INTERNATIONAL BUSINESS CYCLES AND THE DYNAMICS OF THE CURRENT ACCOUNT

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Abstract This paper analyzes the transmission of 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 the Japanese, German and US economies where productivity shocks propagate through trade. We find that there is a strong asymmetry in the propagation of shocks. Shocks to the US propagate quickly to the other two economies while German and Japanese shocks have little impact in other countries' productivity. When we explore the responses of investment and the current account to each of the shocks we find that productivity increases lead to domestic investment booms and current account deficits. However, we also find that foreign investment tends to react positively to productivity shocks, even when the shock is purely national. This result, that foreign investment does not decrease in response to productivity shocks, 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 behavior that their current account and investment growth rates show in response to domestic productivity changes. We interpret this result as evidence of different degrees of capital mobility among the countries in our sample.

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 consumers' desire to smooth consumption and investment flows to those countries where investment opportunities exist. These two forces shape the dynamics of saving and investment rates and, thus, the behavior of the current account.

Most of the research in this area has focused on two issues: the correlation of investment and saving rates and the characteristics of business cycles in an open economy (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 and the analysis is a 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 from two different approaches. First, from an empirical point of view, alternative evidence showed that the current account is countercyclical and that increases in investment are associated to 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

[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.

of the comovements 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 correlation 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. Thus, 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 characterize the international business cycle by making explicit the origin and transmission of shocks. We propose a model where all shocks are country specific and are spread to other countries. For this purpose, we fit an econometric spatial model using data from Japan, the US and Germany. The model allow us to identify 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 takes place through trade. We use bilateral trade weights to identify structural shocks. We then look at the dynamic responses of productivity, investment and the current account to these shocks.

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 Germany and Japan. On the other hand, German 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 countercyclical in response to shocks that raise 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. In the case of Japan we also obtain the S-shaped pattern of the current account found by Backus, Kehoe and Kydland (1994). We find, however, that the response of foreign investment 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 large differences regarding their magnitudes. These responses are much larger in Germany than in the US or Japan. We interpret this finding as evidence of different degrees of openness and capital mobility in our three-country sample.

Our paper relates to previous work in the general issue of characterizing 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 look at 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 get information on the relative importance of different shocks.

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

2.- Open Economy Business Cycles

There are significant differences between open and closed economies regarding business cycles. These differences originate in the possibility of open economies to run current account surpluses and deficits. Domestic spending can be different to income as countries borrow and lend in international financial markets. This behavior is reflected in the different response 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 that lead to cyclical dynamics in the current account.

The nature of the current account dynamics is not only a function of the degree of international capital mobility but also of the type of shocks that cause economic fluctuations. Only shocks that have a significant country-specific component will have an effect on the current account. Therefore, the distinction between country-specific shocks and global shocks is of great interest to understand the behavior of the current account. Moreover, this distinction is closely related to a second major feature of open-economy business cycles, the possibility of transmission of shocks across countries. In an open economy, taste, technology or policy shocks abroad are additional sources of domestic business cycles. As a result, the dynamic behavior of output, investment or consumption can be quite different from the ones of a closed economy. The transmission of shocks also depends on the degree of openness and the degree of capital mobility.

We have two distinct scenarios where international comovements of investment, consumption and the current account can be quite different. When shocks are either global (shared by all countries), or they are country specific but are 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, consumption 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. The empirical analysis reveals large positive cross-country correlations in investment, output, productivity or consumption. 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 the calibration exercises of Backus, Kehoe and Kydland (1992) or Baxter and Crucini (1993). In both cases, a real business cycle model is calibrated to explain the comovements of the key macroeconomic variables. Productivity shocks are assumed to be correlated between countries and to spread across borders through some sort of technology diffusion process. To be more precise, 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 expressed as:

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

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.[4] The results of the model are very sensitive to different values of these parameters. For example, when $\psi = 0$ (shocks are country specific) the predicted cross-country correlation of output and investment is negative.

Our approach, instead of looking at the resulting comovements and correlations, makes explicit the nature of the shocks and measures the dynamic responses of investment and the current account to these shocks. In this sense, we interpret 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. We propose to identify the origin and transmission of the shocks and to measure their contribution to economic fluctuations in each of the countries.

The specification that we propose is based on two assumptions. First, we assume that shocks originate in one country. 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. 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 and we postulate that the transmission of shocks is proportional to these trade weights.

There are several reasons why trade weights are a good source of information to identify 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 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.- In the presence of technological productivity gains in one country are spread to other countries. These transfers could be the result of trade in technology or the presence of 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 occurs via trade flows.[5]

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[4] 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.

[5] One can also imagine situations in which productivity is correlated across countries which

Using the previous 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. Our approach is very close to Glick and Rogoff (1995). They identify country-specific shocks and global shocks and they trace the response of the current account and investment to both types of shocks. We differ from their work in three aspects. First, we construct country-specific shocks that are orthogonal to each other. Glick and Rogoff (1995) construct a measure of world productivity which they used as a measure of global shocks. Country-specific shocks are defined as the differences between domestic and world productivity. Therefore, changes in productivity in any of the countries of their sample have an impact on their measure of global productivity shocks. This could be important as some of the countries (e.g. the US) are large relative to the aggregate. 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 look at the response of both domestic and foreign variables. This allow us to test the predictions of open-economy models regarding cross-country correlations of these variables in response to different shocks.

