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IMF WORKING PAPER

WP/92/96

INTERNATIONAL MONETARY FUND

European I Department

Asymmetry in the ERM: A Case Study of French and German Interest Rates Since Basle-Nyborg

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November 1992

Abstract

We study empirically daily French and German interest rate changes since the Basle-Nyborg agreement of September 1987. In particular, we ask whether the shock associated with German unification altered the degree of leadership of German monetary policy in the ERM. We conclude that Germany's leadership role within the ERM largely disappeared in the year following unification but that the Bundesbank has recently begun to reassert its predominance.

JEL Classification Number:

E43, E52, E58, F31

1/ We thank Leonardo Bartolini for helpful comments. The views expressed in this paper are those of the authors and do not necessarily reflect those of the International Monetary Fund. Part of the work for this project was done while Mr. Perraudin was a visiting scholar in the European I Department of the Fund.

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Summary

This paper analyzes empirically how Germany's leadership role has evolved in the exchange rate mechanism (ERM) of the European Monetary System since the Basle-Nyborg Agreement of September 1987 by examining the joint behavior of French and German short-term interest rates. The Basle-Nyborg Agreement was chosen as the starting point because it represents a significant change in the rules regulating intervention in the ERM. This study, unlike others, uses daily sampling to detect the presence of regime shifts--in particular, structural breaks around the time of German unification--over this shorter period.

There is wide disagreement in the literature over the merits of using onshore versus offshore interest rates for empirical testing. On the one hand, offshore rates have the advantage of not being contaminated by domestic developments related to reserve requirements and other institutional factors. On the other hand, onshore rates are more likely to be influenced by the monetary policy actions of the authorities concerned in the presence of capital controls. In light of these problems, this study uses both rates.

In the estimated models, a vector of daily changes in French, German, and U.S. short-term interest rates is regressed on cross-country contemporaneous interest changes, on five own lags of the interest change vector, and on five lags of changes in benchmark long-term interest rates for each country. To identify the model, it is assumed that (1) French and German interest rates are not directly affected by each other's long-term interest rates; (2) U.S. interest rates are not affected by changes in French and German rates; and (3) the covariance matrix of innovations to the system are orthogonal instantaneously. The Generalized Method of Moments is used to estimate the model.

The results for the whole sample (October 1987-August 1992) reject German dominance--unidirectional causality--thereby confirming the general findings of other authors. The effect of France on Germany is significant, albeit smaller than the German effect on France. However, the results strongly suggest the presence of a structural break coinciding with news of German unification, that is, at the end of 1989. Before unification, the system clearly works asymmetrically, with German monetary policy actions having a stronger effect on France than vice versa, although, to a significant degree, only for offshore rates. In the first year of German unification, France assumes the leadership role, particularly for onshore rates. However, Germany appears to regain its leadership role in 1991-92.

I. Introduction

This paper analyzes the leader-follower relationships between different countries' interest rates within the ERM. Our study is particularly timely given the recent European currency crisis that has seen sterling and the lira suspended as full members of the ERM. Some have suggested that the crisis is the product of German insensitivity to economic developments in, and the policy requirements of, other ERM members. Others have argued that the ERM is predicated upon German monetary leadership and that it is unrealistic to expect credibility gains from adherence to a target zone system unless the leader country is allowed to adopt anti-inflationary policies appropriate to its own domestic situation. By examining high frequency interest rate data, we aim to shed light on what has actually happened over the last five years, focussing especially on the way in which Germany's role was affected by reactions to German unification. Our main conclusion is that, in the year following unification, Germany largely lost its leadership role within the ERM. Since then, however, Germany has increasingly reasserted its predominance.

Various authors have characterized the ERM as a currency block dominated by German monetary policy. Giavazzi and Giovannini (1987, 1988) argued that the ERM evolved from the cooperative system originally intended into one centered on the deutsche mark (DM) because of the desire of countries with poor inflation records to profit from the credibility of German monetary policy. An alternative explanation for the perceived asymmetry in the functioning of the ERM was proposed by Wyplosz (1989a), who explains the leadership role of Germany in terms of an inherent bias rather than the outcome of self-imposed constraints by ERM member countries. In his model, any fixed exchange rate regime produces this sort of bias, essentially because the country with the more restrictive monetary stance, i.e., the country accumulating reserves, has a greater capacity for sterilized intervention than the country losing reserves. Russo and Tullio (1988), and Ungerer et al., (1990) make similar arguments, suggesting that the rules of the ERM confer a central role on German policy since reserve losses caused by interventions within the band have generally obliged the weaker currency country to adjust more than the strong currency country.

The view that German monetary policy dominates the ERM has found surprisingly little support in the empirical literature, however. Most empirical studies suggest that Germany is an important player in the ERM, but that German monetary policy is also affected by innovations in other ERM member countries. For example, Cohen and Wyplosz (1989) and De Grauwe (1989) tested the hypothesis of German leadership through simple Granger causality tests applied to changes in national interest rates and monetary aggregates in ERM countries.

Both studies concluded that the asymmetry in the ERM was much weaker than generally thought, although De Grauwe also found strong evidence of German leadership in off-shore markets, based on the response of Euromarket interest rates to changes in the forward premium vis-a-vis Germany. However, as Weber (1990) and De Grauwe (1989) pointed out, Granger causality tests are of limited significance when policy response is rapid, since they fail to capture contemporaneous "causality" effects. Moreover, Weber noted that causality tests applied to monetary aggregates are likely to be distorted by the effect of sterilization of foreign exchange interventions: any EMS country that intervenes using deutsche marks to support its own currency might appear to "cause" changes in German monetary aggregates simply because of the time it takes for Germany to sterilize.

An alternative way to analyze the joint behavior of innovations in interest rates and monetary aggregates in the ERM, that does not suffer from the problems with Granger causality tests mentioned above, consists of estimating systems of equations in which contemporaneous linkages between interest rates are identified on the basis of an underlying structural model, more or less explicitly derived from a central bank reaction function. Fratianni and von Hagen (1990) and von Hagen and Fratianni (1990) adopt this approach using money supply and interest rate innovations, respectively. Their results generally confirm the conclusions of the other studies: changes in German policy have a strong impact on other ERM members, but Germany itself is not immune to innovations in other countries. In particular, interest rate changes in the Netherlands, France and Italy appear to have a strong effect on German rates, over different periods from 1979 to 1988. However, the study based on changes in base money, found that the effect of innovations in other ERM countries on Germany is only temporary.

Artus et al., (1991) estimated a more general model of interest rate determination for France and Germany, which allows for term-structure and exchange rate effects. They found strong evidence of asymmetry, with German short-term interest rates reacting mostly to the United States interest rates and the DM/US$ exchange rate, and France reacting to German interest rates, the Franc/DM exchange rate and the current account. Long-term interest rates were found to be weakly related to short-term rates but strongly related to foreign long-term rates.

On balance, it appears that the hypothesis of German leadership in the ERM, interpreted in a strict sense, is rejected by the above studies. To be sure, the ERM works asymmetrically, but innovations in other ERM countries affect German interest rates and monetary aggregates. However, as pointed out by Wyplosz (1989b), these results are not sufficient evidence to reject the hypothesis of German leadership. After all, even for a leader it is optimal to set policy on the basis of the actions of the other players. The alternative and less restrictive hypothesis of German independence may be a more appropriate and, according to the evidence discussed above, an empirically more accurate representation of the ERM.

Finally, two other approaches to analyzing asymmetry in the ERM deserve mention. First, in an interesting study, Mastropasqua et al., (1988) use information on foreign exchange interventions and sterilization to develop an alternative test of monetary independence. Under the hypothesis of monetary independence, changes in the net foreign asset position of a member country related to foreign exchange intervention using its currency should be fully sterilized. For the period 1979 to 1987, they found sterilization to be incomplete in the four ERM countries considered, except Germany, for which the hypothesis of full sterilization after three months could not be rejected. They also observed that, while Germany was responsible for nearly all net sales of dollars over the period 1979-87, it took almost no part in interventions in EMS currencies. This provides some evidence in support of German independence, since Germany appears to hold responsibility for the position of the ERM block relative to other currencies, but does not concern itself with the relative position of exchange rates in the band.

Second, in a recent study, Koedijk and Kool (1992) tested whether the ERM had acted as a DM zone by applying a principal components analysis to interest rate and inflation differentials within the EMS, i.e., including the United Kingdom, from 1979 to 1989. Specifically, they investigated whether dominant movements in bilateral interest rate and inflation differentials could be attributed to specific countries or group of countries. They found evidence of persistent independent interest rate and inflation differentials in the EMS originating from the independent movements in two currency blocks: Germany, the Netherlands and the United Kingdom, on one side, and France, Italy and Belgium, on the other; the independent movement of Irish interest rates was another important factor contributing to the overall variance. Although the authors concluded from this that the EMS has not functioned as a DM zone, it seems more appropriate to say that their analysis only rejects the restrictive hypothesis of German dominance.

II. Data and Sample Period

We investigate the issue of German leadership using changes in French and German one-month on-shore and off-shore interest rates sampled daily from October 1987 to August 1992. We choose to restrict our sample to the co-movement of these two rates, in order to present a fuller statistical analysis than would be possible in a broader system. We also believe that our choice of interest rates provides a sound basis for testing the hypothesis of German leadership. First, because France, since 1987, has been one of the most vocal EMS members calling for greater symmetry in the ERM and claiming a greater role for herself. Second, because other ERM members either possess financial markets too small to have much influence on those of Germany or France, or have already openly accepted German monetary leadership. The obvious exception is the case of the United Kingdom, which, however, only entered into the ERM in October of 1990, and then only with a much wider fluctuation margin. 1/

1/ The range of permitted fluctuation above and below the central rates is 6 percent for sterling and the Spanish peseta and 2.25 percent for the other participating currencies.

The use of daily data allows us to look for the presence of regime shifts in the later 1980s and early 1990s. In particular, we look for a structural break around the time of German unification. Such regime shifts are possible because the budgetary and monetary strains induced by unification may have weakened Germany's anti-inflationary resolve, and thus eroded the leadership role of Germany in the ERM. We do not identify a breaking point in the data with any particular historical or news event, since movement towards German unification gained strength over several months. 1/ Rather, we chose to break our sample at the end of December 1989, when the turmoil of unification brought the deutsche mark under pressure in exchange markets.

The nominal convergence vis-a-vis Germany achieved by some ERM participants, notably France, over our sample period is viewed by some as another possible explanation for the erosion of German leadership after 1990. In our view, this development should not by itself lead to a regime shift. The improvement in inflation performance in France increased the credibility of French macroeconomic policy, and thus contributed to the reduction in interest differentials with Germany. However, increased credibility does not immediately confer greater independence; after all, the policy objectives of France did not change.

An important consideration in our selection of a sample period was to ensure that, unification apart, it included no obvious regime switches. Two points should be noted in this regard. First, our sample period begins after the last major realignment in the ERM of January 1987, in which the DM and the Netherlands guilder central parities were revalued by 3 percent, and the Belgian franc by 2 percent. After this realignment, French authorities adopted what became known as the "competitive disinflation" strategy, by which the competitiveness of the economy was to be restored by lowering inflation below that of ERM partners, rather than resorting to further devaluations vis-a-vis the DM and the stronger currency core. Because it precluded further devaluations vis-a-vis the deutsche mark, this strategy could have constituted a form of regime shift.

Second, the chosen sample period coincides with the new ERM rules of intervention and policy coordination formalized in the Basle-Nyborg agreement of September 1987. The Basle-Nyborg agreement represented a

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1/ The first impulse to German unification was given by the mass emigration from the German Democratic Republic (GDR) to West Germany that followed the opening of the border between Hungary and Austria, in September 1989. With the opening of the border between the two Germanies in November of the same year, the volume of people moving from the GDR took on massive proportions, bringing into question the viability of the GDR as a separate nation. A currency union between the two Germanies was proposed by Chancellor Kohl in February 1990 and the final terms of unification were negotiated in April and May 1990. For a further discussion of these events and their economic effects, see Lipschitz and McDonald (1990).

significant change in the rules regulating intervention within the ERM. The agreement permitted intramarginal intervention to be financed for the first time through the Very Short-Term Financing Facility (VSTF, i.e., a network of mutual credit lines between participating central banks). The agreement also stressed that greater fluctuation of exchange rates should be allowed within the band and that interest rate differentials should be used more aggressively to defend exchange rate parities. Under the original rules of the ERM, access to the VSTF was limited to interventions at the margin of the band. Since most interventions occurred intramarginally, the actions of the intervening country had no direct impact on the balance sheet of other central banks. 1/

Given the above discussion, we think it reasonable to regard the behavior of interest rates in our sample period to be homogeneous apart from the shock due to German unification. 2/ The high frequency sampling also distinguishes our study from the rest of the literature in that it permits us to detect dynamics in the data when policy response is very rapid. In fact, with the gradual dismantling of capital controls over our sample period, lags in the response of interest rates to foreign innovations are likely to have been reduced to a few days, at most. In this context, as mentioned above, statistical causality tests based on monthly observation are likely to lose too much information to be meaningful.

There is wide disagreement in the literature over the merits of using on-shore versus off-shore interest rates for empirical testing. In our study, we use both. The off-shore rates employed consist of one-month Euromarket deposit rates (Chart 1), while the on-shore rates are domestic

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1/ The Basle-Nyborg agreement caused some concern in Germany that the obligation to finance intramarginal interventions could lead to excessive liquidity creation by the Bundesbank, thereby undermining the anti-inflationary stance of German monetary policy. Several factors reduced this risk, however. First, intramarginal intervention using a partner's currency still requires the prior approval of the central bank issuing the intervention currency, and, second, the amounts involved are small relative to the total monetary base. Moreover, with most central banks using interest rates as intermediate targets, the monetary effects of intervention tend to be automatically sterilized. Following the ERM crisis of September 1992, Germany, for the first time, intervened intramarginally in support of another ERM currency, i.e., the French franc. This is more likely to reflect the gravity of the strains within the ERM at the time, than a change in Germany's role in the ERM.

2/ Of course, German unification occurred at the same time as Eastern Europe as a whole began its process of reform. Flows of net investment to Eastern Europe, except to the former Eastern Germany, have remained fairly negligible, however, and it is hard to believe that the more general reform process has significantly affected monetary events in the Western economies.

one-month interbank rates. 1/ A potential disadvantage with the use of on-shore money market rates is that they are likely to be contaminated by domestic developments related to reserve requirements and other institutional factors. 2/ An indication of this problem is given by the much higher degree of autocorrelation present in on-shore interest rate data (Table 4). On-shore rates also display a much higher degree of kurtosis, suggesting the presence of larger jumps in on-shore rates (Table 1).

The problem with off-shore rates, in contrast, is that they may not fully reflect monetary policy actions by the authorities concerned, if capital controls are present. In the case of France, capital controls were in effect from 1987 through 1989, although they do not appear to have insulated the domestic market from foreign innovations to any significant degree. As reported in Table 2 and shown in Chart 2, the standard deviation of the French off-shore differential declined after the removal of capital controls, but was relatively small even in the first period (except for the end of 1987) when compared to the German off-shore differential. The off-shore differential rarely rose above 20 basis points for France, whereas persistent deviations of that magnitude are observed in the case of Germany. The lack of segmentation between the French on-shore and off-shore markets is also confirmed by Weber (1990), who found that, over the period 1983-1989, Granger causality ran clearly from French off-shore rates to French on-shore rates, and not vice-versa.

