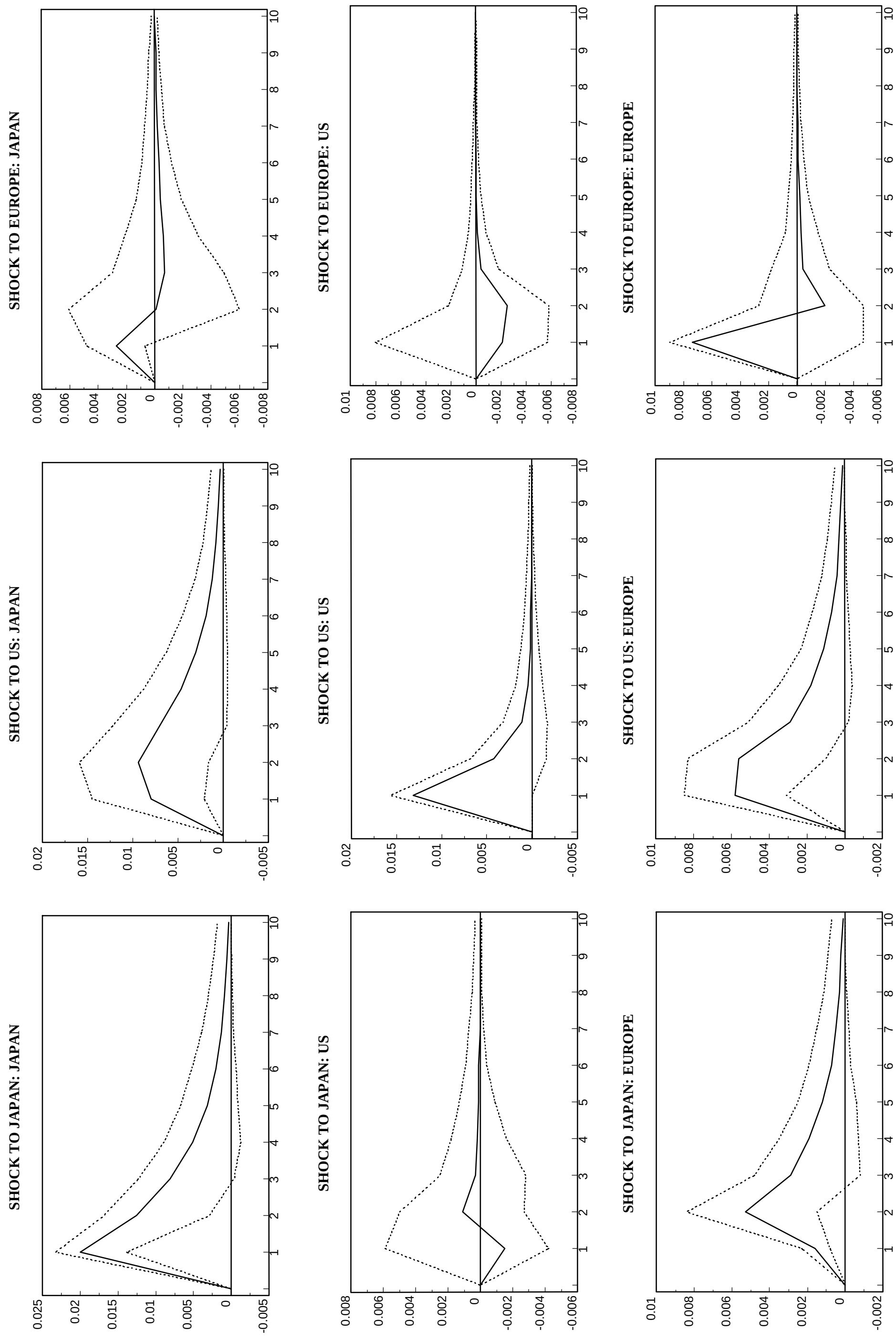


Figure 1. Impulse Response of Productivity Growth

The response of productivity to a domestic shock is, in all three cases, relatively similar. The only noticeable difference is that in the case of Japan, the shock is more persistent. We find, however, substantial differences between the three shocks regarding the effects on other countries' productivity. In the case of Japan and Europe, the shock has a large effect in domestic productivity but relatively little effect on the productivity of the other two countries.[12] In contrast, US shocks are quickly spread to Europe and Japan and the long-run effect of the shock is approximately the same in the three countries.[13] Therefore, the nature of the shocks is considerably different depending on the country; European and Japanese shocks are mostly country-specific while US shocks take the role of global shocks. In other words, most of the reduced-form correlation is coming from the propagation of the structural US shock to Europe and Japan.

Table 2. Variance Decomposition.