There is a second important identification problem that we leave aside in our analysis: the persistence of shocks and whether they are productivity shocks or aggregate demand shocks. Backus, Kehoe and Kydland (1994) show that the response of the current account to shocks to government purchases and productivity are very different. Also, depending on how persistent productivity shocks are, the response of investment and the current account could be very different. The incentives to invest in a country that receives a positive productivity shock are an increasing function of the persistence of the shock. In our analysis, we only consider one shock, productivity. The work of Ahmed, Ickes, Wang and Yoo (1993) deals with some aspects of this identification issue. However, they only analyze the determinants of international business cycle without testing specific predictions of the intertemporal approach to the current account.

3.- Method to Decompose Shocks

The method employed here is to use the structural VAR method (see Watson (1994) for a survey) to decompose shocks into estimated structural shocks

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 trade that they do. In fact, if trade is caused by comparative advantage and countries fully specialize in some 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.

where 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 for the set of n countries $y(t)$, are driven by structural shocks $e(t)$, 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 as

$$y(t) = D(L)e(t)$$

where L is the lag operator and $D(L)$ are coefficients left unrestricted at this point. This model is in its structural form, so that rather than having $e(t)$ correlated we will write $D(0)$ to take into account the cross correlated nature of the shocks (this accords with the usual form of the structural model).

The individual shocks, $e(t)$, thus represent the decomposed country specific shocks to productivity. Of course, the model is not identified - an estimated VAR using the productivity data estimates

$$y(t) = C(L)u(t)$$

where $C(L)u(t) = D(L)R^{-1}Re(t)$ and $C(0) = I$. It is well known that there exist an infinity of models (specifications of R) such that this holds. To identify 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 $u(t) = Re(t)$, 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

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

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 $(2nx1)$ parameter vector, then this requires that the matrix of derivatives

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

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 by 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 nonstructural 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 characterizs 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 Germany, 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.

4.- Decomposition Results

We estimate a VAR with annual data from 3 countries: Japan, United States, and Germany. We describe the data in an appendix and Tables A1 to A3 show the autocorrelations and cross-country correlations of all series. We find that productivity is, in all cases, very persistent and that the cross-country contemporaneous correlations are high.[6]

We run the reduced form VAR using productivity in growth rates.[7] The VAR can be expressed as

$$\Delta y_t = A(L)\Delta y_{t-1} + u_t$$

where Δy_t is a vector that includes productivity growth for the three countries considered. The estimates of the reduced form are shown in Table 1. We use one lag for each variable.

[6] As expected, the correlations are lower when we use first differences. For the linearly-detrended series, the country with the highest average correlation is France (0.874) and the others follow the order: Japan (0.869), Italy (0.865), Canada (0.827), Germany (0.824), United Kingdom (0.77) and the US (0.622). Using first differences the ordering is basically the same (only the UK and the US interchange positions) but all correlations are lower ranging from 0.551 in the case of France to 0.307 in the case of United Kingdom.

[7] We have also run the VAR using productivity in levels. The results of the decomposition are practically identical.

Table 1. Estimation Results.

	Δy_t^{JAP}	Δy_t^{US}	Δy_t^{GER}
Intercept	0.012	0.007	0.014
	(1.557)	(1.478)	(2.713)
Δy_{t-1}^{JAP}	0.669	0.059	0.248
	(4.207)	(0.593)	(2.352)
Δy_{t-1}^{US}	0.392	0.347	0.174
	(1.245)	(1.762)	(0.833)
Δy_{t-1}^{GER}	-0.152	-0.115	0.017
	(-0.469)	(-0.571)	(0.079)

Sample: 1960-94
t-statistics in parentheses

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

$$\begin{pmatrix} 1.000 & 0.253 & 0.264 \\ 0.253 & 1.000 & 0.312 \\ 0.264 & 0.312 & 1.000 \end{pmatrix}$$

Where the order of countries is: Japan, United States and Germany. The cross-country correlations are in the range 0.25-0.32. 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.