The descriptive statistics reported in Table 3 reveal some more interesting information. First, the contemporaneous cross correlation between France and Germany in the on-shore markets is quite strong before January 1, 1990 (correlation coefficient of 0.57), but weakens substantially thereafter (0.09). In contrast, the correlation coefficient in the off-shore market remains quite stable over the two periods (0.15 and 0.16, respectively). Second, the contemporaneous correlation of off-shore and on-shore rates is weaker for Germany than for France in both subperiods. Again, both these observations raise doubts about the effectiveness of capital controls in insulating French monetary policy from external innovations before 1990. Admittedly, the correlation between on-shore and off-shore rates rises in France after 1990, but it does so to an even greater extent in Germany.

Finally, the cross autocorrelations (Table 4) between on-shore and off-shore rates as well as between French and German rates do not reveal the presence of any obvious one day temporal causality in the data, since the off diagonal elements (about the diagonal) of the cross autocorrelation

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1/ Interbank rates have the advantage that their tax-exempt status insulates them from the effect of changes in taxation.

2/ For example, regular movements in rates associated with bank reserve accounting periods introduce negative autocorrelation that has nothing to do with the dynamics of genuine shifts in monetary policy, obscuring actual policy changes.

matrix are all relatively similar (and also relatively small), i.e., the correlation between a lagged change in German rates and the current change in French rates is similar to the correlation between a lagged change in French rates and the current change in German rates.

III. Estimation and VAR Identification

Consider a three-dimensional vector of interest changes for France, Germany and the United States. In the models we estimate, this vector of short interest rate changes is regressed on cross-country contemporaneous interest changes, five own lags of the interest change vector, and five lags of changes in benchmark long term interest rates for each country. In formulating a linear model of this kind, we ignore possible non-linearities due to band effects (see Krugman (1991), and Bertola and Svensson (1991)). Modelling interest rates with such effects explicitly accounted for is quite difficult. Recent empirical work (see, for example, Lindbeck and Soderlind (1991)) suggests that large-scale intramarginal intervention within the band by central banks makes such non-linearities relatively unimportant and Svensson (1991) argues that it is, therefore, legitimate to approximate a target zone using a linear model of a managed float. The approach in this paper can be justified in a similar manner. 1/ To identify the model statistically, we assume (i) that German and French interest rates are not directly affected by each others' long term interest rates (i.e., exclusion restrictions), (ii) that the United States interest rates are not affected by changes in French or German rates at any lag (i.e., exclusion restrictions), and (iii) that the covariance matrix of innovations to the system are orthogonal instantaneously (i.e., covariance restrictions). These assumptions imply that the model is overidentified. 2/ Assumption (iii) implies that all instantaneous cross-correlation between short-term interest rates occurs through the matrix of coefficients on contemporaneous interest changes. Define $X_t \equiv (X_{tF} | X_{tG} | X_{tUS})'$ as a three-dimensional vector of short interest rate changes for, and $Y_t \equiv (Y_{tF} | Y_{tG})'$ a two-dimensional vector of changes in French and German long rates. The models we estimate are then of the form:

$$X_t = AX_t + \sum_{i=1}^{5} B_i X_{t-i} + \sum_{i=1}^{5} C_i Y_{t-i} + \epsilon_t \qquad (1)$$

1/ One might, nevertheless, argue that we should include lagged exchange rate changes in our regressions. Our initial estimations did include such lagged changes but they had no significant explanatory power so we felt justified in omitting them.

2/ (i) and (ii) would be sufficient to identify all but one of the parameters. For discussion of identification in linear models with covariance restrictions, see Hausman and Taylor (1983), and Hausman et al., (1987).

$$\text{where} \quad A \equiv \begin{bmatrix} 0 & a_{12} & a_{13} \\ a_{21} & 0 & a_{23} \\ 0 & 0 & 0 \end{bmatrix} \quad B_i \equiv \begin{bmatrix} b_{11i} & b_{12i} & b_{13i} \\ b_{21i} & b_{22i} & b_{23i} \\ 0 & 0 & 0_{33i} \end{bmatrix} \quad C_i \equiv \begin{bmatrix} c_{11i} & 0 \\ 0 & c_{22i} \\ 0 & 0 \end{bmatrix} \qquad (2)$$

where $\sum^{*} \equiv Cov(\epsilon_t)$ is unrestricted and $\sum^{*} \equiv Cov(\epsilon_t)$ is assumed to be diagonal.

Estimation was carried out using the approach of Generalized Method of Moments (GMM). 1/ The descriptive statistics given in Table 1 suggest that interest rate changes are extremely leptokurtic 2/ suggesting that Maximum Likelihood (ML) estimation based on normal distributions would be inadvisable and that a more robust estimation method such as GMM is to be preferred. 3/ The models were each initially estimated using an arbitrary weighting matrix. The resulting consistent parameter estimates were then used to construct an optimal weighting matrix based on the Newey-West approach 4/ to covariance matrix estimation. The latter was then employed in a second iteration of GMM to obtain asymptotically efficient parameter estimates.

In our initial estimations, we also included three dummy variables that took the value unity if one of the markets in question had been closed one, two or three or more days preceding a given observation, and otherwise were zero. Most studies of financial market data ignore weekends and holidays on the presumption that what matters is some notion of "economic time" reflecting periods in which markets are open. Since these dummies proved insignificant, they were dropped from the version of the regressions actually reported. Rather than looking on the statistical significance of the regression coefficients either individually or in groups, we regard it as more interesting to focus on the significance, both economic and statistical, of the long-run multipliers implied by the regression equations. Such long-run multipliers take into account feedback both within a given equation and within the system as a whole. We calculate two sorts of long-run multipliers. The first incorporates all feedback within the system, while the second limits feedback to within a single equation. To calculate the first of these, one must convert the system into a vector autoregression of order 1 of the form:

1/ See, for example, Gallant (1987).

2/ On-shore rate changes exhibit kurtosis ranging up to almost 200 compared to the kurtosis of any normal random variable of 3.

3/ Artus et al., (1991) use ML on monthly data. While monthly interest changes may be somewhat closer to normal random variables, ML is still probably inappropriate.

4/ See Newey and West (1987).

$$\begin{bmatrix} X_t \\ X_{t-1} \\ \vdots \\ X_{t-4} \end{bmatrix} = \begin{bmatrix} (I-A)^{-1}B_1 & (I-A)^{-1}B_2 & \cdots & (I-A)^{-1}B_5 \\ I & \underline{0} & \cdots & \underline{0} \\ \underline{0} & I & \cdots & \underline{0} \\ \vdots & \vdots & \ddots & \vdots \\ \underline{0} & \underline{0} & \underline{0} & I \end{bmatrix} \begin{bmatrix} X_{t-1} \\ X_{t-2} \\ \vdots \\ X_{t-5} \end{bmatrix} + \begin{bmatrix} \epsilon'_t \\ \underline{0} \\ \vdots \\ \underline{0} \end{bmatrix} \qquad (3)$$

where I is a three-by-three identity matrix, $\underline{0}$ is a three-by-three matrix of zeros, and *where* $\epsilon'_t \equiv (I-A)^{-1}\epsilon_t$. If one denotes the coefficient matrix on the right hand side of the above equation by Φ, then the long-run multipliers for shocks to the different interest rate are given by the upper three rows of: $(I_{15}-\Phi)^{1}[(I-A)^{1}|\underline{0}...|\underline{0}]'$, where I_{15} is a fifteen-dimensional identity matrix. We also calculate simpler equation-by-equation multipliers of the form: $(a_{jk}+\sum_{i=1}^{5} b_{jki})/(1-\sum_{i=1}^{5} b_{jji})$. Using the fact that these multipliers are complicated, non-linear functions of the parameters, their standard errors and t-statistics are calculated based on the covariance matrix of the parameters. The latter equals inv $((\partial q/\partial \theta)' \sum_q (\partial q/\partial \theta))$, *where* $\partial q/\partial \theta$ is the derivative of the sample averaged moment conditions with respect to the parameters and Σ is a Newey-West kernel estimate of the covariance matrix of the moment conditions.

IV. Results

1. VAR estimates and Impulse effects

Tables 5-8 and Charts 3-6 show the long-run effects of unit shocks in French, German and the United States short-term interest rates. Single equation and system wide multipliers differ because the former ignore feedback effects between equations. 1/

The system wide Euro-rate long-run multipliers (Table 5), clearly reject the hypothesis of German dominance, i.e., uni-directional causality, for the whole sample. The effect of French innovations on Germany is significant, albeit smaller than the German effect on France.

However, the results strongly suggest the presence of a structural break coinciding with German unification. In the pre-unification period (1987 through 1989), the German multiplier for France is 0.27 compared with a French multiplier for Germany of 0.11. After unification, the corresponding figures are 0.21 and 0.18. Examining the year-by-year

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1/ Note that we ignore possible feedback effects through changes in long interest rates. According to Artus et. al., (1991), French and German long-term rates are only weakly affected by movements in short-term rates.

estimation results, we find that the post-unification period is very uneven, with Germany losing its leadership role entirely during 1990, and recovering it after that.

Innovations in U.S. interest rates affect only German Euro-rates to any significant degree. A unit shock to the United States rates leads to a 27 basis points rise in German off-shore rates in the long-run. The direct and feedback effects of U.S. rate changes on France are extremely small and not statistically different from zero.

The equation-by-equation multipliers given in Table 6 (that ignore cross-equation feedback effects), broadly resemble the system-wide multipliers of Table 5 although the magnitude of German interest rate innovation multipliers is greater. The reason is that the mean-reverting tendency of German rates mutes the long-run effects of a German innovation on French rates in the system-wide multiplier compared with the single equation case.

System wide multipliers using on-shore rates again give similar results, although they display more symmetry in the pre-unification period and greater asymmetry in 1991-1992 (Table 7). This difference could be related to the presence of capital controls in the pre-unification period, which insulated French domestic interest rates somewhat from foreign innovations. With their elimination at the beginning of 1990, national markets have become more integrated and, possibly because national markets reflect more closely the monetary authorities actions, they may also have become more responsive to each other's innovations. The second main difference between the on-shore and off-shore results is that German interest rates are not mean-reverting (Table 8).

As was noted above, the long-term response of interest rates to a unit shock in the same rate varies across equations and often differs from unity. Hence, it does not necessarily translate into a permanent unit change in that interest rate. Monetary policy actions, however, cannot easily be described in terms of unit shocks. A more realistic description of a monetary policy change is a one time permanent change in short-term interest rates. In Table 9, we therefore report the effects of unit permanent changes in French and German interest rates on each other, based on the estimated coefficients of Tables 5 and 7. This presentation also allows us to measure cross effects based on the same monetary action, rather than on the same temporary shock in the two equations.

The results generally confirm the conclusions drawn above: German monetary policy actions have a stronger effect on France than vice versa in the pre-unification period, although to a significant degree only for off-shore rates. In the first year of German unification, the roles are reversed and France assumes the leadership role, particularly for on-shore rates. However, Germany appears to regain its stronger role in 1991-1992.

relative price of nontraded goods. This, in turn, results from the wealth effects induced by the terms-of-trade shock which dominate the dynamics of consumption after the relative price of exports in terms of imports has returned to its initial equilibrium.

The behavior of net exports is consistent with familiar theoretical results obtained using two-period models (see Greenwood (1984) and Svensson and Razin (1983)). A temporary improvement in the terms of trade in the first period induces agents to increase savings in order to increase consumption permanently, since consumption in the two periods is a normal good. The trade balance improves because agents increase their holdings of foreign assets. In the second period the trade balance deteriorates as agents reduce their holdings of foreign assets to finance additional imports of consumer goods. The budget constraint implies, however, that the present value of the trade balance must be zero. In Figure 1A the improvement in net exports follows the improvement in the terms of trade, then the trade balance starts to deteriorate, reaches a minimum, and improves gradually to return to the initial equilibrium. It is this eventual narrowing of the trade deficit that produces the countercyclical or acyclical behavior of net exports. In present value, the few surpluses at first require deficits for a long period afterwards to be canceled out. This is consistent with the slow adjustment of the current account depicted in Figure 1D.

Compared with the industrial country benchmark, the developing country benchmark displays lower intertemporal elasticity of substitution in consumption (0.38 v. 0.66), higher intratemporal elasticity of substitution between tradables and nontradables (1.28 v. 0.74), slightly less serially correlated income shocks (0.604 v. 0.668) and negative contemporaneous correlation between terms-of-trade and productivity disturbances (-0.18 v. 0.575). The effects of altering each of these parameters on the equilibrium co-movements of the industrial country benchmark are summarized in Table 11 and the impulse responses of macro-aggregates to a 1-percent terms-of-trade shock under all parameter specifications considered are illustrated in Figures 1A-6D in the Appendix.

Table 11 and the impulse response charts indicate that quantitatively, and in the neighborhood of the parameter specifications in question, the persistence of the disturbances and the intratemporal elasticity of substitution between tradable and nontradable goods are the main factors explaining differences in the behavior of the two benchmark models. The intertemporal elasticity of substitution in consumption is not critical as long as it represents a small degree of relative risk aversion--as in the case of the one good model examined in Mendoza (1991). Similarly, changes in the contemporaneous correlation between the two shocks affect investment and savings variability, but are not very important for the equilibrium co-movements of aggregate consumption.

The persistence of the shocks is important because it determines the magnitude of wealth effects, which are not neutral under the assumption of incomplete insurance markets, and because of the Fisherian separation that analytically the direction and magnitude of income and substitution effects produces generally ambiguous results that depend on the relative values of a number of parameters. These theoretical exercises suggest that four key parameters determining equilibrium co-movements are the intertemporal elasticity of substitution in aggregate consumption, the intratemporal elasticity of substitution between tradable and nontradable goods, and the persistence and contemporaneous correlation of shocks to output and the terms of trade. 1/ The role that these parameters play in the benchmark simulations is examined next.

Consider first the adjustment of the industrial country benchmark in response to a 1-percent positive shock to the terms of trade. Figures 1A-1D in the appendix depict the impulse responses of the various macroeconomic aggregates. Figure 1A illustrates the procyclical behavior of consumption and investment at import prices, as well as the acyclical pattern of net exports. The impact effect of the terms-of-trade shock in all four variables is positive, but afterwards their behavior is quite different. After the initial boom, GDP adjusts monotonically and gradually back to the original steady state. Investment adjusts more rapidly reflecting the perfect international mobility of capital. Given that around the steady state adjustment costs are minimal, investors aim to equalize the marginal productivity of capital in the industries of exportables and importables with the world's real interest rate. Figure 1B depicts the impulse responses of the aggregate capital and capital in the two industries; the impact effect is purely a redistribution of existing capital in favor of the exportables industry, favored by the increase in the terms of trade, but afterwards the perceived duration and co-movement of the shocks is such that aggregate capital expands and then returns monotonically to the initial equilibrium.

In contrast with the monotonic adjustment of GDP and investment after the initial boom, consumption and net exports exhibit non-monotonic adjustment patterns which reflect the impulse responses of the components of the consumption basket (Figure 1C) and foreign asset holdings, exports, and imports (Figure 1D). In Figure 1C only the consumption of nontradables is measured at import prices, whereas the other consumption measures are in units of the corresponding good (i.e. importables, exportables, or the CES composite good). When there is an increase in the relative price of exportables in terms of importables, the substitution effect dominates at first and consumption of exportables falls while consumption of importables increases. The supply of nontradables is fixed, and although tradables and nontradables are not good substitutes, the net income and substitution effect on the demand for these goods is positive and hence the relative price of nontradables, and consumption of nontradables valued at import prices, rise. The non-monotonic adjustment of consumption at import prices in Figure 1A follows from the non-monotonic adjustment of the consumption of importables and exportables and the

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1/ The relative expenditure shares of the three goods in the consumption basket, as well as the ratios of consumption to production of the three goods, are also parameters that determine the signs of comparative statics derivatives.

and the intertemporal and intratemporal substitution effects unchained by the effect of terms-of-trade disturbances on the relative productivity of capital in the industries producing exportables and importables. Depending on the persistence and co-movement of the disturbances affecting productivity and the terms of trade, the pro-borrowing effect that a positive productivity shock with some persistence induces, as agents plan to increase investment and take advantage of higher expected returns on domestic capital, may be offset or amplified by expectations regarding the future path of the terms of trade. This pro-borrowing effect is strong enough to weaken the correlation between TB and GDP significantly, relative to results obtained with the endowment economy. In the latter, the industrial country benchmark produced a coefficient of correlation between TB and GDP at import prices of 0.48, while in Table 9 this correlation is only 0.02.