	JAPAN			US			EUROPE		
Years	Jap	US	Eur	Jap	US	Eur	Jap	US	Eur
1	84.9	13.6	1.5	1.3	96.2	2.4	2.7	36.8	60.5
2	77.8	21.3	1.0	1.8	93.0	5.2	20.1	41.9	38.1
4	73.7	25.4	0.9	1.8	92.9	5.3	24.1	42.8	33.1
6	73.0	26.0	0.9	1.8	92.9	5.3	24.6	42.9	32.5
8	73.0	26.1	0.9	1.8	92.9	5.3	24.7	42.9	32.4
10	73.0	26.2	0.9	1.8	92.9	5.3	24.7	42.9	32.4

This table shows the percentage of the variance of the growth rate of productivty due to each of the shocks

Table 2 shows the error-forecast variance decomposition of the structural shocks. It confirms the evidence presented in the impulse responses. In the case of the US, its own shock is responsible for practically 100% of its variance at all possible horizons. In Japan, its own shock is also responsible for the majority of the variance (between 70% and 84%) and the US shock accounts for almost all the rest (around 30%). The case of Europe is very different as its own shock only accounts for only a third of its variance. The rest is mainly due to the US shock (almost 40% in the long run) although Japan also accounts for a significant part (a fourth of the total variance in the long run).[14]

[12] In the case of Europe the effect is not significant as the error bands are large. This suggests that the estimate may overstate the true productivity effect. In the case of Japan there is some propagation of the shock to Europe but this is still small relative to the effects of the shock on Europe.

[13] Although the effect on Japan is not significant, the point estimates are large.

[14] We have also performed the previous decomposition using output and output per worker instead of our measure of productivity. The results are very similar and are available from the authors upon request.

From the previous decomposition, we conclude that there is a strong asymmetry between structural shocks originated in the US and shocks originated in other countries. While US shocks have a significant effect on other countries' productivity, the reverse does not hold. The same asymmetry is found in Ahmed, Ickes, Wang and Yoo (1994).

This asymmetry in the transmission of different shocks is an important source of information to test the implications of open economy models of the business cycle. The distinct nature of each of the shocks leads to different predictions concerning the response of the current account and investment. We explore these implications in the next section.

5.- The Response of Investment and the Current Account

We use the structural decomposition of Section 4 to measure the response of the current account and investment to productivity shocks.[15] We want to exploit the differences in the nature of US and European and Japanese shocks to test some of the theoretical implications of open-economy models. As outlined in Section 2, we expect investment and the current account to respond very differently to each of the shocks. For example, a shock to US productivity, which is quickly transmitted to Europe and Japan, should produce positive cross-country correlations in investment and little current account dynamics. On the other hand, European and Japanese shocks, which are country specific in nature, should lead to increases in domestic investment accompanied by possible decreases in other countries' investment and large swings in the current account.

We now trace the response of the current account and investment to each of the structural shocks. We use as dependent variables the ratio of the current account to GDP and the growth rate of investment and regress each of them on the contemporaneous and lagged values of the structural shocks.[16] Tables A1 and A2 in the appendix show the results and Figures 2 and 3 the implied dynamic responses. Next we summarize our findings with respect to each of the three shocks.

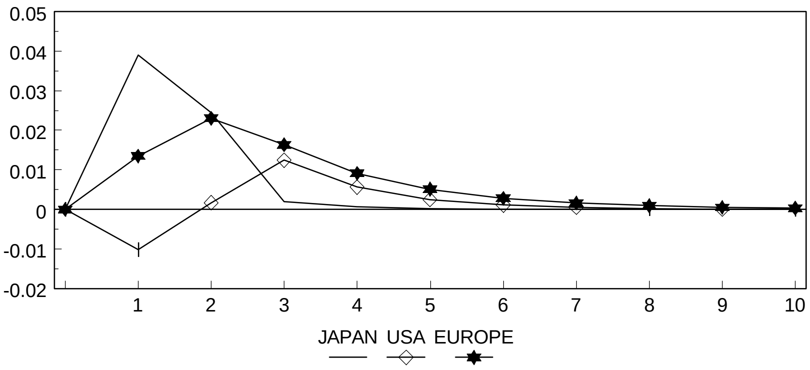
5.1.- Japan productivity shock.

[15] We have also looked at the responses of consumption and output. We concentrate on the behavior of investment and the current account as they are the key variables to test several theoretical predictions of open-economy models. The appendix includes the results and dynamic responses of output and consumption.