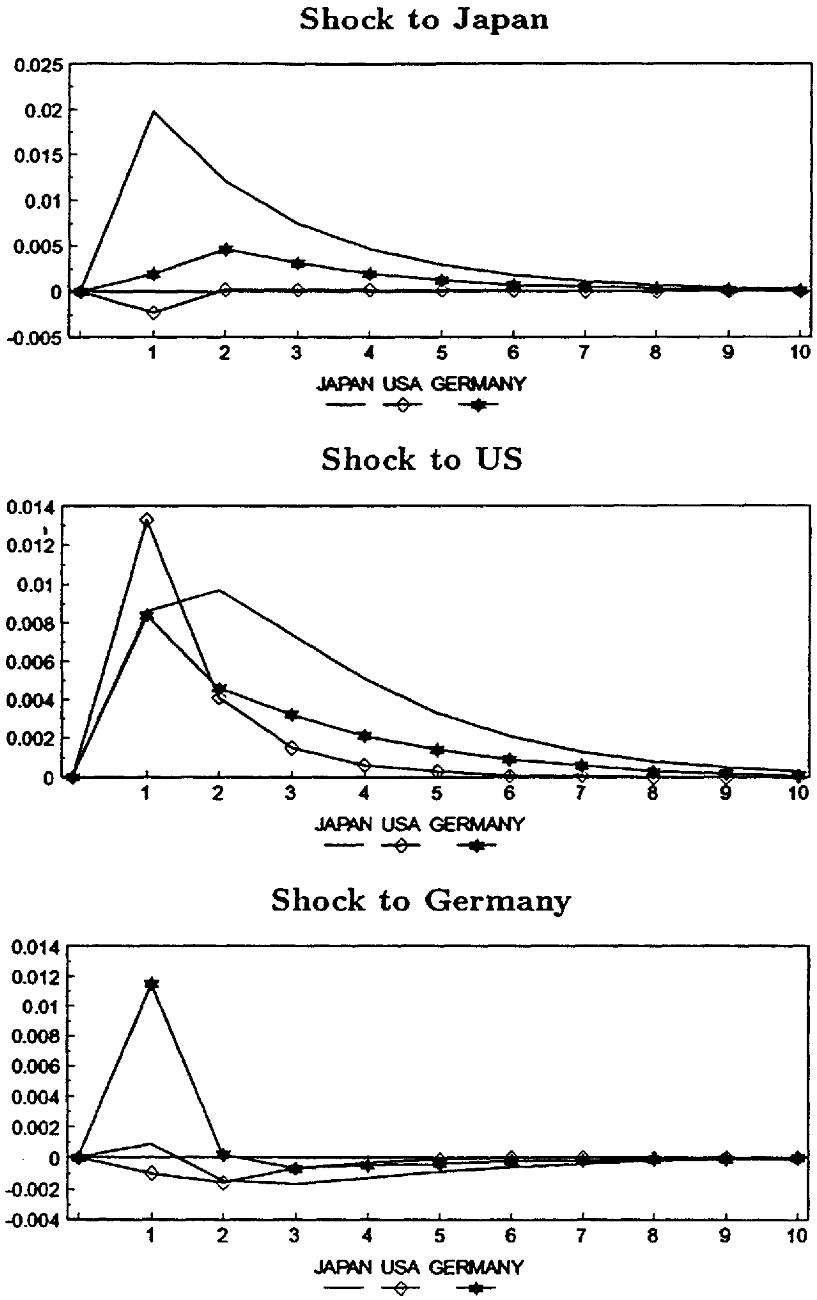
We use bilateral trade weights (see the appendix for a description of the data) to estimate the coefficients of the matrix R following the identification assumptions described in Section 3.[8] Once the coefficients of R are estimated we are able to recover the structural shocks. Figures 1 to 3 show the impulse response functions for each of the three structural shocks. They are drawn for the growth rate of productivity.

The response of domestic productivity 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 substantial differences between the three shocks regarding the effects on other countries' productivity. In the case of Japan and Germany, the shock has a significant effect in domestic productivity but virtually no effect on the productivity of the other two countries.[9] In contrast, US shocks are quickly spread to Germany and Japan and the long-run effect of the shock is approx-

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

[9] In the case of Japan there is some propagation of the shock to Germany but this is still small relative to the effects of the shock on Japan.

Figure 1. Impulse Responses of Productivity Growth



imately the same in the three countries. Therefore, the nature of the shocks is considerably different depending on the country; German and Japanese shocks are mostly country-specific while US shocks are almost equivalent to global shocks. In other words, most of the reduced-form correlation is coming from the propagation of the structural US shock.

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

Table 2. Variance Decomposition.

	Japan			US			Germany		
Years	JAPAN	US	GER	JAPAN	US	GER	JAPAN	US	GER
1	84.0	15.9	0.1	2.8	96.7	0.5	1.8	34.4	63.9
2	75.9	23.7	0.4	2.5	95.7	1.8	9.8	37.0	53.1
4	70.6	28.5	0.9	2.5	95.5	2.0	13.7	38.6	47.8
6	69.7	29.3	1.0	2.5	95.5	2.0	14.1	38.9	47.0
8	69.5	29.5	1.0	2.5	95.5	2.0	14.2	38.9	46.9
10	69.5	29.5	1.0	2.5	95.5	2.0	14.2	38.9	46.9

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

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 Germany is very different as its own shock only accounts for about 50% 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.[10]

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.[11] We want to exploit the differences in the nature of US and German and Japanese shocks to test some of the theoretical implications of open-economy models. As outlined in Section 2,

[10] 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.

[11] 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 some of the theoretical predictions of open-economy models. The appendix includes the results and dynamic responses of output and consumption.

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 Germany and Japan, should produce positive correlations in investment across countries and little current account dynamics. On the other hand, German and Japanese shocks, which are country specific in nature, should lead to increases in domestic investment accompanied by decreases in foreign investment and large current account changes.

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.[12] Tables A4 and A5 in the appendix, show the results and Figures 2 and 3 the implied dynamic responses. We next summarize our findings with respect to each of the three shocks.

5.1.- Japan productivity shock.