The benchmark simulations consider both terms-of-trade and productivity disturbances as driving forces of the business cycle. However, it is important to measure the contribution of shocks to the terms of trade independently from productivity shocks in order to assess their empirical relevance. If the industrial country benchmark is simulated setting $\sigma_{e^y}=0$ and $\rho_{e^y,e^p}=0$, the standard deviation of GDP at import prices is 6.98 percent. Thus, terms-of-trade disturbances account for more than 1/2 of the observed variability of output (the G-7 average is 12.43 percent, 10.25 percent excluding Japan). Nevertheless, there is evidence indicating that productivity disturbances play an important role not only in accounting for the other 1/2 of output variability, but also for producing realistic co-movements among several macroeconomic aggregates--particularly consumption, investment and net exports. Moreover, the model is significantly more sensitive to changes in the magnitude of productivity shocks than in that of terms-of-trade disturbances. Around the stochastic steady state of the industrial country benchmark, a 1 percent increase in the variability of productivity increases the variability of output by 0.55, whereas a 1-percent increase in the variability of the terms of trade increases output variability by only 0.18.

VI. Sensitivity Analysis

The benchmark simulations provide a summary view of how intertemporal and intratemporal income and substitution effects, resulting from the specific parameter values assigned to each benchmark model, interact to produce different equilibrium co-movements. It is important to try to analyze these effects separately to provide a theoretical interpretation of the quantitative results. However, this analysis is complicated by two factors. First, as Frenkel and Razin (1987) noted, the definition of the 'numeraire' in multiple-good models is not innocuous, and hence changes in the units in which goods are measured affect equilibrium co-movements through relative price movements even when preferences and technology are unchanged. The differences in some statistical moments between variables at import prices and variables at consumer prices in Tables 9-10 illustrate this problem. Second, in a simple multiple-good framework similar to the one studied here, Greenwood (1984) and Ostry (1988) showed that comparative statics analysis aimed at determining intertemporal substitution effects that are helpful for explaining some features of consumption behavior. In particular, and in contrast with one-good models of the small open economy, the correlation between C and GDP is positive but not perfect. This is because the response of consumption to output fluctuations resulting form terms-of-trade and productivity shocks reflects not only wealth effects, which affect the demand functions for x, f, and n positively, but also substitution effects between these three goods induced by changes in current and expected relative prices. These substitution effects also play a critical role in the dynamics of other components of the model, particularly the trade balance and the real exchange rate.

The model accounts for large deviations from purchasing power parity. The real exchange rate has been given different interpretations in the intertemporal equilibrium literature. Some of the literature treats the relative price of nontradables as equivalent to the real exchange rate (Ostry (1988)). An extension of the first definition views the real exchange rate as the relative price of nontradables weighted by the share of nontradables in total expenditure, which is the concept used to construct real-exchange-rate moments in Tables 9-10. A third definition assumes that the law of one price for all tradables holds, as in Greenwood (1984), and hence interprets the real exchange rate as equivalent to the domestic CPI--which is a function of both the relative price of nontradables and the terms of trade. According to these three measures, real-exchange-rate fluctuations range between 5.1 percent and 10.9 percent in the industrial country benchmark and between 8.5 percent and 20.8 percent in the developing country benchmark. These ranges are consistent with the evidence reported in Table 5 and in the work of Schlagenhauf and Wrase (1991).

The J-curve dynamics of the cross-correlations between the trade balance and the terms of trade, as identified in the data of the G-7 by Backus, Kehoe, and Kydland (1992b), can only be partially explained by the model. The first-order autoregressive structure of the shocks implies that the correlation between the trade balance at t and the terms of trade at lag k is simply $\theta^k \rho_{tot,tb}$. The evidence documented by Backus, Kehoe, and Kydland shows that this is a good proxy for some G-7 countries, but is not for Canada and the United States. 1/

The results of the simulations undertaken here are also indicative of the importance of modelling investment decisions in empirical research involving intertemporal equilibrium models. For instance, the endowment economy analyzed in Mendoza (1992a) mimics the positive but less-than-perfect correlation between consumption and GDP observed in the data, but fails to duplicate the countercyclical or acyclical behavior of the trade balance and the variability of the real exchange rate. In the model examined here, investment goods are part of the importables, and hence the dynamics of investment reflect the optimal portfolio allocation of savings across K and A,

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1/ Cross-correlations between TB and TOT for the G-7 computed with the data used in Table 1 also support this argument.

ϕ=0.3. Thus, in order to rationalize observed differences in output variability and in the co-movement between GDP and TOT across the G-7 and the DCs, given the larger terms-of-trade shocks affecting the latter, the model requires that developing countries also experience larger productivity disturbances and that these disturbances be negatively correlated with terms-of-trade shocks.

In general, Tables 9-10 show that the models' equilibrium co-movements are consistent with many *qualitative* features of the business cycle, although from a *quantitative* perspective the model fails to mimic some stylized facts. Consider the four empirical regularities mentioned in Section II with regard to the terms of trade and the trade balance. First, the model is consistent with the data in showing that TB and TOT are positively correlated, albeit weakly, and that this correlation is higher in industrial countries--although HLM effects in the data are somewhat higher than in the model. Second, given the differences in parameter values, the economy with more persistent terms-of-trade disturbances does exhibit a stronger HLM effect, as observed in the data. Moreover, the positive cross-country relationship observed in Figure 1 between coefficients of first-order serial autocorrelation of TOT and correlations between TB and TOT is also closely approximated by the model--the figure plots a predicted cross-country linear relationship between the two variables with a slope coefficient of 0.24 and t-statistic of 12, which compares to 0.44 with a t-statistic of 5.65 obtained using actual data. Hence, the fact that countries with more serially correlated disturbances in the terms of trade tend to have a stronger HLM effect cannot be viewed as evidence against intertemporal equilibrium models. Third, despite larger terms-of-trade shocks in the developing country benchmark, the model predicts a smaller standard deviation in the trade balance of DCs than in the G-7, contrary to what the data show. Fourth, the model cannot mimic the uniformity that characterizes the variability of TB *relative* to the variability of TOT because trade-balance fluctuations in industrial countries are significantly overestimated. In the industrial country benchmark the variability ratio is about 5.2, while in the developing country benchmark it is approximately 1. In the data the ratio is about 1.1 for both the average of the G-7 and the average of 23 developing countries.

The data of the G-7 and the DCs indicated that economic fluctuations in GDP, consumption, and investment across countries display similar characteristics. This is well duplicated by the model, except for the correlation between the terms of trade and aggregate consumption and its components deflated with the CPI, which differ significantly between the two benchmark economies. Quantitatively, the model fails to mimic some stylized facts by large margins. In particular, both benchmark models exaggerate the actual variability of consumption at consumer prices, and for developing countries the model underestimates the correlation between C and TOT regardless of the price index used to deflate consumption. Nevertheless, most stylized facts of consumption and investment measured at import prices are fairly well duplicated by the two benchmark economies.

The separation of the consumption basket into exportable, importable, and nontradable components allows the model to capture intratemporal and

Table 10. Properties of Business Cycles in the Model of Developing Countries 1/

	A Variables at import prices				B Variables at consumer prices 2/			
Variable x=	σ_x/σ_{tot}	ρ_x	$\rho_{x,y}$	$\rho_{x,tot}$	σ_x/σ_{tot}	ρ_x	$\rho_{x,y}$	$\rho_{x,tot}$
Terms of trade	1.00	0.604 (1.000)*	0.278 (0.786)*	1.000	1.00	0.604 (1.000)*	0.145 (0.634)	1.000
GDP	0.91 (1.83)*	0.820 (1.504)	1.000	0.278 (0.786)*	0.84 (2.55)	0.724 (1.382)	1.000	0.145 (0.634)
GNP	1.16	0.890	0.941	0.221	0.89	0.754	0.863	0.143
Consumption	1.36 (1.21)	0.914 (1.893)	0.719 (0.793)	-0.007	0.96 (2.10)	0.844 (2.084)	0.381 (0.660)	-0.152 (0.374)4/
Tradables	1.48	0.921	0.695	-0.009	1.07	0.870	0.311	-0.141
Nontradables	1.22	0.901	0.751	-0.004	0.85	0.800	0.479	-0.166
Savings	2.11	0.826	0.383	0.381	2.49	0.841	0.717	0.264
Investment	1.39 (0.89)*	0.518 (1.051)	0.762 (1.037)	0.431 (1.456)	1.44 (1.30)	0.559 (1.169)	0.780 (1.305)	0.321 (1.202)
Trade balance 3/	1.09 (0.99)	0.593 (1.208)	-0.156	0.109 (0.459)	6.88	0.579	0.370	0.109
Current account 3/	0.69	0.028	0.264	0.183	4.44	0.039	0.384	0.181
Net factor payments 3/	0.83	0.999	-0.424	-0.009	5.15	0.998	0.163	-0.011
Relative price of nontradables	1.16	0.921	0.415	0.102	--	--	--	--
Real exchange rate	0.47	0.927	0.423	0.117	--	--	--	--
Exports	2.71	0.647	0.532	0.920	2.73	0.653	0.540	0.869
Imports	3.02	0.585	0.582	0.727	2.79	0.519	0.212	0.763
Consumer prices	--	--	--	--				
Consumption basket: 5/								
Importables	--	--	--	--	1.48	0.921	--	-0.009
Exportables	--	--	--	--	1.80	0.810	--	-0.561
Nontradables	--	--	--	--	0.67	0.604	--	-0.180
Miscellaneous correlations:								
Savings-investment		0.563				0.702		
Trade balance-lagged terms of trade		0.066				0.066		

1/ The statistical moments reported are the percentage standard deviation relative to the percentage standard deviation of the terms of trade, σ_x/σ_{tot}, the first order serial auto correlation, ρ_x, the correlation with GDP, $\rho_{x,y}$, and the correlation with the terms of trade, $\rho_{x,tot}$. The numbers in brackets are the ratios of moments in the model to moments in actual data measured as averages for the 23 developing countries in Table 1--the asterisks denote calibrated and exogenous parameters.

2/ Except for the components of the consumption basket.

3/ Variability ratio computed using standard deviations, not percentage standard deviations.

4/ Absolute value of the difference between actual and estimated moments.

5/ Each component measured in units of the corresponding consumption good.

Table 9. Properties of Business Cycles in the Model of Industrial Countries 1/

Variable x=	A Variables at import prices				B Variables at consumer prices 2/			
	σ_x/σ_{tot}	ρ_x	$\rho_{x,y}$	$\rho_{x,tot}$	σ_x/σ_{tot}	ρ_x	$\rho_{x,y}$	$\rho_{x,tot}$
Terms of trade	1.00	0.668	0.742	1.000	1.00	0.668	0.689	1.000
		(1.000)*	(0.985)*			(1.000)*	(2.452)	
GDP	1.71	0.703	1.000	0.742	1.39	0.700	1.000	0.689
	(1.00)*	(1.130)		(0.985)*	(3.86)	(1.243)		(2.452)
GNP	1.78	0.735	0.992	0.710	1.40	0.717	0.986	0.681
Consumption	1.85	0.615	0.931	0.582	1.32	0.653	0.877	0.581
	(1.18)	(1.370)	(0.940)	(0.793)	(3.77)	(1.212)	(1.016)	(1.533)
Tradables	1.73	0.626	0.953	0.603	1.25	0.663	0.924	0.591
Nontradables	2.00	0.604	0.906	0.552	1.43	0.638	0.816	0.562
Savings	3.42	0.574	0.473	0.625	3.71	0.528	0.654	0.489
Investment	1.70	0.349	0.838	0.662	1.45	0.493	0.765	0.566
	(0.90)*	(0.720)	(0.930)	(0.948)	(1.45)	(1.008)	(0.901)	(1.993)
Trade balance 3/	5.15	0.179	0.022	0.277	0.28	0.187	0.381	0.288
	(4.68)	(0.369)	(0.111)	(0.764)				
Current account 3/	4.62	0.024	0.190	0.338	0.25	0.028	0.444	0.336
Net factor payments 3/	2.08	0.996	-0.368	-0.060	0.11	0.996	-0.054	-0.043
Relative price of nontradables	1.51	0.516	0.523	0.290	--	--	--	--
Real exchange rate	0.70	0.528	0.524	0.291	--	--	--	--
Exports	2.58	0.708	0.890	0.900	2.47	0.663	0.911	0.820
	(1.91)			(1.475)				
Imports	2.42	0.420	0.883	0.692	1.88	0.424	0.756	0.735
	(1.97)			(1.923)				
Consumer prices	--	--	--	--	0.74	0.539	0.214	0.422
Consumption basket: 4/								
Importables	--	--	--	--	1.73	0.626	--	0.603
Exportables	--	--	--	--	1.39	0.586	--	0.032
Nontradables	--	--	--	--	1.16	0.668	--	0.575
Miscellaneous correlations:								
Savings-investment	0.338				0.496			
Trade balance-lagged terms of trade	0.186				0.192			

1/ The statistical moments reported are the percentage standard deviation relative to the percentage standard deviation of the terms of trade, σ_x/σ_{tot}, the first order serial auto correlation, ρ_x, the correlation with GDP, $\rho_{x,y}$, and the correlation with the terms of trade, $\rho_{x,tot}$. The numbers in brackets are the ratios of moments in the model to moments in actual data measured as averages for the G-7--the asterisks denote calibrated and exogenous parameters.

2/ Except for the components of the consumption basket.

3/ Variability ratio computed using standard deviations, not percentage standard deviations.

4/ Each component measured in units of the corresponding consumption good.

the average of earnings as a percent of value added in manufacturing determines $1-\chi$ for industrial countries and $1-\iota$ for developing countries. Similarly, the averages of labor earnings as a percent of value added in other sectors are used to set ι for industrial countries and χ for developing countries. The efficiency parameter Q is a multiplicative constant that does not affect the statistics examined in the rest of the paper. However, to be consistent with observed differences in economy size between industrial countries and large developing countries, Q is set to unity for industrial countries and for DCs is set to make their mean output about 1/5 of the mean output of industrial countries. 1/ The depreciation rate δ is set to 10 percent and the real interest rate r^* is set to 4 percent following the literature on real business cycles.