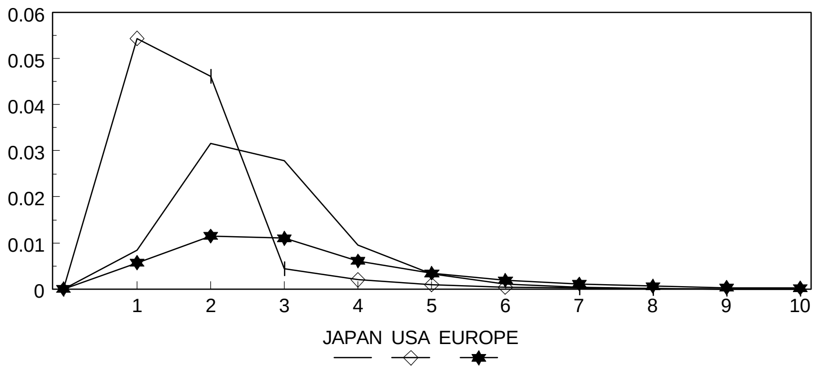
[16] We use, in all cases, two lags of the shocks and a lag of the dependent variable as regressors. We have also run the same regressions using differences in the current account to GDP ratio. The results are very similar to the ones in levels.

Figure 2. Impulse Responses of Investment Growth

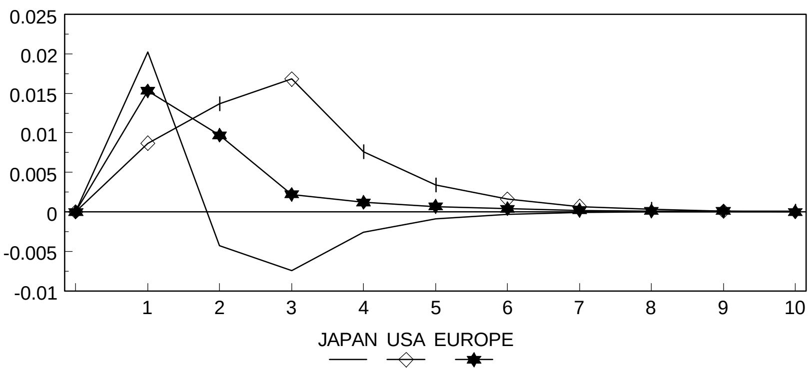
Shock to Japan



Shock to US



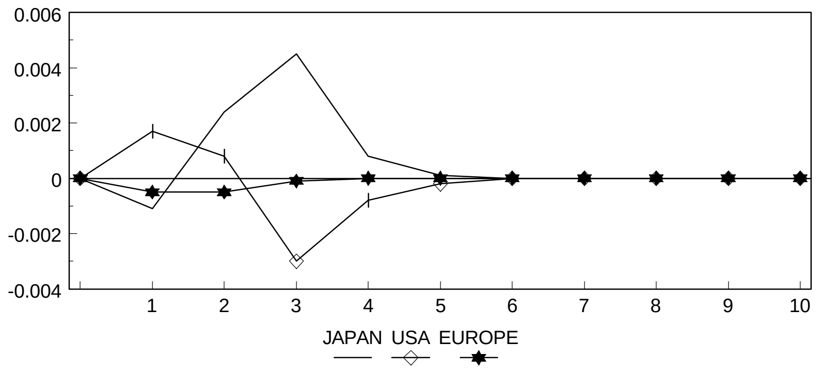
Shock to Europe



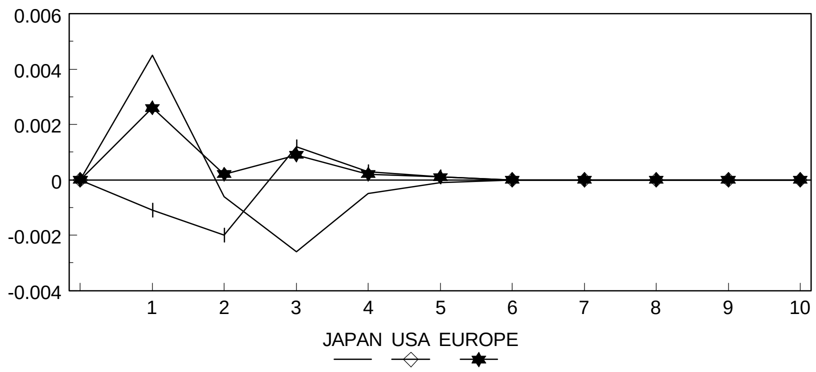
There is an immediate positive response of investment in both Japan and to a lesser extent Europe. In the US, the response, although initially negative, turns positive after two periods. The response of investment in Europe is somehow surprising. Although productivity in Europe increases, the increase is small relative to the increase in productivity in Japan (shown in Figure 2). In this sense, we do not expect a large positive response of investment in Europe. The calibrations of Backus, Kehoe and Kydland (1992) and Baxter and Crucini (1993) show that in response to country-specific shocks investment should increase in the country where the shock originates but it should decrease in the other countries (as capital flows to the country where the technological innovation occurs).[17] Although the Japanese shock is not a purely country-specific shock, the spillover to European productivity does not seem to be large enough to justify the response of investment in Europe. We will come back later to this effect as it is also present in the response to the other shocks in the system.