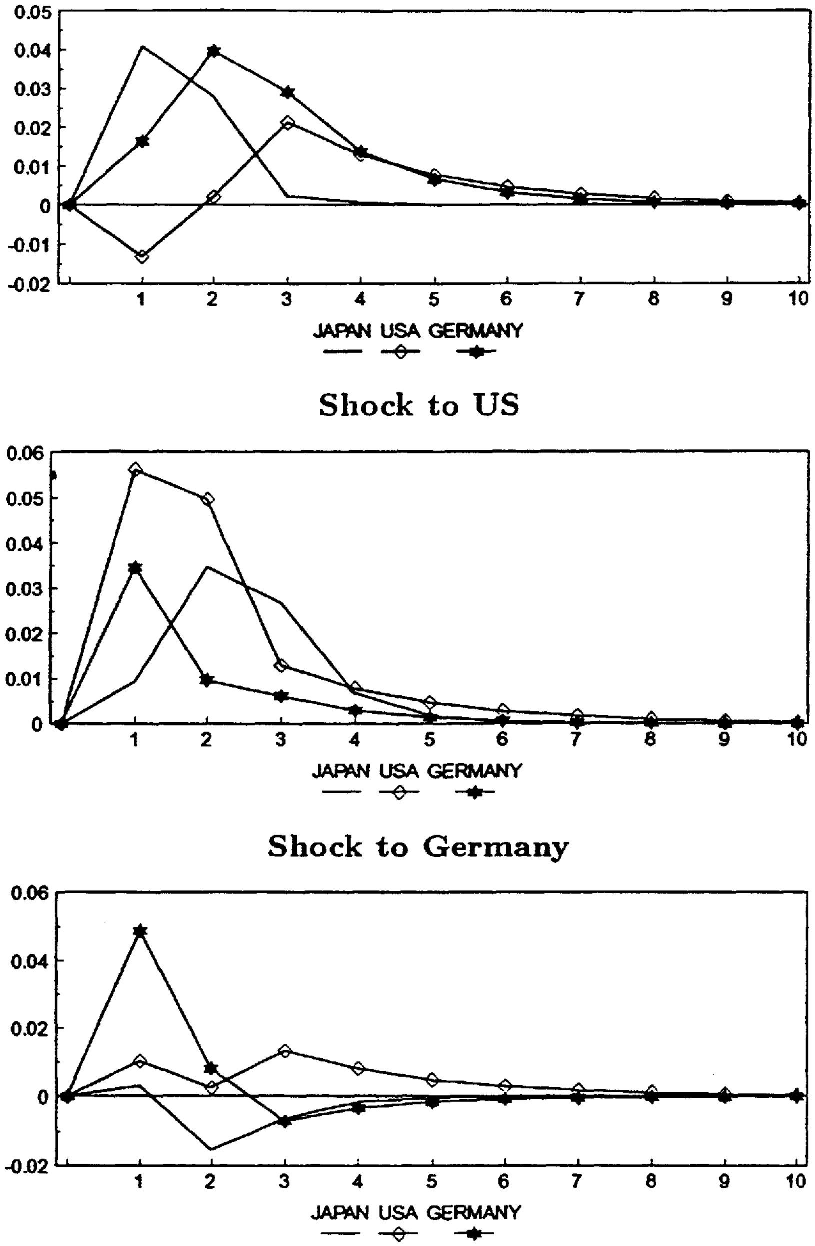
There is an immediate positive response of investment in both Japan and Germany. In the US, the response, although initially negative, turns positive after two periods. The response of investment in Germany is somehow puzzling. Given the small transmission of the shock in terms of productivity (shown in Figure 2), we did not expect a large positive response of investment in Germany (same was true for the US). In fact, a shock that is largely national in nature, as the Japanese shock is, should generate negative correlations of investment across countries. The calibrations of Backus, Kehoe and Kydland (1992) and Baxter and Crucini (1993) show that in the presence of country-specific shocks, while domestic investment should increase, foreign investment should decrease.[13] This theoretical prediction is satisfied for the US but not in the case of Germany, where we obtain a positive correlation.

The response of the Japanese current account is 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. Also, the current account is S shaped which confirms the evidence 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

[12] 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.

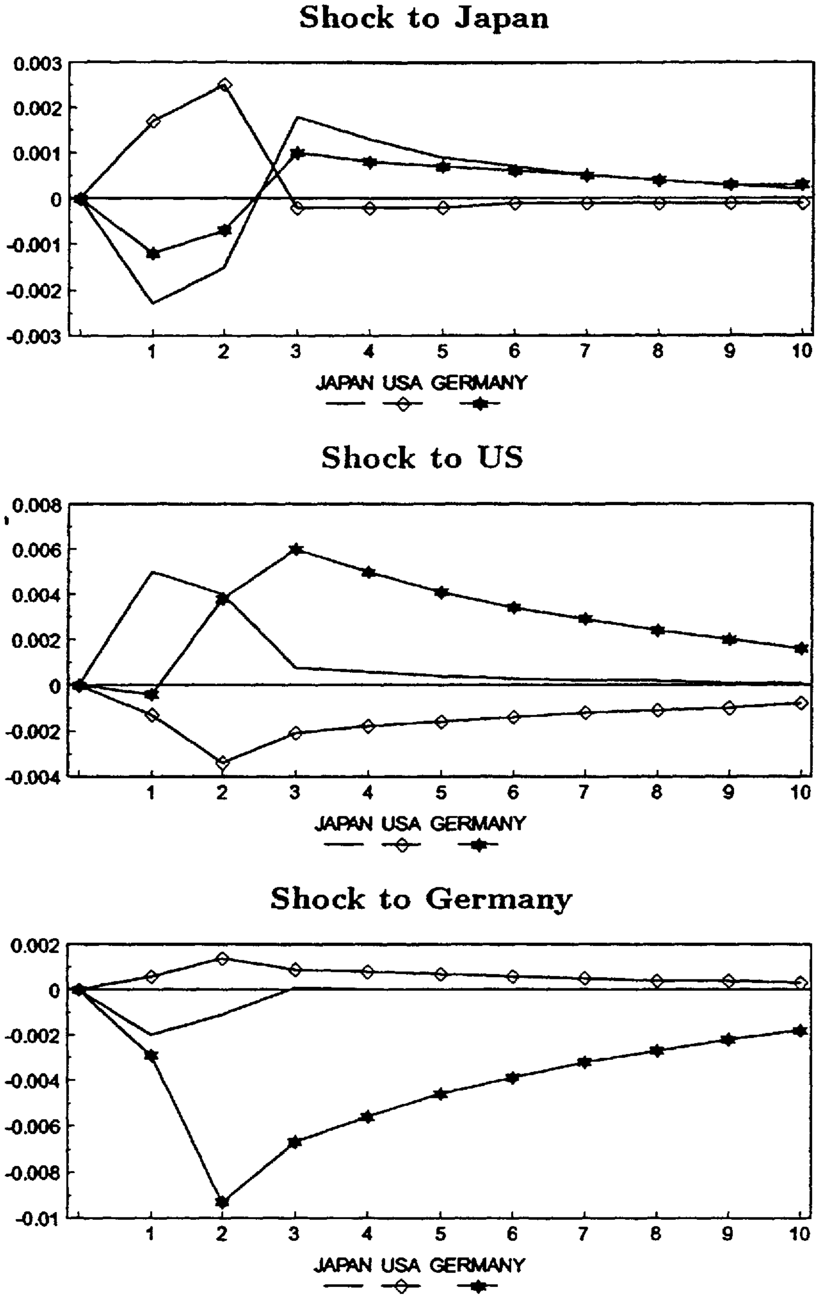
[13] Their calibrations have to rely on positive cross-country correlations and diffusion of shocks to generate the positive unconditional correlation of investment across countries.