Given χ, ι, δ, Q, r^*, γ, and μ, a system of eight equations determines α, β, N, and the deterministic steady state of p^n, K, K^f, K^h and A. The equations are: (1) the stationary equilibrium condition that equates the rate of time preference with r^*; (2) the marginal rate of substitution between nontradables and importables; (3) the ratio of net foreign interest payments to output ω; (4) the ratio of expenditure on nontradables to expenditure on tradables Ω; (5) the ratio of total trade to output T; (6) the equilibrium condition that equates the net marginal productivity of K^f with r^*; (7) a similar condition that equates the net marginal productivity of K^h with r^*; and (8) the definition of aggregate capital $K=K^f+K^h$. To solve these equations, p^x is assumed to be equal to 1 in the steady state, and ω, Ω, and T are set using cross-country and time-series averages of actual data from Tables 6 and 7. Column (1) in Table 7 shows that the average Ω for industrialized and developing countries is similar, 0.87 and 0.86 respectively. The last column of the table shows that the mean T for industrialized countries is 0.62 and for developing countries is 0.51. The sixth column of Table 6 shows that the cross-section mean of ω for time-series averages of the G-7 and 23 DCs are -0.2 and -2.8 percent respectively. 2/

V. Simulation of the Benchmark Models

Tables 9 and 10 list the properties of the equilibrium stochastic processes that characterize macroeconomic variables in the benchmark models. Statistical moments for variables deflated using both import prices and the consumption-based price index are reported. The former can be compared with moments computed from actual data at constant import prices in Tables 1-6, and consumption deflated with the CPI can be compared with consumption at constant domestic prices in Table 3. The industrial country benchmark is calibrated by setting $\sigma_{e^y}=8.5$ percent, $\rho_{e^y,e^p}=0.575$, and $\phi=0.1$, while in the developing country benchmark these parameters are $\sigma_{e^y}=12.25$ percent, $\rho_{e^y,e^p}=-0.18$, and

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1/ This estimate is based on measures of GDP per capita adjusted for purchasing power provided by Kravis, Heston, and Summers (1982).

2/ Given that Canada's relatively large ω dominates the average for the G-7, ω is set at zero for industrial countries to reflect more closely the typical ratio of net factor payments to output in these countries.

Table 8. Sectoral Value Added and Labor Income, 1975. 1/

Country	Share of value added in total GDP: Agriculture	Industry	Manufacturing	Other Industry	Services	Manufacturing earnings in percent of value added	Total earnings in percent of total value added 2/	Earnings in other sectors in percent of their value added 3/
Industrialized Countries:								
Japan	5.6	42.6	27.3	15.3	57.4	40.4	55.0	56.2
Austria	5.5	45.6	30.9	14.7	65.7	56.2	53.9	52.9
Belgium	2.6	40.6	28.0	12.6	68.3	49.7	56.6	59.3
Denmark	5.7	29.1	19.3	9.8	65.2	59.1	56.8	56.2
France	NA	NA	NA	NA	NA	NA	54.6	NA
Germany	2.6	48.6	36.9	11.7	61.0	49.4	57.0	61.5
Ireland	NA	NA	NA	NA	NA	46.0	56.9	NA
Italy	7.1	39.8	25.6	14.1	58.4	39.7	49.3	52.6
Luxembourg	3.1	40.3	28.5	11.7	56.7	63.6	63.3	63.2
Netherlands	3.6	39.3	NA	NA	67.4	57.1	59.6	NA
Spain	NA	NA	NA	NA	NA	59.6	51.1	NA
U.K.	1.8	44.3	29.9	14.3	53.9	51.3	64.5	70.1
U.S.	3.3	37.0	23.0	14.0	69.3	43.1	59.4	64.2
Average						51.3	56.9	59.6
Developing Countries:								
Kenya	35.6	20.4	11.6	8.7	44.0	43.7	48.1	48.6
Malawi	35.1	19.2	NA	NA	45.7	40.0	44.0	NA
Zambia	15.8	47.8	19.9	27.9	46.9	30.1	33.1	33.8
India	42.6	23.8	16.4	7.5	33.6	47.2	51.9	52.8
Iran	NA	NA	NA	NA	NA	NA	NA	NA
Korea	27.3	36.2	25.1	11.1	47.2	23.6	26.0	26.7
Malaysia	29.4	37.7	19.9	17.8	43.9	27.4	30.1	30.8
Pakistan	32.1	22.3	14.5	7.8	45.6	25.5	28.0	28.5
Philippines	27.0	38.3	27.3	11.0	45.5	14.8	16.3	16.8
Sri Lanka	29.1	28.2	19.6	8.6	42.8	NA	NA	NA
Syria	NA	NA	NA	NA	NA	21.5	23.6	NA
Thailand	31.1	30.5	21.7	8.8	50.4	24.7	27.2	27.8
Brazil	11.6	37.8	29.2	8.7	50.6	18.9	20.8	21.6
Colombia	22.0	35.7	26.2	9.6	50.6	20.6	22.7	23.4
Jamaica	7.8	48.4	21.0	27.4	53.8	46.3	50.9	52.1
Mexico	10.0	33.0	22.8	10.2	63.1	39.1	43.0	44.2
Uruguay	12.3	30.8	NA	NA	56.9	NA	NA	NA
Average						30.2	33.3	33.9

1/ GDP shares and manufacturing earnings are from STARS, World Bank, 1990. Total labor income share for industrial countries is from OECD, National Accounts.

2/ For developing countries, except Mexico, it is estimated by assuming that the ratio of earnings relative to Mexico is the same as in manufacturing industries. For Mexico it is taken from Mendoza (1992b), where it was claculated on the basis of data from Indicadores Economicos, Banco de Mexico.

3/ Computed using the GDP shares of nonmanufacturing sectors and the total labor income share by assuming a constant labor income share in those sectors.

Table 7. Selected Data on the Composition of Consumption Expenditures and Imports, 1975 1/

Country	(1) Relative expenditure nontradable/tradable goods	(2) Relative prices nontradable/tradable goods (index, US=100)	(3) Imports of consumer goods in percent of total imports	(4) Imports of consumer goods in percent of expenditure on tradables	(5) Total trade in percent of output
Industrialized Countries:					
Japan	0.90	89.3	25.1	11.0	27.4
Austria	0.74	81.6	35.4	24.9	63.1
Belgium 2/	0.74	88.0	36.1	53.9	92.0
Denmark	1.15	74.5	32.9	31.7	61.1
France	0.83	77.1	31.7	15.7	36.9
Germany	0.79	81.7	39.6	22.4	49.9
Ireland	0.97	68.5	38.6	46.4	91.4
Italy	0.88	62.7	29.3	15.7	39.1
Luxembourg	0.94	81.2	--	--	145.1
Netherlands	0.64	92.2	38.4	48.7	96.4
Spain	0.81	62.1	26.0	9.5	30.9
United Kingdom	1.03	70.7	39.9	28.3	52.7
United States	0.74	100.0	28.3	5.5	18.4
mean 3/	0.87	77.5	35.4	28.0	61.9
Developing Countries					
Kenya	1.05	48.2	23.2	15.0	64.3
Malawi	0.66	41.6	37.1	24.4	75.0
Zambia	1.36	49.5	29.1	39.8	92.2
India	0.80	27.4	30.7	4.1	12.8
Iran	0.71	56.9	29.3	21.4	--
Korea	0.69	50.7	23.0	18.2	64.4
Malaysia	1.17	42.4	33.9	37.1	86.8
Pakistan	0.71	41.6	32.8	10.4	33.1
Philippines 4/	0.77	34.5	25.1	11.5	43.9
Sri Lanka	0.91	25.7	58.8	31.8	62.4
Syria	0.48	80.3	38.1	26.8	55.4
Thailand	0.53	54.0	15.2	6.4	41.3
Brazil	0.80	53.1	13.9	3.8	19.0
Colombia	1.11	44.6	21.5	5.4	29.8
Jamaica	1.11	52.6	41.1	41.1	80.9
Mexico	0.85	48.3	23.3	3.9	14.7
Uruguay	0.93	56.2	15.3	5.0	35.9
mean	0.86	47.5	28.9	18.0	50.8

1/ Columns (1) and (2) correspond to the ratios of column (8) to column (9) in Tables 6-10 and 6-12 of Kravis, Heston, and Summers (1982). Column (3) is the sum of the shares of imports of food and manufactures (excluding chemical products and machinery and equipment) in total imports obtained from UNCTAD (1987) pp. 158-179. Column (4) is generated by applying the shares from Column (3) to data on total imports (UNCTAD (1987)), and then using the resulting U.S. dollar amount of consumer good imports to produce the shares of imports in consumption of tradables using the data on private consumption, exchange rates, and share of tradables in total private consumption from Tables 1-2, 1-7, and 6-10 in Kravis, Heston, and Summers (1982). Column (5) is the ratio of the sum of exports and imports of goods and nonfactor services to total GDP at current prices computed with data from World Bank (1990).

2/ For Columns (3) and (4) Belgium includes Luxembourg.

3/ Excluding the United States which is the base for the purchasing power correction in Kravis, Heston, and Summers (1982).

4/ Data on imports for the Philippines includes unallocated imports.

estimated using data on relative expenditures and relative prices for traded and nontraded goods listed in Table 7 and obtained from Kravis, Heston, and Summers (1982). As in Stockman and Tesar (1990), μ is obtained by regressing logged relative expenditures on logged relative prices and logged per capita GDP adjusted for purchasing power (also from Kravis, Heston and Summers). This gives an estimate of $1/(1+\mu)$ of 0.74 with a standard error of 0.438. 1/ For developing countries, Ostry and Reinhart (1992) estimated $1/(1+\mu)$ at 1.279 with a standard error of 0.154, and showed that in the more industrialized DCs the coefficient is lower. 2/ α is set to mimic the average ratios of total trade to output for the G-7 and the DCs in the deterministic steady state, 3/ and the value of β is also determined as part of the steady-state conditions described below.

Production parameters are difficult to define because of limitations in the data on sectoral input earnings, capital stocks, and employment in many countries. Some of the information that is available on the STARS database and the OECD National Accounts (OECD (1988)) regarding these variables is summarized in Table 8. For the countries in the Kravis-Heston-Summers sample, the table reports GDP shares in agriculture, industry, manufacturing industry, non-manufacturing industry, and services; the percentage of manufacturing value added pertaining to labor earnings; total labor income as a percentage of total value added; and earnings in sectors other than manufacturing as a percentage of value added in those sectors. For the last two variables, the table reports actual data only for OECD countries and Mexico, 4/ while for the rest of the DCs it reports estimates constructed by assuming that unit labor costs in sectors other than manufacturing relative to Mexico are the same as those observed in the manufacturing sector. Given that industrialized countries are net exporters of manufactures, while most DCs are net importers,

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1/ Stockman and Tesar (1990) used a sample that includes 17 developing countries. Their point estimate of the elasticity of substitution is 0.44 with a standard error of 0.225.

2/ Using the same regression method applied to industrial countries with the data for DCs in Table 7 yields $1/(1+\mu)=0.43$. This estimate is incompatible with the GMM estimates of Ostry and Reinhart (1991), and it requires the use of GDP per capita as an explanatory variable in violation of the homotheticity assumption implicit in (2). The estimate for industrial countries also violates homotheticity, but is in line with the view that these countries exhibit lower intratemporal substitution, as implied by the GMM estimates of Ostry and Reinhart.

3/ Alternatively, α can be set by computing the share of consumer good imports in tradable expenditures. Column (3) of Table 7 lists consumer good imports as a percent of total imports obtained from UNCTAD (1987), and this combined with data from Kravis, Heston, and Summers (1982) would yield $1-\alpha$ in Column (4)--resulting in averages of 0.28 (α=.72) and 0.18 (α=0.82) for industrial and developing countries respectively. This computation excludes consumption of importables produced in the domestic economy and the resulting high α values imply total trade ratios significantly below those observed in the data.

4/ The labor income share for Mexico is taken from Mendoza (1992b).

IV. Selection of Parameters

Two sets of parameter values are defined to construct model economies that reproduce some essential characteristics of industrialized and developing countries. Unfortunately, the information available in international databases provides only a crude approximation for some of the variables defined in the model, particularly the breakdown of production and consumption into tradables and nontradables, and hence the parameterization proposed here is only a first approximation. The two sets of parameters are as follows:

Industrial country benchmark parameters:

$$I = \{ e^{y}=8.5,\ e^{p}=7.3,\ \theta=0.668,\ \Pi=0.394,\ r^{*}=0.04,\ N=3.29,\ \chi=0.487,\ \iota=0.404,\ \delta=0.1,\ \phi=0.1,\ Q=1.0,\ \gamma=1.5,\ \mu=0.35,\ \alpha=0.19,\ \beta=0.125 \}. \quad (22)$$

Developing country benchmark parameters:

$$\Lambda = \{ e^{y}=12.25,\ e^{p}=18.0,\ \theta=0.604,\ \Pi=0.205,\ r^{*}=0.04,\ N=0.702,\ \chi=0.661,\ \iota=0.698,\ \delta=0.1,\ \phi=0.3,\ Q=0.3,\ \gamma=2.61,\ \mu=-0.218,\ \alpha=0.15,\ \beta=0.019 \}. \quad (23)$$

The values of parameters describing stochastic disturbances are determined by combining information from actual data with a calibration strategy, taking into account the conditions listed in (20). The variability and persistence of the terms of trade are determined by taking averages for the G-7 and the DCs from Table 1. The variability of productivity shocks and their contemporaneous correlation with terms-of-trade shocks are set to mimic the variability of real GDP at import prices and its correlation with TOT as given by averages for the G-7 and the DCs from Table 2. The parameter ϕ is also set by calibration, so as to mimic the average standard deviation of investment at import prices for the G-7 and the DCs in Table 4.

Preference parameters are assigned values using information on consumption of nontradables and tradables, combined with evidence from econometric studies and the conditions imposed by the non-stochastic steady-state equilibrium of the model. The value of γ is in the range of estimates obtained in studies of industrial and developing countries. Point estimates of γ are controversial, but real business cycle models for industrial countries have shown that values between 1 and 2 are useful to mimic key stylized facts (see, for example, Prescott (1986), Greenwood, Hercowitz, and Huffman (1988) and Mendoza (1991)). For DCs, γ=2.6 corresponds to a GMM estimate of $1/\gamma$ produced by Ostry and Reinhart (1992) for a sample combining time series for 13 developing countries. 1/ μ for industrial countries is

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1/ These authors estimate $1/\gamma$ at 0.383 with a standard error of 0.087 (they also provide an alternative estimate at 0.504 with a standard error of 0.228).

starting state s. These probabilities are given by the rule of simple persistence,

$$\pi_{s,u} = (1-\theta)\Pi_u + \theta Z_{s,u}. \tag{17}$$

Here, θ governs the persistence of the two shocks, Π_u is the long-run probability of state u, and $Z_{s,u}$=1 if s=u and 0 otherwise. The symmetry conditions are:

$$\bar{e}^y=-\underline{e}^y=e^y,\ \bar{e}^p=-\underline{e}^p=e^p, \tag{18}$$

and

$$\Pi_{(\bar{e}^y,\bar{e}^p)}=\Pi_{(\underline{e}^y,\underline{e}^p)}=\Pi,\ \ \Pi_{(\bar{e}^y,\underline{e}^p)}=\Pi_{(\underline{e}^y,\bar{e}^p)}=\frac{1}{2}-\Pi. \tag{19}$$

This setup simplifies the analysis by minimizing the number of parameters that characterize the stochastic structure of the model. Once the values of e^y, e^p, θ, and Π are determined, the properties of the stochastic processes of the two disturbances are given by,

$$\sigma_{e^y}=e^y,\ \sigma_{e^p}=e^p,\ \rho_{e^y}=\rho_{e^p}=\theta,\ \rho_{e^y,e^p}=4\Pi-1. \tag{20}$$

The standard deviations of shocks to productivity and the terms of trade are $\sigma_e{}^y$ and $\sigma_e{}^p$ respectively, $\rho_e{}^y$ and $\rho_e{}^p$ are their coefficients of first-order serial autocorrelation, and their contemporaneous correlation is ρ_{e^y,e^p}.