Figure 3. Impulse Responses of Current Account to GDP Ratio

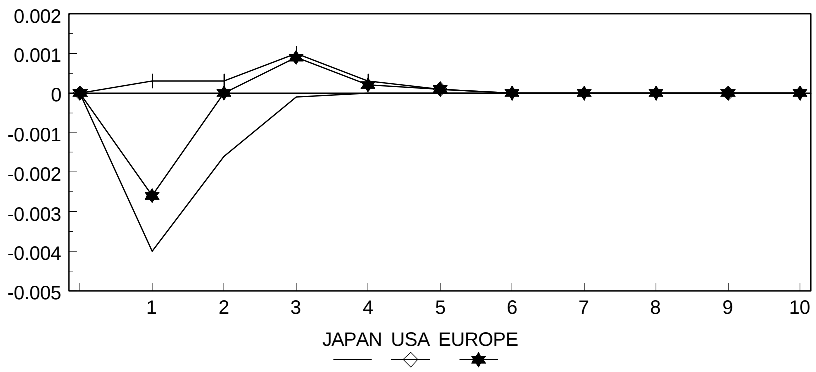
Shock to Japan



Shock to US



Shock to Europe



[17] Their calibrations have to rely on positive cross-country correlations and diffusion of shocks to generate the positive unconditional correlation of investment across countries.

The response of the Japanese current account is initially negative. An improvement in domestic productivity leads to an investment boom and a worsening of the current account. This result is consistent with the regressions of Sachs (1981) which shows that deficits in the current account are associated with investment booms. However, the relatively small response of the current account indicates that there is an increase in saving that partially offsets the large response of investment. Also, the current account is S shaped which confirms the results of Backus, Kehoe and Kydland (1994). The S shape is the result of the initial increase in investment (larger than the increase in output) which is followed by faster output growth as investment returns to its steady-state level. The US current account mirrors the Japanese current account. This is the result of the country-specific nature of the shock which leads to a decline of US investment which in turn improves the current account. The behavior of the European current account is the result of the response of investment. The surge in European investment leads to a small worsening of the current account. This behavior contradicts the prediction of an RBC open-economy model as we expect countries like Europe to experience initial current account surpluses as investment flows to Japan, where productivity is relatively higher. One possible explanation for this result is that the propagation of the shock to European productivity, although being relatively small, attracts investment from other countries, not included in our sample, where the shock is not propagated. This explanation could only be consistent if there are differences in the degree of capital mobility among countries. For example, it could be that capital mobility between Japan and European countries is smaller than between our European aggregate and other European countries not included in the aggregate.

5.2.- US productivity shock.

There is a strong positive response of investment in the US, Japan and, to a lesser extent, in Europe. This positive cross-country correlation in investment is consistent with the impulse response functions of productivity which showed a rapid and significant transmission of the shock from the US to Japan and Europe.[18]

The US current account shows a negative response while the Japanese and European current accounts increase in response to a US productivity shock. As was the case with the shock to Japan, a shock to US productivity increases domestic investment and leads to a worsening of the current account. The worsening of the current account implies that other countries see their current account improving. This is true for both Europe and Japan. However, we should note that

[18] It is noticeable that both productivity and investment in Japan seem to respond with a lag.

the improvement in the European and Japanese current account is not the consequence of a decrease in investment but rather of a large increase in saving. In both countries, investment increases but this increase is compensated by a larger increase in output that leads to a current account surplus. This is apparent from the large response of output growth in each country shown in the appendix.

Therefore, the responses to the US shock differ from the responses to a Japanese shock. In the US, the shock is propagated to other countries which generates a global investment boom. However, this investment boom is larger (relative to the change in saving) in the US than in Europe or Japan which leads to a temporary worsening of the US current account.

5.3.- European productivity shock.

As in the case of Japanese shocks, European shocks do not spill over to other countries as much as US shocks. The response of investment in Europe is, as expected, positive. Investment in Japan and the US also increase. Once more, it is surprising that in response to an increase in European productivity, we observe a large increase in investment in both Japan and the US. In the case of Japan there exist some (small) spillover effects to productivity, but in the case of the US it is evident that productivity does not increase after a European shock. This type of investment dynamics seem to indicate that, in response to a positive productivity shock in Europe, there are lower than expected capital inflows from Japan and the US.

The previous result is confirmed when we look at the current account response. Although the large domestic investment boom produces a broad worsening of the European current account, the US and Japanese current account do not respond in the direction expected (improving). In the case of the Japanese current account, the direction of the change is the opposite of what is expected in that it worsens in response to the European shock. It is alsoo noticeable that, despite the relatively small transmission of the European productivity shock to Japan, the response of investment and the current account are larger in Japan than in Europe.