Figure 2. Impulse Responses of Investment Growth
Shock to Japan



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 improves the current account. The response of the German current account takes us back to the investment puzzle. Despite the relatively low propagation of the shock from Japan to Germany, there is a surge in German investment that leads to a worsening of the current account. As we previously pointed out, this behavior does not match the theoretical predictions of an open-economy model as we expect coun-

Figure 3. Impulse Responses of Current Account to GDP Ratio



tries like Germany to experience initial current account surpluses as investment flows to Japan, where productivity is now higher. One possible explanation to this result is that the propagation of the shock to German productivity, although being relatively small, attracts investment from other countries not included in our sample, where the shock is not propagated at all. This explanation could only be consistent if there are differences in the degree of capital mobility among countries. For example, it may be that capital mobility between Japan and Germany is smaller than between Germany and countries not included in our sample (e.g. other European countries). This would explain why Germany runs a current account surplus despite the minor increase in productivity relative to Japan. We will come back to this point later.

5.2.- US productivity shock.

There is a strong positive response of investment in the US, Japan and Germany. 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 Germany. It is noticeable that both productivity and investment in Japan respond with a lag.

The US current account shows a negative response while the Japanese and German current accounts increase in response to a US productivity shock. As it 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 Germany and Japan. However, we need to remark that the improvement in the German and Japanese current account is not the consequence of a fall in investment but 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.

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 Germany or Japan which leads to a temporary worsening of the US current account.

5.3.- German productivity shock.

As in the case of Japanese shocks, German shocks do not significantly spread to other countries in terms of productivity. The response of investment in Germany is, as expected, positive. Investment in Japan and the US are practically unaffected by the German shock. It is again surprising that, in response to an increase in German productivity, we do not observe any decrease in investment in Japan and the US. This lack of investment dynamics indicates that, in response to positive productivity shocks, there are not significant capital flows from Japan and the US to Germany.

The previous result is confirmed when we look at the the current account response. Although the large domestic investment boom produces a broad worsening of the German current account, the US and Japanese current account do not respond. Moreover, it is important to notice that the size of the change of the German current account is very large relative to the two previous cases. The reason is that the increase in domestic investment relative to the increase in output is much larger than in the US or Japanese shocks. The ratio of the initial change in domestic investment to the change in domestic output is four in the case of a German shock, while in the US and Japan cases this ratio is only two.[14] This is not surprising when we compare the German and the US shock because the former is country-specific in nature while the later plays the role of a global shock. However, when we compare the case of Japan and Germany, the change in the current account (and investment) in the case of a Japanese shock is too small. Both the Japanese and the German shocks are nation-specific shocks, but the resulting current account (and investment) dynamics are much larger in the case of Germany. This could be a sign of differences in the degree of capital mobility (and openness) in Germany and Japan and it would confirm the presumption that in more open economies, or economies with a larger degree of capital mobility, investment and the current account are more volatile.

The lack of reaction of the US and Japanese current account in response to a shock to German productivity is to, a certain extent, surprising. Of course, this is only possible because the three countries that we use do not represent 100% of world output. There are other countries (possibly European) that are absorbing the changes in the German current account. In a world of perfect capital mobility, it will be difficult to explain the absence of capital flows from Japan and the US in response to an increase in German productivity. It is nevertheless hard to contrast this evidence with models of the international business cycle as most models are two-country models that make no prediction about what would happen if investment flows can originate in more than one country.

6.- Conclusions

This paper analyzes the transmission of 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 the Japanese, German and US economies where productivity shocks propagate through trade. We find that there is a strong asymmetry in the propagation of shocks. Shocks to the US propagate quickly to the other two economies and lead to permanent effects which are similar in size in the three countries. On the other hand, German and Japanese shocks have little impact in other countries' productivity. Accordingly, we find that US shocks tend to be global shocks while German and Japanese shocks are mainly national in nature.

[14] The response of output is shown in Figure A2 in the appendix.