Up to this point, macroeconomic aggregates have been measured in units of importables, and hence they are comparable with actual data expressed at constant import prices, as documented in Section II. It is also useful, as Frenkel and Razin (1987) argued, to express these aggregates in terms of a consumption-based price index (CPI) to produce equilibrium co-movements that can be compared with more familiar definitions of variables at constant prices--which involve price indices that consider traded and nontraded goods--and to obtain measures that can be used as basis for welfare comparisons in policy analysis. 1/ This is done by applying duality principles to create the CPI. Because the CES component of (2) is homogenous of degree one, there is an expenditure function at date t that embodies the following consumer price index:

$$P_t = \left[\left(\alpha^{-\alpha}(1-\alpha)^{-(1-\alpha)}\left(e_t^p p^x\right)^{\alpha}\right)^{\frac{\mu}{1+\mu}} + \left(p_t^n\right)^{\frac{\mu}{1+\mu}}\right]^{\frac{1+\mu}{\mu}}. \tag{21}$$

1/ Note, however, that as Frenkel and Razin (1987) acknowledge, the choice of units in which variables are to be expressed is not innocuous in circumstances where relative prices change.

$$f_t = (1-\alpha)\left[Qe_t^y\left(e_t^p p^x(\hat{K}_t^x)^\chi + (\hat{K}_t^f)^\iota\right) - K_{t+1} + K_t(1-\delta) - \frac{\phi}{2}(K_{t+1}-K_t)^2 + (1+r^*)A_t - A_{t+1}\right], \tag{15}$$

$$A_t,\ A_{t+1} \geq \Delta \quad and \quad K_t,\ K_{t+1}, f_t \geq 0.$$

At the beginning of date t, agents start with foreign assets or debt A_t and aggregate capital K_t. They observe disturbances affecting the terms of trade and productivity--a state of nature λ_t that is given by the realizations e_t^y and e_t^p--and they know the stochastic process that governs the behavior of future realizations of these shocks. Agents formulate optimal decision rules regarding the accumulation of foreign assets and domestic capital. Given these, equilibrium stochastic processes for the allocation of capital between firms producing exportables and importables, the relative price of nontradables, and consumption of the three goods in the utility function are determined by equations (10)-(13) and (15). Once these processes are determined, equilibrium processes for other variables of interest follow from the appropriate definitions.

A variety of algorithms are available for solving stochastic dynamic programming problems like (14). Linear and log-linear approximation methods are widely used in the real business cycle literature, but they may not provide reliable results in this case because of the large magnitude of terms-of-trade shocks and their interaction with sizable productivity disturbances (for a discussion of how the accuracy of approximation methods deteriorates as the variance of the underlying disturbances increases see Christiano (1989) and Dotsey and Mao (1992)). Consequently, the method applied here is an exact-solution procedure based on iterations of the value function and the transition probability matrix using discrete grids to approximate the state space. This procedure is an extension of the method used by Mendoza (1991), following previous work by Greenwood, Hercowitz, and Huffman (1988) on the basis of algorithms designed by Bertsekas (1976). The drawback is that this method adopts simple representations for the stochastic shocks in order to minimize the dimension of the state space.

In this case the shocks are assumed to follow two-point symmetric Markov chains according to the simple persistence rule. There are four states of nature,

$$\lambda_t^s, \lambda_{t+1}^u \in \left[(\bar{e}^y,\bar{e}^p),(\bar{e}^y,\underline{e}^p),(\underline{e}^y,\bar{e}^p),(\underline{e}^y,\underline{e}^p)\right]. \tag{16}$$

The transition probability of the current state s moving to state u in one period is $\pi_{s,u}$ for s,u=1,4. Transition probabilities satisfy usual conditions--each one ranges between 0 and 1 and they add up to unity for each

The equilibrium of this economy can be expressed as the solution to a dynamic programming problem with only three state variables. Using (2), (3) and (6), one can show that in equilibrium the ratio of x to f, using f as the numeraire, is given by $\alpha/(1-\alpha)$. Hence optimal consumption of exportables as a function of importables is:

$$\hat{x}_t = \left(\frac{\alpha}{1-\alpha}\right)\left(\frac{f_t}{e_t^p p^x}\right). \tag{10}$$

The market of nontradables must clear so $n_t = Qe_t^y N$, and hence from (7) it follows that:

$$p_t^n = \frac{\left(Qe_t^y N\right)^{-\mu-1}}{\left(x_t^\alpha f_t^{1-\alpha}\right)^{-\mu-1}(1-\alpha)x_t^\alpha f_t^{-\alpha}}. \tag{11}$$

Given production parameters and the equality $K_t = K_t^x + K_t^f$, equation (8) determines optimal allocations of capital in the exportables and importables industries as functions of the aggregate capital stock and the shocks:

$$\hat{K}_t^x = k^x(K_t, e_t^p, e_t^y), \tag{12}$$

$$\hat{K}_t^f = k^f(K_t, e_t^p, e_t^y), \tag{13}$$

It follows from (10)-(13) that, if the stochastic structure of the model is simplified as explained below, the problem of maximizing (1) subject to (4) can be rewritten as:

$$V(K_t, A_t, \lambda_t^s) = \max\left\{ \frac{\left[\left(\hat{x}_t^\alpha f_t^{1-\alpha}\right)^{-\mu} + \left(Qe_t^y N\right)^{-\mu}\right]^{-\frac{(1-\gamma)}{\mu}}}{(1-\gamma)} + \left(1 + \left[\left(\hat{x}_t^\alpha f_t^{1-\alpha}\right)^{-\mu} + \left(Qe_t^y N\right)^{-\mu}\right]^{-\frac{1}{\mu}}\right)^{-\beta} \left[\sum_{u=1}^{4} \pi_{s,u} V\left(K_{t+1}, A_{t+1}, \lambda_{t+1}^u\right)\right] \right\}, \tag{14}$$

subject to, 1/

1/ Δ in the resource constraint (15) is a non-binding borrowing constraint that ensures intertemporal solvency (see Mendoza (1991) for details).

corresponding capital stocks. Since capital is homogenous the aggregate capital stock is $K_t = K_t^x + K_t^f$, and ϕ is the parameter governing the marginal adjustment cost of capital in terms of importables. N is the endowment of nontradables. The holdings of real foreign assets, denominated in units of importables, are given by A_t, and the world's real interest rate is r^*.

3. Equilibrium and dynamic programming formulation

The equilibrium of this economy is characterized by the stochastic processes $\{K_{t+1}\}_0^\infty$, $\{A_{t+1}\}_0^\infty$, $\{K_t^x\}_0^\infty$, $\{K_t^f\}_0^\infty$, $\{x_t\}_0^\infty$, $\{f_t\}_0^\infty$, and $\{n_t\}_0^\infty$ that maximize (1) subject to the resource constraint (4). Given (2) and (3), the optimality conditions of this problem can be expressed as follows:

$$\frac{\mho_f(t)}{\exp(-v(t))E_t[\mho_f(t+1)]} = (1+r^*), \tag{5}$$

$$\frac{\mho_x(t)}{\mho_f(t)} = e_t^p p^x, \tag{6}$$

$$\frac{\mho_n(t)}{\mho_f(t)} = p_t^n. \tag{7}$$

$$(e_t^y e_t^p p^x)\chi(K_t^x)^{\chi-1} = e_t^y \iota(K_t^f)^{\iota-1}, \tag{8}$$

$$\begin{aligned} &\exp(v(t))\mho_f(t)[1+\phi(K_{t+1}-K_t)] = \\ &E_t\Big[\mho_f(t+1)\Big(\big(Qe_{t+1}^y e_{t+1}^p p^x\big)\chi\big(K_{t+1}-K_{t+1}^f\big)^{\chi-1} + (1-\delta) + \phi(K_{t+2}-K_{t+1})\Big)\Big]. \end{aligned} \tag{9}$$

These conditions have straightforward interpretation, except that the lifetime marginal utilities of importables, $\mho_f(t)$, exportables, $\mho_x(t)$, and nontradables, $\mho_n(t)$, include a term that accounts for the impact of changes in current consumption on the rate of time preference. Condition (5) sets the intertemporal marginal rate of substitution in consumption of importables equal to their intertemporal relative price, $(1+r^*)$, while (6) and (7) set the intratemporal marginal rates of substitution between exportables and importables, and nontradables and importables equal to their corresponding relative prices. Equation (8) determines the optimal allocation of capital across firms producing exportables and importables, and (9) sets optimal investment by equating the marginal costs and benefits of sacrificing a unit of consumption of importables.

and

$$v(x,f,n) = \beta \ln\left(1 + \left[(x^{\alpha} f^{1-\alpha})^{-\mu} + n^{-\mu}\right]^{-\frac{1}{\mu}}\right), \tag{3}$$

$$0 \leq \alpha \leq 1,\ \mu > -1,\ \gamma > 1,\ \beta > 0.$$

Preferences over tradables and nontradables are described by a constant elasticity of substitution (CES) function, where $1/1+\mu$ is the elasticity of substitution. The composite of tradables is a Cobb-Douglas function, where α is the share of home goods in total expenditure on tradables. The intertemporal elasticity of substitution in aggregate consumption is also constant and given by $1/\gamma$. The elasticity of the rate of time preference with respect to the CES composite is approximated by β.

2. Production technology and financial markets

Firms produce exportable and importable goods using capital, which is an homogeneous, importable good, as the only variable input. 1/ The supply of nontradables is assumed to be given by an endowment to keep the number of state variables at a minimum. Firms maximize the present value of profits facing convex, quadratic adjustment costs. Firms and households have access to an international financial market in which they trade non-contingent one-period real bonds paying a fixed real interest rate with the rest of the world. Stochastic disturbances affect productivity in the exportables and importables industries, the endowment of nontradables, and the terms of trade. The resource constraint of the economy is:

$$\begin{aligned} f_t + e_t^p p^x x_t + p_t^n n_t &= Q e_t^y \left(e_t^p p^x (K_t^x)^{\chi} + (K_t^f)^{\iota} + p_t^n N\right) \\ &- K_{t+1} + K_t(1-\delta) - \frac{\phi}{2}(K_{t+1} - K_t)^2 - A_{t+1} + A_t(1+r^*), \end{aligned} \tag{4}$$

for $t=0,..,\infty$. The price of foreign goods is the numeraire, so p^x is the exogenous, time-invariant mean of the relative price of exportables in terms of importables (i.e. the terms of trade), and p_t^n is the endogenous relative price of nontradables in terms of importables. The random variables e_t^y and e_t^p are the disturbances affecting domestic output and the terms of trade, and these follow stochastic processes as defined below. Q is a productivity scale factor that accounts for the different size of developing and industrialized economies. χ and ι are the income shares of capital in the industries producing exportables and importables respectively, and K_t^x and K_t^f are the

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1/ Labor is assumed to be supplied inelastically or available to firms as a fixed endowment, and to simplify notation it is dropped from the utility and production functions. Alternatively, it is possible to introduce labor as independent of the dynamics of consumption--as in Greenwood, Hercowitz, and Huffman (1988) or Mendoza (1991a). In either case, the model would not mimic the stylized facts of hours worked because of the reasons argued in McCallum (1989) and Christiano and Eichembaum (1992).

national accounts aggregates are not reported because the sample period of these exchange rates covers only 10 years. Considering quarterly data, the table indicates that RER fluctuates between 2 and 9.5 percent in industrial countries and up to 38 percent in developing countries, with first-order serial autocorrelations for all countries generally in excess of 0.82 (0.45 annually). Moments reported by Schlagenhauf and Wrase (1991) for Hodrick-Prescott-filtered real exchange rates of four of the G-7, defined using bilateral U.S. dollar exchange rates and consumer price indexes, are roughly consistent with these results--the standard deviation of RER is between 2.9 and 9.7 percent and the first-order autocorrelation is about 0.8. Thus, as Mussa (1990) argued, the evidence shows that there have been large deviations from purchasing power parity in recent years.

III. The Model

This section describes the structure of preferences, technology, and financial markets that characterizes a three-good, stochastic intertemporal equilibrium model of a small open economy. The design of the model is based on the literature of the 1980s on the HLM effect, in particular Obstfeld (1982) and Greenwood (1984), and on open-economy real business cycle models by Mendoza (1991), Tesar (1990), and Stockman and Tesar (1990).

1. Preferences

The economy is inhabited by identical, infinitely-lived individuals that consume three goods; nontradables, n, and two tradables, exportable or home goods, x, and importable or foreign goods, f. 1/ Individuals maximize expected lifetime utility given by a stationary cardinal utility function: 2/

$$U(x,f,n) = E\left[\sum_{t=0}^{\infty}\left\{u(x_t,f_t,n_t)\exp\left(-\sum_{\tau=0}^{t-1}v(x_\tau,f_\tau,n_\tau)\right)\right\}\right]. \tag{1}$$

The functions u(.) and v(.) adopt the following form:

$$u(x,f,n) = \frac{\left(\left[(x^{\alpha}f^{1-\alpha})^{-\mu} + n^{-\mu}\right]^{-\frac{1}{\mu}}\right)^{1-\gamma}}{1-\gamma}, \tag{2}$$

1/ Whether exportable and importable goods are actually exported or imported in this model is not arbitrary. It is an equilibrium outcome in which production of exportables exceeds consumption and consumption of importables exceeds production.

2/ The reader interested in the theoretical aspects of stationary cardinal utility is referred to Epstein (1983). Obstfeld (1981), Engel and Kletzer (1989), and Mendoza (1991a) discuss the role of the endogenous rate of time preference present in this utility function on the dynamics of models of small open economies.

countries in which the terms of trade are more volatile, but with a uniform proportionality factor.

To summarize, Table 1 illustrates four facts: (1) there is a Harberger-Laursen-Metzler effect, albeit not a very strong one; (2) countries with more persistent terms-of-trade shocks are not the ones that exhibit less correlation between the trade balance and the terms of trade; (3) the ratio of variability of the real trade balance to variability in the terms of trade is similar for all countries; and (4) the trade balance fluctuates more in developing countries, which also experience larger fluctuations in the terms of trade.

The stylized facts of output, consumption, and investment reported in Tables 2-4 also support the view that there is some uniformity in business cycles across countries. Qualitatively, the properties of business cycles in DCs are the same as those reported in studies of Canada, the United States, and the G-7 (see, for example, Backus and Kehoe (1992), Backus, Kehoe, and Kydland (1992a), Cardia (1991), Stockman and Tesar (1990), and Mendoza (1991)). Considering variables measured at constant domestic prices, C is always less variable than the terms of trade and is less variable than GDP in 12 countries, 1/ while I varies about as much as TOT in many countries and significantly more than GDP in all countries. Using data measured at constant import prices, consumption and investment tend to fluctuate more than the terms of trade and GDP. Regardless of which deflator is used, C and I are procyclical and the fluctuations around trend of all three macroeconomic aggregates exhibit some persistence. The correlations with the terms of trade are less well defined, and although in general they are weakly positive, they range from large negative to large positive coefficients.

There are also interesting quantitative similarities. Although the G-7 exhibit less variability in GDP, C, and I than developing countries, the ratios of variability relative to the standard deviation of TOT do not differ significantly. Comparing averages of regional means for the G-7 and the four regions of DCs, the data shows that with respect to the standard deviation of TOT, the standard deviation of GDP at constant import prices (constant domestic prices) ranges from 0.87 to 1.71 (0.30 to 0.39), the standard deviation of C ranges from 0.78 to 1.56 (0.35 to 0.79), and the standard deviation of I is between 1.25 and 2.74 (0.9 and 1.3). The coefficients of first-order serial autocorrelation of TB, TOT, GDP, C, and I are also similar across countries. Cyclical components are stationary processes with positive roots well inside the unit circle. For all 30 countries, the cross-country average of the first-order autocorrelations range from 0.44 for consumption at domestic prices to 0.62 for the terms of trade, with standard deviations that are generally less than 1/3 of the corresponding average.