We should also notice that the reason why it is possible that neither the US nor the Japanese current account improve in response to a shock to European productivity is that the countries that we have in our sample do not represent 100% of world output. In other words, there are other countries that must be absorbing the changes in the European current account.[19] This asymmetry raises

[19] In a previous version of the paper we performed the same exercise but having Germany instead of the European aggregate as the third country. As expected, we found an even larger response of the German current account possibly reflecting capital flows from the other countries

interesting theoretical questions about the behavior of capital flows in a world with many countries. In principle, it seems difficult to explain the absence of capital flows from Japan and the US in response to an increase in European productivity. It is nevertheless hard to contrast this evidence with models of the international business cycle as most models are two-country symmetric models that make no prediction about investment flows that can originate in more than one country.

5.4.- Summary of results.

Overall, our results provide support for some of the features of the open-economy RBC models but, at the same time, they question several of their predictions regarding cross-country correlations.

We found, as expected, that productivity shocks cause a worsening of the current account as investment increases faster than saving. However, we find that other countries' investment tend to move in the same direction than domestic investment even if the shock does not significantly spill over to them. Therefore, the theoretical predictions of Baxter and Crucini (1993) or Backus, Kehoe and Kydland (1992), who obtain negative cross-country correlations of investment rates in the presence of idiosyncratic shocks, are not supported by our results.

Regarding the differences in the response of the current account to global and idiosyncratic shocks, we confirm the results of Glick and Rogoff (1995) concerning the negative response of the current account to idiosyncratic productivity shocks. However, when we compare the Japanese and European shocks (almost purely idiosyncratic shocks) with the US shock (which is quickly spread to other countries and plays the role of a global shock) we do not find, contrary to Glick and Rogoff (1995), that the global shock has a significantly smaller impact on the current account than the idiosyncratic shock. On the contrary, at least when comparing the US and Japanese shocks, we observe that the US shock leads to larger current account changes. A possible explanation for the disagreement between our results and those of Glick and Rogoff (1995) is their definition of global shocks. They measure global shocks as the sum of individual countries' productivity which is likely to be affected by idiosyncratic shocks originating in different countries. If this were the case, the absence of a response of the current account to global shocks would not be surprising as the current account should respond in different directions depending on the specific origin of the shock.

There are two possible explanations for the previous disagreements between our findings and international RBC models. First, it could be that our results are caused by differences in the degree of capital mobility (and openness) in the

that compose the European aggregate used in the current sample.

countries in our sample. For example, regarding the behavior of the current account, a larger degree of capital mobility and openness possibly leads to larger swings in the current account. As long as there are significant differences between Japan, the US and Europe regarding openness and capital mobility, these differences could explain the relatively small response of the current account in Japan relative to the other two countries. A second explanation could be that our measure of productivity shocks is contaminated with other sources of shocks (e.g. aggregate demand shocks). In fact, some of the results that we find could be explained within the framework of a static (Mundell-Fleming type) model of the current account where expansions abroad lead to an increase in demand for exports which in turn raises domestic output, consumption and investment.

6.- Conclusions

This paper analyzes the transmission of productivity shocks across countries and explores the impact of these productivity shocks on investment and the current account with reference to the implications drawn from simulations of international RBC models. One major finding is that there is a strong asymmetry in the propagation of the shocks, in particular US shocks spill over quickly to Europe and Japan while the Japanese and European shocks are much more country specific in nature. This asymmetry, found in related studies, is a feature usually neglected in RBC models.

This asymmetry has strong implications as to the expected responses of investment and the current account. We find that positive productivity shocks lead to domestic investment booms and current account deficits, This is consistent with the empirical results reported in Sachs (1981) which finds that in a regression of the current-account-to-output ratio, the coefficient on the investment ratio is negative. This is also consistent with international RBC models where the current account is countercyclical in response to technology shocks. However, we find that the reaction of investment to productivity shocks in other countries is generally positive, while the RBC models would expect this only to be true for the US productivity shock (which acts like a global shock). In fact, the response of investment to shocks abroad seems to be more suited to static models of the current account. In these models, expansions abroad lead to increases in domestic output which in turn cause an increase in investment through an accelerator effect.

Also contrary to what is expected, when we compare the response of the current account to Japanese and US shocks we find that the shock which is more global in nature (the US shock) generates larger movements in the current account that the idiosyncratic shock (the Japanese shock). This contradicts the results of Glick and Rogoff (1995) who find a significantly smaller response of the current account in the case of global shocks than in the case of idiosyncratic shocks.

Finally, there are two reasons which could explain the previous anomalies and that we leave for future research. First, we do not control for differences in the degree of capital mobility. Given the strong dependence of the current account behavior on the degree of capital mobility, differences in this respect between the countries in our sample could be the origin of some of the previous anomalies. Second, we have restricted ourselves to the analysis of productivity shocks. It could be that our measure of productivity is contaminated with other sources of shocks from which the expected response of investment and the current account could be very different.

7.- Appendix

Description of the data.

Productivity.