When we explore the responses of investment and the current account to each of the shocks we find that productivity increases 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. However, we also find that foreign investment tends to react positively to productivity shocks. This is true even if the shock is purely national (as in the German and Japanese cases). Therefore, although we generally see an improvement in other countries' current account in response to a positive productivity shock, the improvement seems to be the result of a larger increase in saving relative to the increase in investment. This result, that foreign investment does not necessarily decrease in response to productivity shocks, contradicts the predictions of Backus, Kehoe and Kydland (1992) and Baxter and Crucini (1993). They predict that, 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 behavior that their current account and investment growth rates show in response to domestic productivity changes. The largest response is in Germany, followed by the US and Japan. Although the difference between the US and Germany could be explained by the fact that the US shock is almost a global shock, the difference of both of them with respect to Japan is difficult to explain. Shocks to Japan are largely national in nature and they should lead to larger investment booms and larger swings in the current account.

Asymmetries in responses are also present when we look at pairs of countries. In the case of US and Japanese shocks, the current account of Japan and the US behave as expected. A positive productivity shock worsens the domestic current account and improves the foreign current account. This is not the case when we look at the behavior of the German current account which worsens in response to a favorable productivity shock in Japan. This worsening of the German current account could only occur if the degree of capital mobility between Germany (and other European countries) and Japan is relatively low. In this case, investment, instead of flowing only to Japan where the improvement in productivity is significantly larger, flows also to Germany. We obtain similar conclusions when we look at the response to a German shock. The German current account worsens but this is not reflected in an improvement in the Japanese or US current accounts. Again, countries outside our sample must be financing the German investment boom which may be a reflection of the different degrees of capital mobility among countries.

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. Tables A1 to A3 present the basic univariate properties of each series.

Table A1. Autocorrelations of linearly detrended productivity

Country	Lag 1	Lag 2	Lag 3	Lag 4
Canada	0.82	0.57	0.38	0.21
France	0.85	0.70	0.57	0.43
Germany	0.84	0.68	0.52	0.35
Italy	0.85	0.69	0.55	0.44
Japan	0.86	0.72	0.58	0.43
UK	0.79	0.52	0.34	0.22
US	0.78	0.55	0.35	0.17

Table A2. Cross-country correlations. Linearly detrended productivity.

	Canada	France	Germany	Italy	Japan	Uk	US
Canada	1	0.88	0.90	0.85	0.86	0.83	0.63
France	0.88	1	0.93	0.98	0.98	0.79	0.66
Germany	0.90	0.93	1	0.90	0.91	0.78	0.49
Italy	0.85	0.98	0.90	1	0.97	0.79	0.68
Japan	0.86	0.98	0.91	0.97	1	0.82	0.65
UK	0.83	0.79	0.78	0.79	0.82	1	0.59
US	0.63	0.66	0.49	0.68	0.65	0.59	1

Table A3. Cross-country correlations. First differences.

	Canada	France	Germany	Italy	Japan	Uk	US
Canada	1	0.49	0.51	0.34	0.32	0.43	0.66
France	0.49	1	0.57	0.75	0.80	0.24	0.43
Germany	0.51	0.57	1	0.44	0.40	0.25	0.36
Italy	0.34	0.75	0.44	1	0.63	0.29	0.33
Japan	0.32	0.80	0.40	0.63	1	0.26	0.36
UK	0.43	0.24	0.25	0.29	0.26	1	0.36
US	0.66	0.43	0.36	0.33	0.36	0.36	1

Trade Weight Matrix.

The weights on the following matrix are computed using bilateral data on exports plus imports for the three countries. All values are for 1980 (which approximately corresponds with the middle of our sample). The order in the matrix is Japan, US and Germany. We have rescaled the weights so that they add up to one.

$$\begin{pmatrix} 0.000 & 0.904 & 0.096 \\ 0.604 & 0.000 & 0.396 \\ 0.185 & 0.815 & 0.000 \end{pmatrix}$$

Investment, Current Account, Consumption and Output.

The source for Investment, the Current Account, 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.

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): $r_{11} = 0.020$, $r_{22} = 0.013$, $r_{33} = 0.011$, $r_1 = 0.010$, $r_2 = -0.003$, $r_3 = 0.010$.

Results from the second step regressions

Tables A4 to A7 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^{GER}). They also include a lag of the dependent variable. t-statistics in parentheses.

Table A4. Regression Results.
Dependent Variable: ΔI_t

	JAP	US	GER
Intercept	0.0354	0.0120	0.0031
	(3.3874)	(1.4770)	(0.2508)
e_t^{JAP}	0.0409	-0.0131	0.0165
	(7.8435)	(-2.9492)	(1.6967)
e_{t-1}^{JAP}	0.0176	0.0100	0.0317
	(1.0340)	(1.5790)	(2.3699)
e_{t-1}^{JAP}	-0.0047	0.0201	0.0102
	(-0.4243)	(3.0806)	(0.6233)
e_t^{US}	0.0093	0.0562	0.0346
	(1.5449)	(7.2763)	(2.0925)
e_{t-1}^{US}	0.0323	0.0156	-0.0069
	(2.5779)	(2.7710)	(-0.5918)
e_{t-1}^{US}	0.0180	-0.0171	0.0015
	(1.4099)	(-3.3127)	(0.1206)
e_t^{GER}	0.0031	0.0102	0.0489
	(0.4853)	(1.9453)	(3.8404)
e_{t-1}^{GER}	-0.0162	-0.0036	-0.0153
	(-2.2261)	(-0.4133)	(-1.1611)
e_{t-1}^{GER}	-0.0025	0.0116	-0.0109
	(-0.2967)	(2.0209)	(-0.8143)
ΔI_{t-1}	0.2504	0.6044	0.4770
	(1.0794)	(4.4203)	(3.4953)
R^2	0.8043	0.7579	0.6616