Table 5 reports the variability and persistence of fluctuations in the IMF's measure of the real effective exchange rate. Correlations with annual

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1/ Consumption data here includes durables. Usually, consumption becomes less variable than output once durables are taken out.

Table 6. Real Net Foreign Factor Payments (NFFP): Summary Statistics

	Real NFFP at Import Prices					NFFP/GDP
Country	Sd.	Sd.Tot.	Rsd.	Ac.(1)	Corr.Tot.	Mean
A. Industrialized Countries: Group of Seven						
United States (70)	5.08	4.83	1.05	0.105	0.375	0.69
United Kingdom (65)	6.41	5.46	1.17	0.118	−0.011	0.92
France (78)	3.45	3.41	1.01	0.024	0.249	0.04
Germany (65)	8.86	6.87	1.29	−0.105	0.272	0.15
Italy (84)	4.45	3.24	1.37	−0.676	−0.969	−0.93
Canada (65)	14.54	3.73	3.90	0.599	−0.199	−2.27
Japan (66)	14.74	15.81	0.93	0.582	0.735	0.15
Mean	8.22	6.19	1.33	0.092	0.065	−0.18
B. Developing Countries: Western Hemisphere						
Argentina (67)	66.97	10.39	6.45	0.528	0.097	−4.59
Brazil (67)	42.22	13.53	3.12	0.389	0.439	−2.69
Chile (67)	82.69	11.63	7.11	0.251	0.321	−5.04
Mexico (67)	26.83	13.73	1.95	0.569	0.495	−1.64
Peru (67,79)	64.17	10.51	6.11	0.609	0.009	−5.77
Venezuela (67)	46.62	25.99	1.79	0.529	0.234	−2.55
Mean	54.92	14.30	3.84	0.479	0.266	−3.71
C. Developing Countries: Middle East						
Israel (65)	302.23	5.04	59.97	0.477	0.182	−3.23
Saudi Arabia (67)	46.15	33.25	1.39	0.004	0.016	−0.29
Egypt (67,70)	113.51	9.55	11.89	0.597	0.387	−2.87
Mean	153.96	15.95	9.65	0.359	0.195	−2.13
D. Developing Countries: Asia						
Taiwan (67,73)	25.08	7.96	3.15	0.339	0.158	0.55
India (67)	75.51	10.00	7.55	0.701	−0.535	−0.30
Indonesia (67)	190.88	14.42	13.24	0.339	0.265	−3.34
Korea (65)	32.16	9.08	3.54	0.427	0.006	−1.67
Philippines (67)	43.80	11.55	3.79	0.547	0.336	−2.89
Thailand (65)	34.16	9.50	3.60	0.611	0.460	−1.27
Mean	66.93	10.42	6.42	0.494	0.115	−1.49
E. Developing Countries: Africa						
Algeria (66,70)	42.16	28.48	1.48	0.419	0.389	−3.10
Cameroon (68,70)	36.92	19.92	1.85	−0.036	0.092	−2.50
Zaire (67)	221.85	13.66	16.24	0.577	−0.194	−3.25
Kenya (65,70)	43.66	10.22	4.27	0.465	0.022	−4.21
Morocco (65,67)	45.64	11.57	3.94	0.584	0.709	−3.26
Nigeria (67,73)	108.37	31.56	3.43	0.662	0.577	−3.17
Sudan (67,73)	71.72	18.18	3.94	0.195	−0.475	−4.52
Tunisia (65)	60.19	16.28	3.70	0.418	0.284	−2.96
Mean	78.81	18.73	4.21	0.411	0.175	−3.37
Mean developing countries	79.28	15.04	5.27	0.444	0.186	−2.81

Note: The data are the net of credits and debits in the factor payments accounts of the balance of payments in U.S. dollars, deflated using U.S. dollar import unit values. The data are expressed in per capita terms, logged, and detrended with a quadratic time trend. The number in brackets indicates the year of the first observation in the sample of factor payments data; when necessary, a second number appears in brackets to indicate the year of the first observation in the sample of GDP in U.S. dollars used to compute the ratio NFPP/GDP. The moments are the standard deviation (Sd.), the standard deviation of the terms of trade in the sample of NFPP (Sd.Tot.), the standard deviation relative to the standard deviation of the terms of trade (Rsd.), the first-order serial autocorrelation (Ac(1)), and the correlation with the terms of trade (Corr.Tot.). The source of the data is the IMF's WEO Database.

Table 5. Variability and Persistence of Real Effective Exchange Rate Fluctuations 1/

Country	Quarterly Data		Annual Data	
	σ	$\rho(1)$	σ	$\rho(1)$
A. Industrial countries: Group of Seven				
United States	7.94	0.895	7.79	0.573
United Kingdom	6.95	0.913	5.84	0.393
France	3.07	0.855	2.69	0.426
Germany	3.33	0.892	3.02	0.300
Italy	2.02	0.824	1.71	-0.156
Canada	5.45	0.922	5.05	0.571
Japan	9.55	0.907	8.70	0.467
B. Developing countries: Western Hemisphere				
Argentina	22.45	0.813	17.64	0.093
Brazil	11.62	0.753	11.37	0.247
Chile	15.07	0.942	14.32	0.621
Mexico +	14.68	0.916	13.06	0.147
Peru	17.26	0.867	15.06	0.484
Venezuela +	14.91	0.854	14.38	0.505
C. Developing countries: Middle East				
Israel	4.47	0.784	3.85	0.398
Saudi Arabia +	10.19	0.929	9.92	0.639
Egypt	14.30	0.829	13.79	0.358
D. Developing countries: Asia				
Taiwan	n.a.	n.a.	n.a.	n.a.
India	4.52	0.721	3.98	0.366
Indonesia +	14.84	0.922	13.99	0.613
Korea	7.98	0.925	7.29	0.473
Philippines	9.11	0.839	8.27	0.291
Thailand	7.63	0.949	7.40	0.747
E. Developing countries: Africa				
Algeria +	9.39	0.804	8.69	0.001
Cameroon +	7.34	0.936	7.03	0.648
Zaire	22.36	0.694	18.86	0.140
Kenya	6.38	0.431	5.16	0.282
Morocco	2.33	0.672	1.49	0.078
Nigeria +	37.95	0.916	35.86	0.522
Sudan	36.09	0.602	36.45	-0.135
Tunisia	6.53	0.886	6.25	0.577

Source: International Monetary Fund, International Financial Statistics, and Information Notice System.

1/ The data are for the period 1979.1-1992.2 quarterly and 1979-1991 annually. Real effective exchange rates are equal to nominal, trade-weighted effective exchange rates adjusted for relative changes in consumer prices. The data have been lagged and detrended using a quadratic time trend. σ is the standard deviation in percent and $\rho(1)$ is the first-order serial autocorrelation. A "+" sign identifies countries that are major fuel exporters according to WEO standard.

Table 4. Real Investment at Domestic Prices and Import Prices: Summary Statistics

		Investment at Constant Domestic Prices					Investment at Constant Import Prices				
Country	Sd.Tot	Sd.	Rsd.	Ac.(1)	Corr.GDP	Corr.Tot.	Sd.	Rsd.	Ac.(1)	Corr.GDP	Corr.Tot.
A. Industrialized Countries: Group of Seven.											
United States	5.27	7.24	1.37	0.452	0.933	0.324	13.53	2.57	0.496	0.953	0.782
United Kingdom	5.81	5.89	1.01	0.586	0.894	−0.481	7.13	1.23	0.364	0.817	0.381
France	4.88	5.30	1.09	0.543	0.910	0.523	9.59	1.97	0.499	0.941	0.827
Germany	6.37	5.76	0.90	0.560	0.823	0.352	13.53	2.12	0.575	0.954	0.829
Italy	6.23	4.07	0.65	0.331	0.824	0.108	11.46	1.84	0.459	0.969	0.906
Canada	3.72	5.26	1.42	0.461	0.600	0.398	7.03	1.89	0.468	0.680	0.189
Japan	13.66	8.05	0.59	0.489	0.958	0.766	24.43	1.79	0.537	0.992	0.972
Mean	6.56	5.94	0.90	0.489	0.849	0.284	12.38	1.89	0.485	0.901	0.698
B. Developing Countries: Western Hemisphere											
Argentina	9.25	13.66	1.48	0.560	0.403	0.072	51.41	5.56	0.567	0.970	0.406
Brazil	14.10	11.58	0.82	0.683	0.919	0.670	30.07	2.13	0.673	0.952	0.810
Chile	11.65	17.11	1.47	0.526	0.868	0.233	21.42	1.84	0.620	0.734	0.306
Mexico	14.03	12.23	0.87	0.474	0.848	0.608	18.24	1.30	0.419	0.946	0.486
Peru	10.05	16.06	1.60	0.500	0.743	0.361	20.20	2.01	0.518	0.803	0.149
Venezuela	23.97	19.15	0.80	0.631	0.870	−0.313	17.71	0.74	0.488	0.079	−0.179
Mean	13.84	14.97	1.08	0.562	0.775	0.272	26.51	2.26	0.548	0.747	0.330
C. Developing Countries: Middle East											
Israel	4.78	12.88	2.70	0.592	0.879	0.230	21.01	4.40	0.626	0.936	0.254
Saudi Arabia	31.10	na	na	na	na	na	42.02	1.35	0.646	0.788	0.600
Egypt	9.80	18.59	1.90	0.605	0.533	0.497	24.16	2.47	0.555	0.669	0.195
Mean	15.22	15.74	1.03	0.599	0.706	0.363	29.06	2.74	0.609	0.798	0.350
D. Developing Countries: Asia											
Taiwan	−−	na	na	na	na	na	na	na	na	na	na
India	9.77	3.72	0.38	0.356	0.427	0.394	12.37	1.27	0.489	0.919	0.903
Indonesia	13.62	11.71	0.86	0.322	−0.035	0.358	12.61	0.93	0.428	0.808	0.514
Korea	7.04	11.71	1.66	0.641	0.437	0.396	21.41	3.04	0.699	0.848	0.649
Philippines	11.36	20.80	1.83	0.633	0.958	−0.596	21.86	1.92	0.634	0.817	−0.647
Thailand	8.93	7.28	0.82	0.474	0.746	−0.109	9.50	1.06	0.355	0.901	0.266
Mean	10.14	11.04	1.09	0.485	0.506	0.088	15.55	1.64	0.521	0.858	0.337
E. Developing Countries: Africa											
Algeria	24.42	6.75	0.28	0.308	0.347	0.201	8.58	0.35	0.134	0.393	0.119
Cameroon	20.31	18.72	0.92	0.512	0.597	0.560	16.42	0.81	0.223	0.809	0.386
Zaire	13.17	20.38	1.55	−0.106	0.497	0.317	23.77	1.81	0.265	0.576	−0.204
Kenya	10.29	16.47	1.60	0.260	0.566	0.360	20.20	1.96	0.386	0.802	0.490
Morocco	11.77	16.80	1.43	0.511	0.553	0.303	18.45	1.57	0.538	0.651	0.092
Nigeria	−−	na	na	na	na	na	na	na	na	na	na
Sudan	−−	na	na	na	na	na	na	na	na	na	na
Tunisia	13.11	11.38	0.87	0.596	0.213	0.532	13.11	1.00	0.604	0.292	0.334
Mean	11.63	15.08	1.30	0.347	0.462	0.379	16.76	1.25	0.358	0.587	0.203
Mean dev. cts.	13.63	14.05	1.11	0.478	0.598	0.267	21.23	1.56	0.493	0.735	0.296

Note: Investment at constant domestic prices is the standard measure of real fixed investment, and investment at constant import prices is the U.S. dollar value of fixed investment deflated using U.S. dollar import unit values. The data are expressed in per capita terms, logged, and detrended with a quadratic time trend. The sample period is 1968−1988 and the source is the STARS database in World Bank (1990). The moments listed are the percentage standard deviation (Sd.), the percentage standard deviation of the terms of trade (Sd.tot), the standard deviation relative to the standard deviation of the terms of trade (Rsd.), the first−order serial autocorrelation (Ac.(1)), the correlation with GDP (Corr.GDP), and the correlation with the terms of trade (Corr.Tot). For Mexico, Peru, Israel, Saudi Arabia, Egypt, Indonesia, Algeria, Cameroon, Kenya, and Nigeria the moments correspond to total real investment including inventories.

Table 3. Real Consumption at Domestic Prices and Import Prices: Summary Statistics

		Consumption at Constant Domestic Prices					Consumption at Constant Import Prices				
Country	Sd.Tot	Sd.	Rsd.	Ac.(1)	Corr.GDP	Corr.Tot.	Sd.	Rsd.	Ac.(1)	Corr.GDP	Corr.Tot.
A. Industrialized Countries: Group of Seven											
United States	5.27	2.03	0.39	0.605	0.839	0.558	10.31	1.96	0.489	0.996	0.906
United Kingdom	5.81	3.13	0.54	0.546	0.796	−0.058	8.12	1.40	0.447	0.985	0.695
France	4.88	1.24	0.25	0.409	0.869	0.753	7.20	1.48	0.285	0.992	0.856
Germany	6.37	2.30	0.36	0.621	0.801	0.654	10.63	1.67	0.599	0.994	0.946
Italy	6.23	1.83	0.29	0.453	0.887	0.192	10.92	1.75	0.407	0.997	0.973
Canada	3.72	3.23	0.87	0.723	0.950	−0.166	4.02	1.08	0.400	0.966	−0.198
Japan	13.66	2.42	0.18	0.417	0.902	0.720	20.28	1.48	0.517	0.997	0.979
Mean	6.56	2.31	0.35	0.539	0.863	0.379	10.21	1.56	0.449	0.990	0.737
B. Developing Countries: Western Hemisphere											
Argentina	9.25	4.52	0.49	0.344	0.816	−0.279	35.15	3.80	0.559	0.994	0.445
Brazil	14.10	5.79	0.41	0.592	0.878	0.635	19.66	1.39	0.583	0.976	0.901
Chile	11.65	10.33	0.89	0.634	0.894	−0.027	19.34	1.66	0.659	0.965	0.236
Mexico	14.03	4.07	0.29	0.577	0.971	0.832	11.40	0.81	0.150	0.925	0.224
Peru	10.05	6.49	0.65	0.549	0.732	−0.026	16.27	1.62	0.597	0.909	−0.147
Venezuela	23.97	na	na	na	na	na	13.97	0.58	0.618	0.892	0.357
Mean	13.84	6.24	0.53	0.539	0.858	0.227	19.30	1.39	0.528	0.943	0.336
C. Developing Countries: Middle East											
Israel	4.78	4.05	0.85	0.102	0.351	0.290	13.43	2.81	0.564	0.961	0.311
Saudi Arabia	31.10	na	na	na	na	na	31.37	1.01	0.727	0.772	0.589
Egypt	9.80	7.52	0.77	0.488	0.080	0.430	11.89	1.21	0.365	0.922	−0.216
Mean	15.22	5.78	0.79	0.295	0.216	0.360	18.90	1.24	0.552	0.885	0.228
D. Developing Countries: Asia											
Taiwan	--	na	na	na	na	na	na	na	na	na	na
India	9.77	3.17	0.32	0.208	0.893	0.593	13.47	1.38	0.528	0.966	0.883
Indonesia	13.62	5.66	0.42	0.705	0.375	0.586	15.09	1.11	0.543	0.953	0.484
Korea	7.04	2.97	0.42	0.356	0.833	0.436	15.35	2.18	0.583	0.985	0.814
Philippines	11.36	4.00	0.35	0.578	0.798	−0.344	10.40	0.92	0.634	0.939	−0.594
Thailand	8.93	4.17	0.47	0.198	0.797	0.395	7.15	0.80	0.218	0.980	0.274
Mean	10.14	3.99	0.39	0.409	0.739	0.333	12.29	1.21	0.501	0.965	0.372
E. Developing Countries: Africa											
Algeria	24.42	6.13	0.25	0.408	0.578	0.755	9.46	0.39	0.031	0.732	0.213
Cameroon	20.31	7.00	0.34	0.373	0.373	0.407	10.05	0.49	0.451	0.612	0.273
Zaire	13.17	10.75	0.82	0.609	0.785	−0.046	27.17	2.06	0.499	0.972	−0.271
Kenya	10.29	9.20	0.89	0.267	0.608	−0.183	9.46	0.92	0.476	0.927	0.283
Morocco	11.77	2.13	0.18	−0.051	0.243	−0.314	10.24	0.87	0.404	0.909	−0.166
Nigeria	--	na	na	na	na	na	na	na	na	na	na
Sudan	--	na	na	na	na	na	na	na	na	na	na
Tunisia	13.11	2.63	0.20	0.346	0.410	−0.137	5.85	0.45	0.469	0.854	−0.433
Mean	15.51	6.31	0.41	0.325	0.500	0.080	12.04	0.78	0.388	0.834	−0.020
Mean dev. cts.	13.63	5.59	0.46	0.405	0.634	0.222	15.31	1.12	0.483	0.907	0.222

Note: Consumption at constant domestic prices is the standard measure of real private consumption, and consumption at constant import prices is the U.S. dollar value of private consumption deflated using U.S. dollar import unit values. The data are expressed in per capita terms, logged and detrended with a quadratic time trend. The sample period is 1968–1988 and the source is the STARS database in World Bank (1990). The moments listed are the percentage standard deviation (Sd.), the percentage standard deviation of the terms of trade (Sd.Tot), the standard deviation relative to the standard deviation of the terms of trade (Rsd.), the first-order serial autocorrelation (Ac.(1)), the correlation with GDP (Corr.GDP), and the correlation with the terms of trade (Corr.Tot.).