We use annual data of total factor productivity from the OECD Economic Outlook (series 'PDTY'). The series span from 1960 to 1994. The European aggregate is constructed as a GDP-weighted average of the productivity series of France, Italy, Germany and Great Britain.

Trade Weight Matrix.

The trade weights were computed by first calculating the shares of exports and imports of each country separately, and normalising these shares to one. The data is taken in 1980 as reported in the United Nations publication Directions of Trade, Volume 1, 1982. For the European aggregate, total trade of the European countries in our sample was calculated adjusted for trade within these countries. The actual trade matrix used was the average of the imports and exports share matrices. The order in the matrix is Japan, US and Europe. We have rescaled the weights so that they add up to one.

$$\begin{pmatrix} 0.000 & 0.749 & 0.251 \\ 0.425 & 0.000 & 0.575 \\ 0.214 & 0.786 & 0.000 \end{pmatrix}$$

Investment, Current Account, Consumption and Output.

The source for Investment, Consumption and Output is the International Financial Statistics published by the IMF. Investment is Gross Private Fixed Capital Formation, Consumption is Private Consumption and Output is Gross Domestic Product. Current Account figures for all countries except France are also from the IFS publication. In the case of France we use figures from the national accounts published by the OECD as they IFS series is only available from 1967 onwards.

Empirical results

Estimated values for the R matrix.

The estimated values for the parameters of the matrix R are (following the notation of Section 3): $r_{11} = 0.020$, $r_{22} = 0.013$, $r_{33} = 0.007$, $r_1 = 0.011$, $r_2 = -0.004$, $r_3 = 0.007$.

Results from the second step regressions

Tables A1 to A4 show regressions of, investment growth rates (ΔI), the current account/GDP ratio (CA/GDP), consumption growth rates (ΔC) and output growth rates (ΔY) on contemporaneous and lagged values of the structural shocks (e^{JAP}, e^{US}, e^{EUR}). They also include a lag of the dependent variable. t-statistics in parentheses.

Table A1. Regression Results.
Dependent Variable: ΔI_t

	JAP	US	EUR
Intercept	0.0315	0.0181	0.0057
	(3.5761)	(2.8970)	(0.8608)
e_t^{JAP}	0.0390	-0.0102	0.0135
	(6.9017)	(-2.7906)	(1.6163)
e_{t-1}^{JAP}	0.0110	0.0063	0.0155
	(0.8033)	(1.1083)	(1.4280)
e_{t-1}^{JAP}	-0.0065	0.0117	0.0035
	(-0.6596)	(1.8885)	(0.4016)
e_t^{US}	0.0084	0.0544	0.0057
	(1.3045)	(9.2819)	(1.2726)
e_{t-1}^{US}	0.0287	0.0216	0.0083
	(2.6792)	(2.4990)	(1.4920)
e_{t-1}^{US}	0.0169	-0.0165	0.0046
	(1.2144)	(-2.6260)	(0.5191)
e_t^{EUR}	0.0202	0.0087	0.0153
	(3.7602)	(0.8071)	(1.9682)
e_{t-1}^{EUR}	-0.0113	0.0098	0.0011
	(-1.4021)	(0.7290)	(0.0858)
e_{t-1}^{EUR}	-0.0059	0.0106	-0.0032
	(-0.9848)	(1.2961)	(-0.3387)
ΔI_{t-1}	0.3451	0.4522	0.5576
	(1.7225)	(2.1533)	(1.9102)
R^2	0.8046	0.8096	0.6579

Table A2. Regression Results.
Dependent Variable: CA_t/GDP_t

	JAP	US	EUR
Intercept	0.0006	-0.0004	0.0003
	(0.2175)	(-0.2715)	(0.2860)
e_t^{JAP}	-0.0011	0.0017	-0.0005
	(-1.1512)	(1.9047)	(-0.2459)
e_{t-1}^{JAP}	0.0026	0.0004	-0.0003
	(1.9525)	(0.5696)	(-0.3204)
e_{t-1}^{JAP}	0.0041	-0.0032	0.0000
	(1.8957)	(-3.3374)	(0.0002)
e_t^{US}	0.0045	-0.0011	0.0026
	(4.0544)	(-0.9032)	(1.9164)
e_{t-1}^{US}	-0.0014	-0.0017	-0.0005
	(-1.1637)	(-2.8955)	(-0.1804)
e_{t-1}^{US}	-0.0025	0.0017	0.0009
	(-1.5680)	(1.4240)	(0.8082)
e_t^{EUR}	-0.0040	0.0003	-0.0026
	(-1.5016)	(0.1977)	(-1.4156)
e_{t-1}^{EUR}	-0.0009	0.0002	0.0007
	(-0.6204)	(0.1200)	(0.1711)
e_{t-1}^{EUR}	0.0002	0.0009	0.0009
	(0.1568)	(0.8902)	(0.8425)
CA_{t-1}/GDP_{t-1}	0.1774	0.2530	0.2419
	(1.0957)	(0.8733)	(0.9852)
R^2	0.4547	0.3980	0.3397