Table A5. Regression Results.
Dependent Variable: CA_t/GDP_t

	JAP	US	GER
Intercept	0.0048	-0.0016	0.0017
	(3.3641)	(-1.2364)	(0.6147)
e_t^{JAP}	-0.0023	0.0017	-0.0012
	(-1.4290)	(2.3524)	(-0.8524)
e_{t-1}^{JAP}	0.0002	0.0010	0.0003
	(0.1458)	(1.2696)	(0.1369)
e_{t-1}^{JAP}	0.0028	-0.0024	0.0016
	(2.1474)	(-2.4217)	(0.7776)
e_t^{US}	0.0050	-0.0013	-0.0004
	(3.5624)	(-1.4839)	(-0.1953)
e_{t-1}^{US}	0.0003	-0.0023	0.0041
	(0.2117)	(-2.8135)	(2.5607)
e_{t-1}^{US}	-0.0021	0.0009	0.0028
	(-1.2651)	(1.3219)	(2.0415)
e_t^{GER}	-0.0020	0.0006	-0.0029
	(-1.2149)	(0.7413)	(-1.3223)
e_{t-1}^{GER}	0.0004	0.0008	-0.0069
	(0.3508)	(0.9110)	(-3.0135)
e_{t-1}^{GER}	0.0008	-0.0003	0.0010
	(0.8226)	(-0.2869)	(0.6882)
CA_{t-1}/GDP_{t-1}	0.7298	0.8770	0.8314
	(6.0613)	(6.4080)	(6.3816)
R^2	0.7354	0.8415	0.7045

Table A6. Regression Results.
Dependent Variable: ΔC_t

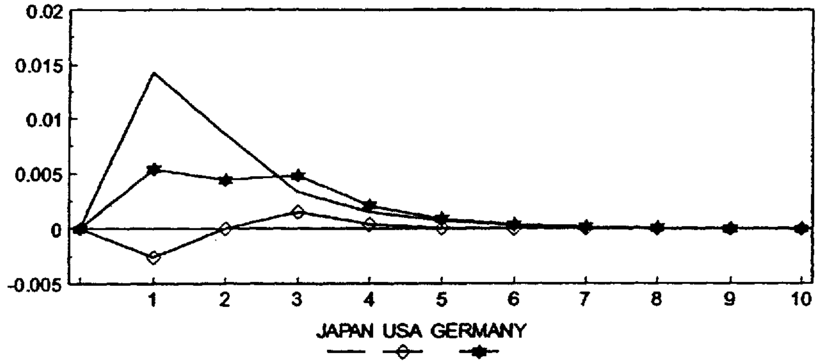
	JAP	US	GER
Intercept	0.0268	0.0233	0.0143
	(2.2921)	(5.3255)	(4.4646)
e_t^{JAP}	0.0143	-0.0026	0.0054
	(4.8420)	(-2.2813)	(2.8249)
e_{t-1}^{JAP}	0.0022	0.0007	0.0021
	(0.9232)	(0.3871)	(1.1069)
e_{t-1}^{JAP}	-0.0006	0.0015	0.0029
	(-0.1426)	(0.7432)	(1.9165)
e_t^{US}	0.0068	0.0120	0.0075
	(1.6088)	(7.4015)	(4.8860)
e_{t-1}^{US}	-0.0007	0.0043	0.0005
	(-0.1298)	(1.8132)	(0.2757)
e_{t-1}^{US}	0.0013	0.0027	-0.0016
	(0.3164)	(1.9313)	(-0.8691)
e_t^{GER}	-0.0012	0.0033	0.0054
	(-0.2255)	(1.5154)	(3.5203)
e_{t-1}^{GER}	0.0027	-0.0031	0.0035
	(0.7867)	(-1.3926)	(1.6421)
e_{t-1}^{GER}	-0.0032	-0.0003	-0.0042
	(-1.0442)	(-0.1427)	(-2.0010)
ΔC_{t-1}	0.4514	0.2559	0.4261
	(2.0832)	(1.8883)	(4.4636)
R^2	0.7093	0.7154	0.6986

Table A7. Regression Results.
Dependent Variable: ΔY_t

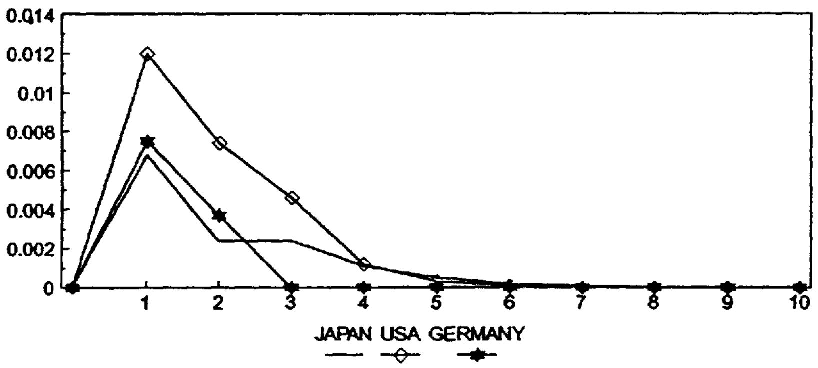
	JAP	US	GER
Intercept	0.0230	0.0090	0.0209
	(4.3014)	(1.6618)	(3.3627)
e_t^{JAP}	0.0206	-0.0041	0.0052
	(11.1086)	(-2.0598)	(1.9066)
e_{t-1}^{JAP}	0.0048	0.0019	0.0075
	(1.5092)	(0.9110)	(2.4478)
e_{t-1}^{JAP}	-0.0011	0.0038	0.0036
	(-0.8551)	(1.9337)	(0.7195)
e_t^{US}	0.0117	0.0208	0.0082
	(11.7630)	(6.5776)	(2.0012)
e_{t-1}^{US}	0.0061	0.0024	0.0040
	(3.0237)	(0.7701)	(1.2617)
e_{t-1}^{US}	0.0036	-0.0046	0.0006
	(3.0828)	(-2.1304)	(0.2988)
e_t^{GER}	0.0000	0.0024	0.0126
	(0.0262)	(1.3359)	(3.5514)
e_{t-1}^{GER}	-0.0022	-0.0041	-0.0009
	(-2.9285)	(-2.0928)	(-0.2296)
e_{t-1}^{GER}	-0.0024	0.0030	-0.0018
	(-1.7794)	(1.3933)	(-0.6095)
ΔY_{t-1}	0.5288	0.6909	0.2902
	6.1108)	(4.2708)	(2.7969)
R^2	0.9825	0.8693	0.4668