Table 2. Real GDP at Domestic Prices and Import Prices: Summary Statistics

Country	Real GDP at Domestic Prices					Real GDP at Import Prices				
	Sd.	Sd.Tot	Rsd.	Ac.(1)	Corr.Tot.	Sd.	Sd.Tot	Rsd.	Ac.(1)	Corr.Tot
A. Industrial Countries: Group of Seven										
United States (65,65)	2.36	5.75	0.41	0.474	0.332	13.06	5.75	2.27	0.675	0.911
United Kingdom (65,65)	2.53	5.46	0.46	0.649	-0.358	7.81	5.46	1.43	0.483	0.751
France (65,65)	1.82	5.22	0.35	0.582	0.526	8.74	5.22	1.67	0.521	0.916
Germany (65,65)	2.05	6.87	0.30	0.438	0.382	12.45	6.87	1.81	0.744	0.941
Italy (65,65)	2.11	7.27	0.29	0.412	0.332	14.69	7.27	2.02	0.678	0.978
Canada (65,65)	2.46	3.73	0.66	0.641	-0.076	4.75	3.73	1.27	0.557	-0.217
Japan (65,65)	4.83	16.59	0.29	0.745	0.826	25.52	16.59	1.54	0.699	0.991
Mean	2.59	7.27	0.36	0.563	0.281	12.43	7.27	1.71	0.622	0.753
B. Developing Countries: Western Hemisphere										
Argentina (65,65)	4.25	10.73	0.40	0.465	-0.094	36.34	10.39	3.50	0.625	0.472
Brazil (65,65)	5.24	12.99	0.40	0.658	0.526	24.11	12.99	1.86	0.671	0.731
Chile (65,65)	7.18	12.94	0.55	0.571	0.292	21.59	12.94	1.67	0.746	0.176
Mexico (65,65)	4.18	13.85	0.30	0.711	0.881	11.07	13.85	0.80	0.303	0.426
Peru (65,68)	5.01	10.25	0.49	0.308	-0.094	14.41	10.05	1.43	0.581	-0.163
Venezuela (65,65)	4.37	30.52	0.14	0.641	-0.153	14.83	30.52	0.49	0.712	0.454
Mean	5.04	15.21	0.33	0.559	0.226	20.39	15.12	1.35	0.606	0.349
C. Developing Countries: Middle East										
Israel (65,65)	4.73	5.05	0.94	0.776	0.292	14.64	5.05	2.90	0.749	0.401
Saudi Arabia (65,65)	9.68	38.19	0.25	0.595	0.531	27.05	38.19	0.71	0.768	0.844
Egypt (65,65)	4.25	9.49	0.45	0.587	-0.071	13.78	9.79	1.41	0.462	-0.322
Mean	6.22	17.58	0.35	0.653	0.251	18.49	17.68	1.05	0.660	0.308
D. Developing Countries: Asia										
Taiwan (65,73)	7.59	8.82	0.86	0.401	0.566	7.85	5.02	1.56	0.478	0.896
India (65,65)	2.87	10.39	0.28	0.315	0.603	14.42	10.39	1.39	0.722	0.849
Indonesia (65,65)	3.66	20.28	0.18	0.569	0.571	24.65	20.28	1.22	0.313	-0.340
Korea (65,65)	5.10	9.08	0.56	0.673	0.469	18.67	9.08	2.06	0.616	0.865
Philippines (65,65)	5.30	12.57	0.42	0.774	-0.614	9.57	12.57	0.76	0.424	-0.321
Thailand (65,65)	2.85	9.50	0.30	0.466	0.244	10.65	9.50	1.12	0.545	0.571
Mean	4.56	11.77	0.39	0.533	0.307	14.30	11.14	1.28	0.516	0.420
E. Developing Countries: Africa										
Algeria (65,68)	5.00	30.39	0.16	0.307	0.533	11.88	24.42	0.49	0.262	0.142
Cameroon (65,68)	7.51	20.46	0.37	0.529	0.165	9.49	20.32	0.47	0.483	0.471
Zaire (65,65)	5.43	15.56	0.35	0.625	0.298	22.92	15.56	1.47	0.604	-0.042
Kenya (65,68)	3.29	10.22	0.32	0.500	-0.067	9.76	10.29	0.95	0.453	0.506
Morocco (65,67)	3.46	11.57	0.30	0.024	0.238	10.86	11.40	0.95	0.519	-0.001
Nigeria (65,68)	13.62	36.56	0.37	0.646	-0.225	29.17	29.47	0.99	0.512	0.813
Sudan (65,73)	5.20	17.78	0.29	0.410	-0.230	22.69	12.79	1.77	0.578	0.492
Tunisia (65,65)	4.64	16.28	0.29	0.498	0.610	4.86	16.28	0.30	0.417	0.228
Mean	6.02	19.85	0.30	0.442	0.165	15.20	17.57	0.87	0.479	0.326
Mean developing countries	5.41	16.24	0.33	0.524	0.229	16.75	15.27	1.10	0.545	0.354

Note: Real GDP at domestic prices is the standard measure, and real GDP at import prices is the U.S. dollar value of GDP deflated using U.S. dollar import unit values. The data are expressed in per capita terms, logged, and detrended with a quadratic time trend. The first number in brackets indicates the year of the first observation in the sample of real GDP at domestic prices, and the second indicates the year of the first observation in the sample of real GDP at import prices. The last observation for all data is 1989. The moments listed are the percentage standard deviation (Sd.), the percentage standard deviation of the terms of trade in the corresponding sample of real GDP (Sd.Tot), the standard deviation relative to the standard deviation of the terms of trade (Rsd.), the first-order serial autocorrelation (Ac.(1)), and the correlation with the terms of trade (Corr.Tot.). The source of the data is the IMF WEO Database.

Table 1. The Terms of Trade and the Real Trade Balance:
Summary Statistics (concluded)[a]

Country	Terms of Trade		Real Trade Balance		
	σ	$\rho(1)$	σ	$\rho(1)$	$\rho_{tb,tot}$
D.- Developing Countries: Asia					
Taiwan	10.57	0.645	13.84	0.539	0.574
		(0.186)*		(0.186)*	(0.152)*
India	10.28	0.662	17.60	0.666	0.482
		(0.186)*		(0.186)*	(0.163)*
Indonesia+	29.16	0.752	12.48	0.261	0.325
		(0.186)*		(0.186)	(0.179)
Korea	10.50	0.725	16.47	0.556	0.254
		(0.186)*		(0.186)*	(0.183)
Philippines	13.73	0.769	13.80	0.357	0.496
		(0.186)*		(0.186)	(0.161)*
Thailand	9.70	0.545	12.72	0.534	-0.301
		(0.186)*		(0.186)*	(0.177)
E.- Developing Countries: Africa					
Algeria+	36.06	0.722	23.72	0.334	0.135
		(0.186)*		(0.186)	(0.187)
Cameroon+	22.21	0.763	17.74	0.459	0.428
		(0.186)*		(0.186)*	(0.174)*
Zaire	17.16	0.502	19.53	0.693	0.493
		(0.186)*		(0.186)*	(0.164)*
Kenya	9.88	0.373	16.58	0.361	0.301
		(0.186)*		(0.186)	(0.177)
Morocco	10.73	0.556	16.19	0.636	0.259
		(0.186)*		(0.186)*	(0.179)
Nigeria+	45.14	0.741	29.70	0.468	-0.246
		(0.186)*		(0.186)*	(0.183)
Sudan	16.69	0.777	28.89	0.552	0.632
		(0.186)*		(0.186)*	(0.147)*
Tunisia	20.31	0.772	12.57	0.435	-0.064
		(0.186)*		(0.186)*	(0.185)

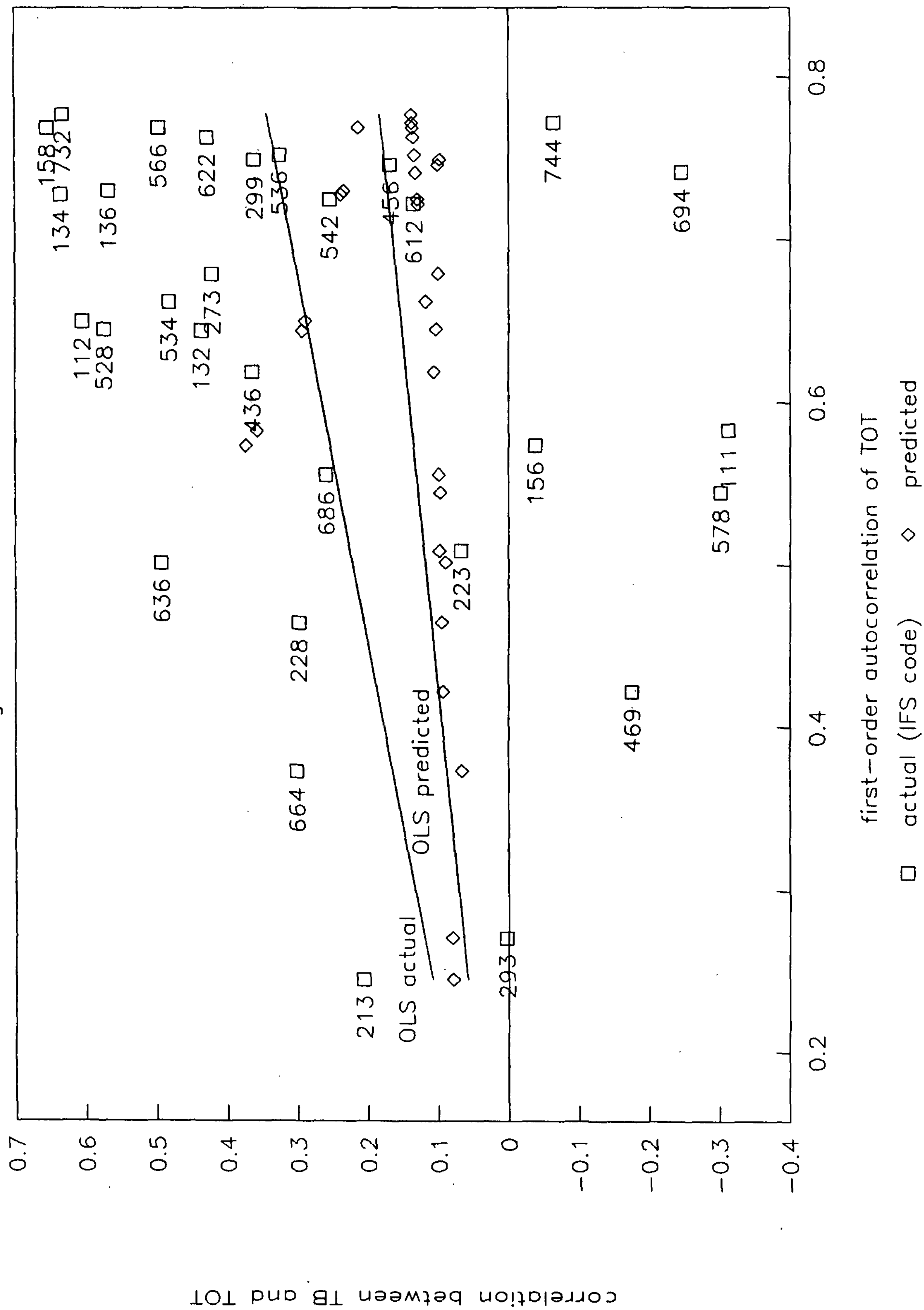
[a] Data from the IMF WEO Database for the period 1960-89 for the G7 and 1961-89 for developing countries. Terms of trade are the ratio of export to import unit values with 1985=100. Trade data are current exports and imports in US dollars, deflated by import unit values and divided by total population. Real exports, real imports and the terms of trade are logged and detrended with a quadratic time trend. The real trade balance corresponds to detrended exports minus detrended imports. σ is the percentage standard deviation, $\rho(1)$ is the first-order serial autocorrelation (Bartlett standard error in parentheses) and $\rho_{tb,tot}$ is the correlation between terms of trade and the real trade balance (least squares standard error in parentheses). An asterisk denotes statistical significance at the 5 percent level. A "+" sign identifies countries that are major fuel exporters according to WEO standard.

Table 1. The Terms of Trade and the Real Trade Balance: Summary Statistics[a]

Country	Terms of Trade		Real Trade Balance		
	σ	$\rho(1)$	σ	$\rho(1)$	$\rho_{tb,tot}$
A.- Industrialized Countries: Group of Seven					
United States	5.88	0.583	8.53	0.425	-0.312
		(0.183)*		(0.183)*	(0.176)
United Kingdom	5.33	0.650	7.99	0.648	0.605
		(0.183)*		(0.183)*	(0.148)*
France	5.20	0.644	4.66	0.176	0.436
		(0.183)*		(0.183)	(0.167)*
Germany	7.55	0.728	6.25	0.636	0.635
		(0.183)*		(0.183)*	(0.143)*
Italy	7.81	0.730	10.33	0.477	0.568
		(0.183)*		(0.183)*	(0.153)*
Canada	3.62	0.574	5.44	0.505	-0.038
		(0.183)*		(0.183)*	(0.186)
Japan	16.19	0.769	13.34	0.523	0.654
		(0.183)*		(0.183)*	(0.140)*
B.- Developing Countries: Western Hemisphere					
Argentina	10.72	0.245	26.00	0.305	0.206
		(0.186)		(0.186)	(0.185)
Brazil	12.56	0.509	20.10	0.514	0.067
		(0.186)*		(0.186)*	(0.188)
Chile	13.69	0.465	19.09	0.418	0.298
		(0.186)*		(0.186)*	(0.180)
Mexico+	13.85	0.679	28.54	0.623	0.421
		(0.186)*		(0.186)*	(0.171)*
Peru	9.66	0.271	26.22	0.520	0.003
		(0.186)		(0.186)*	(0.189)
Venezuela+	35.38	0.749	26.57	0.348	0.361
		(0.186)*		(0.186)	(0.176)*
C.- Developing Countries: Middle East					
Israel	5.78	0.619	11.90	0.482	0.364
		(0.186)*		(0.186)*	(0.173)*
Saudi Arabia+	43.83	0.746	31.80	0.611	0.168
		(0.186)*		(0.186)*	(0.186)
Egypt	10.01	0.422	18.07	0.619	-0.175
		(0.186)*		(0.186)*	(0.186)

Figure 1

The Harberger–Laursen–Metzler Effect



using the HP filter; the results show that although HP standard deviations are smaller, ratios of standard deviations as well as coefficients of correlation and persistence do not differ significantly.