Table A3. Regression Results.
Dependent Variable: ΔC_t

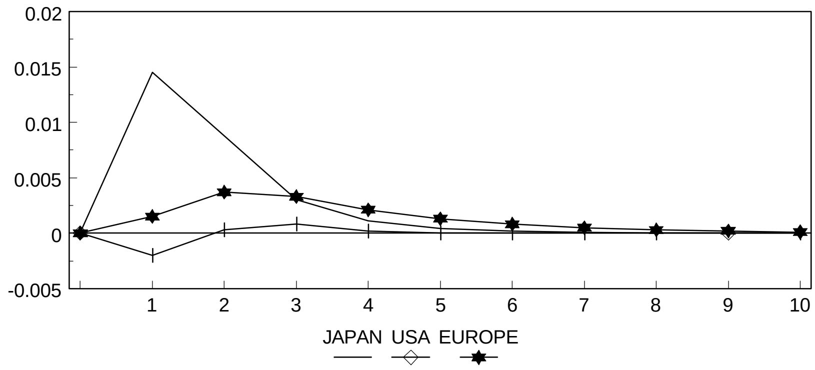
	JAP	US	EUR
Intercept	0.0305	0.0246	0.0090
	(1.7858)	(4.9622)	(0.7741)
e_t^{JAP}	0.0145	-0.0020	0.0015
	(4.5406)	(-1.2166)	(0.7702)
e_{t-1}^{JAP}	0.0032	0.0008	0.0027
	(1.5925)	(0.4206)	(0.8205)
e_{t-1}^{JAP}	-0.0005	0.0008	0.0010
	(-0.1192)	(0.4442)	(0.4859)
e_t^{US}	0.0071	0.0121	0.0045
	(1.6700)	(6.1128)	(2.4140)
e_{t-1}^{US}	0.0003	0.0045	0.0043
	(0.0458)	(1.2634)	(3.1585)
e_{t-1}^{US}	0.0022	0.0017	-0.0014
	(0.5148)	(1.0082)	(-0.5097)
e_t^{EUR}	-0.0001	0.0023	0.0035
	(-0.0154)	(0.7793)	(0.6855)
e_{t-1}^{EUR}	0.0029	-0.0010	-0.0044
	(0.9074)	(-0.2848)	(-1.6743)
e_{t-1}^{EUR}	-0.0007	-0.0015	0.0025
	(-0.2482)	(-0.6169)	(0.7247)
ΔC_{t-1}	0.3880	0.2198	0.6356
	(1.2634)	(1.0187)	(2.5694)
R^2	0.6981	0.7228	0.6835

Table A4. Regression Results.
Dependent Variable: ΔY_t

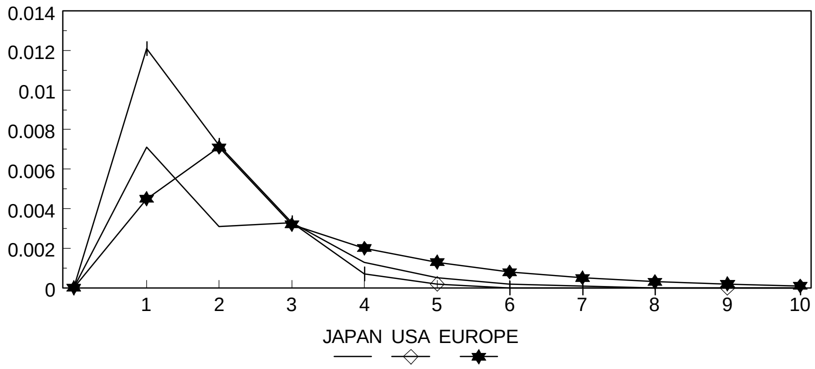
	JAP	US	EUR
Intercept	0.0241	0.0093	0.0123
	(4.3521)	(1.2324)	(0.8175)
e_t^{JAP}	0.0207	-0.0034	0.0038
	(18.6244)	(-1.6763)	(1.6627)
e_{t-1}^{JAP}	0.0057	0.0019	0.0077
	(2.0453)	(1.0843)	(3.3986)
e_{t-1}^{JAP}	-0.0001	0.0021	0.0019
	(-0.0882)	(1.3335)	(0.5793)
e_t^{US}	0.0108	0.0207	0.0071
	(8.1370)	(6.9469)	(3.1975)
e_{t-1}^{US}	0.0060	0.0024	0.0062
	(3.2773)	(0.5186)	(1.1714)
e_{t-1}^{US}	0.0040	-0.0058	0.0005
	(2.2358)	(-1.8898)	(0.0851)
e_t^{EUR}	0.0030	0.0021	0.0074
	(2.5180)	(0.7807)	(2.6012)
e_{t-1}^{EUR}	-0.0025	-0.0024	-0.0048
	(-2.0290)	(-1.1050)	(-1.2047)
e_{t-1}^{EUR}	-0.0019	0.0029	0.0008
	(-2.7259)	(1.2183)	(0.3085)
ΔY_{t-1}	0.5094	0.6919	0.5221
	(5.8745)	(2.9250)	(1.3244)
R^2	0.9830	0.8807	0.8446