Figure A1. Impulse Responses of Consumption Growth

Shock to Japan



Shock to US



Shock to Germany

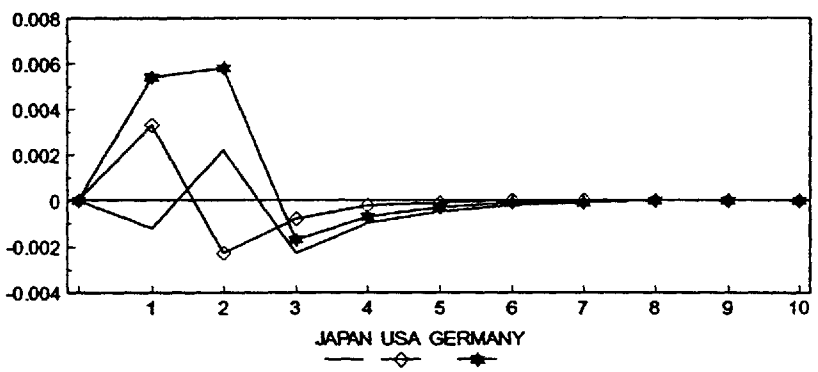
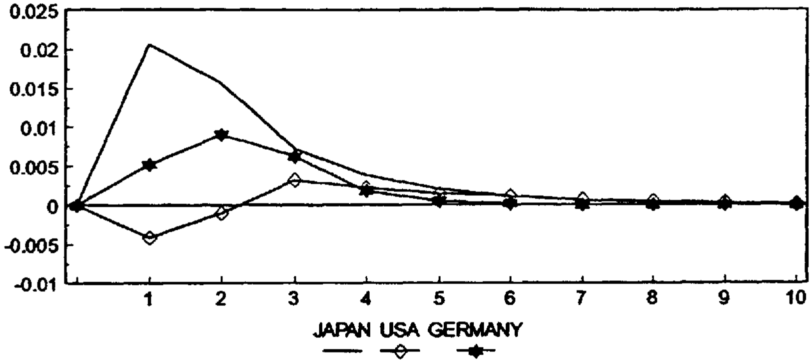


Figure A2. Impulse Responses of Output Growth

Shock to Japan



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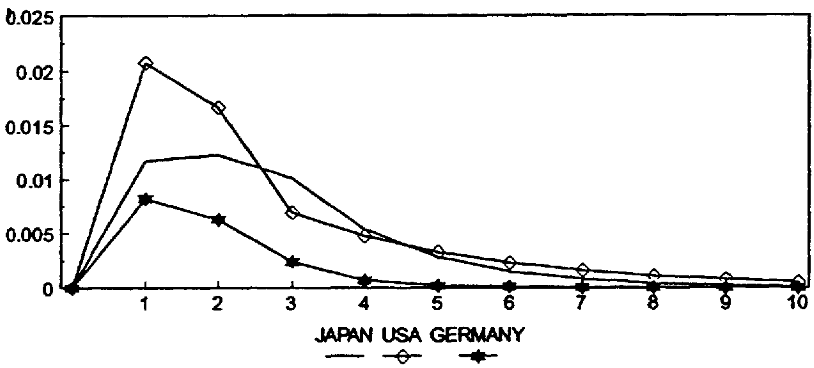
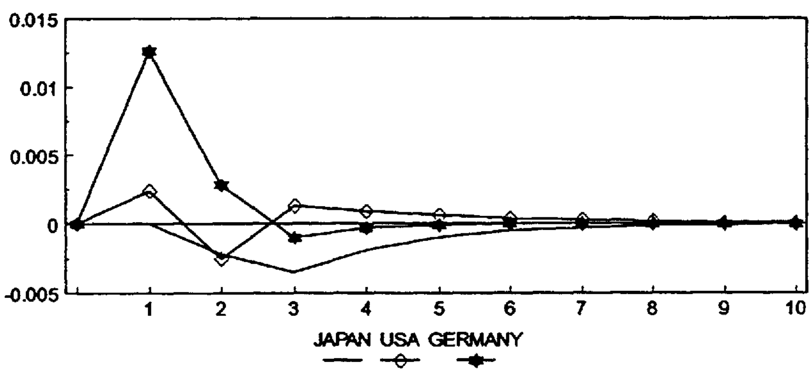


Shock to Germany



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