Figure A1. Impulse Responses of Consumption Growth

Shock to Japan



Shock to US



Shock to Europe

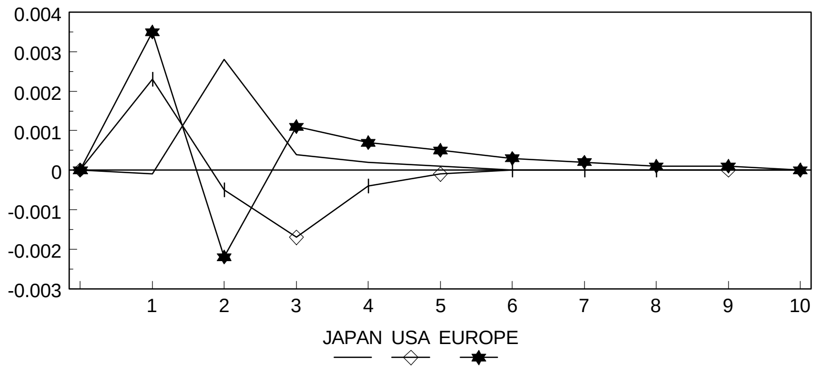
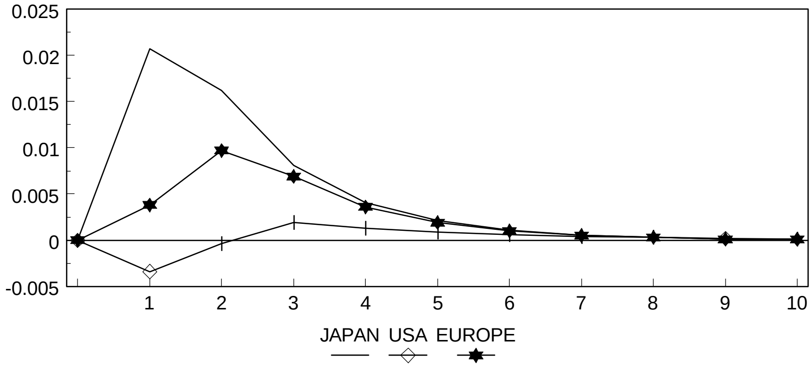
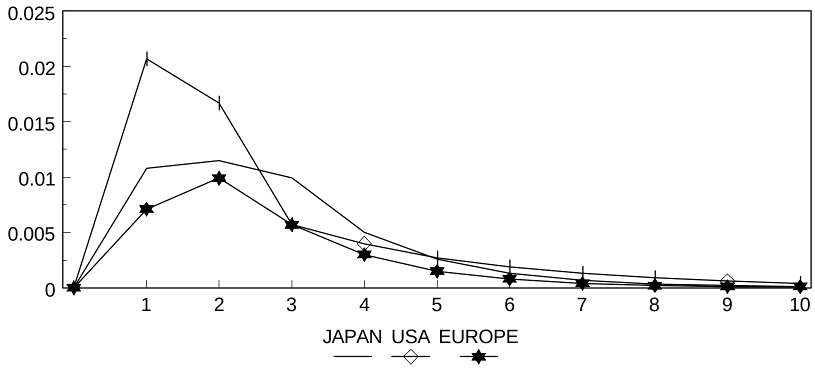


Figure A2. Impulse Responses of Output Growth

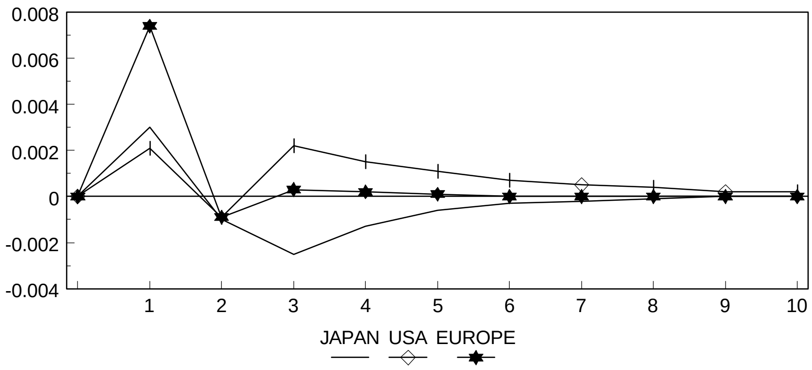
Shock to Japan



Shock to US



Shock to Europe



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