Table 1 reports the standard deviation, contemporaneous correlation, and first-order serial autocorrelation of the terms of trade and the trade balance. Because the last two moments are critical for the analysis that follows, standard errors assessing their statistical significance are also reported. This table illustrates some interesting regularities. First, in every case in which the co-movement between TOT and TB is statistically significant, the correlation is positive. Thus, there is an HLM effect in the sense that positive deviations from trend of the terms of trade are associated with cyclical improvements in the trade balance. This observation is consistent with the Obstfeld-Svensson-Razin framework because fluctuations in TOT are not highly persistent--the average first-order autocorrelation is 0.62. However, that framework also predicts that the co-movement between TB and TOT should be positively related to the persistence of the latter, contrary to what the table shows. As illustrated in Figure 1, countries with higher autocorrelation in the terms of trade exhibit higher correlation between the trade balance and the terms of trade--a linear regression between the two produces a coefficient of 0.44 with a t-statistic of 5.65. The theoretical result follows from pro-saving and pro-borrowing wealth effects that tend to cancel out as income shocks become more persistent, 1/ given a fixed structure of preferences and technology. In contrast, the numerical analysis of the following sections explores to which extent international differences in tastes and technology could account for this puzzle.

Another interesting regularity emerges from Table 1 by comparing the statistics reported for the G-7 and the DCs. The terms of trade for the G-7 exhibit on average a 7.4 percent standard deviation, which is about 2 to 3 times less than the average variability of the terms of trade for developing countries. Similarly, trade balances in DCs are 2 to 3 times more variable than in the G-7. This reflects the fact that the export base of developing countries is less diversified and that they specialize in exporting commodities that experience sharp price changes. Surprisingly, however, net exports are slightly more variable than the terms of trade in most countries, by a factor of 1.1 on average, regardless of differences in the export base. 2/ Thus, the data show that the trade balance fluctuates more in

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1/ The assumption of incomplete markets in the Obstfeld-Svensson-Razin models is also crucial for this result. As Backus (1989) proved, under complete markets the co-movement between TOT and TB is independent of country-specific shocks.

2/ In terms of individual countries, the ratio of the standard deviation of the trade balance to the standard deviation of the terms of trade can be as low as 0.4 for Indonesia and as high as 2.7 for Peru, but for most countries is between 0.8 and 1.6.

documenting stylized facts for developing countries. 1/ The section emphasizes the co-movement of macroeconomic aggregates with the terms of trade, particularly the correlation between the trade balance and the terms of trade as a measure of the HLM effect.

Documenting stylized facts for several countries is difficult because it involves dealing with international databases created with country data of uneven quality. The data used here were obtained from the IMF's WEO Database and the *International Financial Statistics Yearbook 1991* and from the World Bank's World Tables as contained in the *Socio-economic Time-series Access and Retrieval System* (STARS) version 1.0 from March 1990. The data are annual observations of the U.S. dollar import and export unit values; the U.S. dollar value of credits and debits in the trade balance and factor payments accounts of the balance of payments; GDP, consumption, and investment at constant and current prices from national accounts; the average U.S. dollar exchange rate; and total population. Imports are selected as the 'numeraire', following Svensson and Razin (1983) and Greenwood (1984), and hence the terms of trade are the ratio of export to import unit values and all real variables are measured at constant *import* prices. Stylized facts for standard measures of real variables at constant prices have also been computed, and for simplicity these are referred to as variables at constant *domestic* prices. The sample period varies with country and variable, but in general it covers from 1960 or 1965 to 1988 or 1989. Details on this and other data-related issues are described in the notes to Tables 1-6. These tables list the statistical moments that characterize fluctuations in the terms of trade (TOT), the trade balance (TB), gross domestic product (GDP), private consumption (C), fixed investment (I), the real exchange rate (RER), and net foreign factor payments (NFFP).

The moments reported in Tables 1-6 correspond to cyclical components of filtered data. The Hodrick-Prescott (HP) filter is the one most commonly used in the real business cycle literature to separate trend and cyclical components of macroeconomic time series, although a quadratic time trend and a first difference filter have also been used occasionally. Despite the controversy surrounding filtering procedures (see Canova (1991)), there is evidence suggesting that these filters produce similar results for the relevant statistics used in this study. 2/ The data are filtered here using the quadratic time trend for simplicity, given the short sample of the cross-country data bases and the stagnating pattern of GDP per capita in many developing countries over the last two decades. For G-7 countries, Mendoza (1992a) reports the stylized facts for the same set of data examined here

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1/ Costello and Praschnik (1992) and Mendoza (1992b) report some stylized facts for developing economies.

2/ The statistical moments that Stockman and Tesar (1990) and Backus, Kehoe, and Kydland (1992b) calculated for the U.S., the U.K., Italy, Canada and France using the Hodrick-Prescott filter and the first-difference filter are roughly consistent with the corresponding moments reported in Table 1--taking into account that these authors define the terms of trade as the ratio of import to export prices.

(1991), Mendoza (1991), and Correia, Neves, and Rebelo (1991). These models mimic many of the stylized facts, with the exception that savings and consumption are almost perfectly correlated with output due to weak intertemporal substitution in a setup where the intertemporal relative price of consumption (i.e. the world's real interest rate) is independent of domestic saving decisions. Mendoza (1992a) examined an endowment model with nontraded goods and showed that, because the intertemporal relative price of consumption is affected by changes in the terms of trade and in the relative price of nontradables, consumption behavior is more realistic. However, the absence of investment produced unrealistic dynamics for the trade balance, foreign assets, and the real exchange rate.

A model in which changes in the terms of trade induce economic fluctuations may also be helpful for studying business cycles in developing countries. Since these countries typically import large amounts of capital goods and export primary commodities, terms-of-trade shocks affect significantly the productivity of investment and domestic relative prices. The mechanism by which changes in these variables cause economic fluctuations is well captured in real business cycle models, but until now research in this area has not focused much on developing countries. This paper documents stylized facts for 23 developing countries, and produces simulations for a version of the model parameterized and calibrated to represent a typical developing country.

The rest of the paper is organized as follows. Section II reviews the stylized facts that the model attempts to mimic, with emphasis on the Harberger-Laursen-Metzler effect and other properties of the terms of trade. Section III presents the model and discusses optimal intertemporal planning. Section IV discusses the determination of relevant parameter values and the simulation technique. Section V presents the results of numerical simulations for benchmark models of industrial and developing countries. Section VI discusses the robustness of the results to changes in preference parameters and in the stochastic processes of exogenous shocks. Some concluding remarks are included in the last section.

II. The Stylized Facts

This section documents some of the characteristics of recent business cycles in the seven largest industrialized countries (G-7) and 23 developing countries (DCs). Business cycle properties among industrialized countries have received much attention recently, 1/ but less work has been devoted to

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1/ Backus and Kehoe (1992) documented historical evidence on the international properties of business cycles, and some international stylized facts were also reported in Backus, Kehoe, and Kydland (1992a) and Baxter and Crucini (1992). The stylized facts of the terms of trade, including their correlation with net exports, were examined by Backus, Kehoe, and Kydland (1992b).

regularities are well reproduced by the models, actual terms-of-trade fluctuations are significantly underestimated--the terms of trade in industrial countries fluctuate 2 to 6 1/2 times more than in the models.

In two-country real business cycle models, the terms of trade are endogenous and their stochastic properties reflect the influence of exogenous shocks. Hence, the fact that the variability of the terms of trade is underestimated suggests that the effects of changes in the relative price of exports in terms of imports may not be fully captured. In contrast, this paper introduces shocks to the terms of trade of the magnitude observed in the data directly as an input for model simulations. This approach follows McCallum's (1989) view that real business cycle models should incorporate terms-of-trade effects explicitly to reduce their reliance on unobserved productivity disturbances, and to separate the effects of changes in imported input prices from the effects of technological change. As Finn (1991) showed, exogenous energy price shocks account for as much as one third of actual output variability in a closed-economy real business cycle model and, when these shocks are present, the conventional measure of Solow residuals is a misleading proxy for true productivity disturbances. 1/ This paper shows that terms-of-trade shocks account for more than half of actual output variability, although productivity disturbances continue to play an important role. 2/

The model examined here also departs from the three-good, two-country real business cycle framework in two important aspects. First, foreign assets in the form of one-period, risk-free bonds are the only claim exchanged internationally, and hence world markets of contingent claims are incomplete. 3/ Second, agents are allowed to trade internationally capital and consumption goods to be consistent with the fact that two thirds of a typical country's imports are capital and intermediate goods and one third are consumption goods (see Section IV for details). Thus, the model combines the production and investment framework of a real business cycle model with the Obstfeld-Svensson-Razin intertemporal equilibrium approach to the analysis of the current account in a small open economy--particularly the extensions that introduced nontraded goods (Greenwood (1984) and Ostry (1988)). Previous work on real business cycle theory for small open economies has examined a variety of models in which all goods are tradable--as in Cardia (1991), Lundvik

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1/ Praschnik and Costello (1992) obtained similar results in a study that examines technology and oil-price shocks as sources of business cycles in a two-country real business cycle model.

2/ Lundvik (1991) arrives to a similar conclusion using Swedish data and an overlapping generations model in which all goods are tradable.

3/ Market incompleteness limits the agents' ability to completely insure away country-specific shocks and strengthens the wealth effects resulting from these disturbances. Although it potentially could induce excessive consumption variability, Mendoza (1991a) showed that this is not the case. Moreover, Cole and Obstfeld (1991), showed that market incompleteness per se does not affect competitive allocations significantly under some specifications of preferences and technology.

the relative price of nontraded goods, as in Greenwood (1984), and hence that there is nominal-exchange-regime neutrality.

While early work on intertemporal equilibrium models questioned the savings behavior implicit in the HLM effect, it did not provide an interpretation of the link between terms of trade and business cycles because it focused mostly on deterministic models of endowment economies. Engel and Kletzer (1989) and Macklem (1991) showed both the complications that emerge with formal analysis when investment decisions are incorporated into these models, and the relevance of such decisions for predictions regarding the co-movement among macroeconomic aggregates. Moreover, the question of whether observed real-exchange-rate variability can be explained exclusively by adjustments in the relative price of nontraded goods stemming from real shocks was left unanswered and open to criticism. Mussa (1990) argued, for instance, that the variability of real exchange rates under floating nominal exchange rates has been too large to be accounted for by real disturbances.

Following the tradition of Obstfeld and Svensson and Razin, this paper examines the relationship between terms of trade and business cycles in a small open economy from a perspective of intertemporal equilibrium. The contribution is that this study derives the quantitative implications of a three-sector dynamic stochastic model and examines whether these implications are consistent with actual business cycles. Despite extensive theoretical work on the subject (see Frenkel and Razin (1987)), the actual co-movement between fluctuations in the terms of trade and other macroeconomic aggregates has not been documented in detail, nor has it been compared with the predictions obtained from theory. 1/ In this regard, the multi-country data base analyzed here highlights four stylized facts: (1) fluctuations in the terms of trade are large, not as persistent as productivity disturbances, and procyclical; (2) there is a Harberger-Laursen-Metzler effect and this effect is stronger in countries where terms-of-trade shocks are more persistent; (3) business cycles across countries exhibit similar characteristics; and (4) deviations from purchasing power parity are significant. The paper shows that business cycles in model economies driven by terms-of-trade shocks like those observed in the data, together with productivity shocks, are roughly consistent with these stylized facts.

Other recent research, related to the development of open-economy real business cycle models, focuses on issues similar to those examined here. A number of researchers have examined a two-country framework with complete markets following Backus, Kehoe, and Kydland (1992a) and Baxter and Crucini (1992). This framework explains some international business cycle facts, although complete markets lead to excessive risk sharing and excessive correlation of consumption across countries. Backus, Kehoe, and Kydland (1992b) and Stockman and Tesar (1990) examined three-good variants of this approach with specialized trade and found that, although some key empirical

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1/ Recently, Backus, Kehoe, and Kydland (1992b) have examined the stylized facts of the terms of trade in industrial countries using a two-country real business cycle model.

I. Introduction

Recurrent fluctuations in the terms of trade are commonly viewed as an important factor behind the generation and transmission of business cycles. Past issues of the International Monetary Fund's bi-annual review of the world economy, the World Economic Outlook (WEO), have documented sharp fluctuations in economic activity that affected many countries after the large terms-of-trade disturbances caused by the increases in the price of oil in 1973-74 and 1979-80, and the subsequent declines in 1982-83 and 1985-86. The WEO has also documented marked fluctuations in non-oil commodity prices that induced large variations in the terms of trade of developing countries and played a key role in the business cycle of these economies--the terms of trade increased by 7 percent during 1983-84 for exporters of non-oil primary commodities, and then declined by more than 18 percent from 1985 to 1990 (see International Monetary Fund (1991a)).

Because of its empirical relevance, the link between terms of trade and economic fluctuations has been subject of intense theoretical debate. The well-known Keynesian analysis of Harberger (1950) and Laursen and Metzler (1950) argued that, when the terms of trade worsen, the trade balance worsens and savings decline because a fall in the purchasing power of exports is in fact a reduction in income, and the marginal propensities to consume and save are less than unit--the Harberger-Laursen-Metzler (HLM) effect. 1/ When introduced into the IS-LM apparatus under conditions of perfect capital mobility, this widening of the trade deficit produces a decline in output that is transitory or permanent depending on the exchange-rate regime. 2/ Central to this argument was the conjecture that, because prices and wages adjust slowly, the response of the real exchange rate to a terms-of-trade shock is not determined by domestic relative price movements and depends on the behavior of the nominal exchange rate--i.e. the property of nominal-exchange-regime neutrality, as described in Mussa (1990), breaksdown.

In the early 1980s some doubts were cast on the analysis of Harberger and Laursen and Metzler. Obstfeld (1982), Svensson and Razin (1983), and Persson and Svensson (1985) showed that, when savings in a small open economy are modeled as the outcome of optimal intertemporal plans, the effect of a change in the terms of trade on savings and the trade balance depends on the perceived duration of terms-of-trade shocks. In general, with a fixed rate of time preference, transitory changes in the terms of trade result in the HLM effect, but permanent changes tend to leave savings and net exports unaffected. Further work argued also that the response of the real exchange rate to a terms-of-trade shock is determined by the effect of the latter on

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1/ Harberger and Laursen and Metzler aimed to show that even under a flexible exchange rate the economy could not be protected from business cycles abroad. For a review of this issue see Svensson and Razin (1983).

2/ A widening of the trade deficit shifts the IS curve to the left, and with a flexible exchange rate it produces a temporary fall in output and the nominal interest rate. With a fixed exchange rate the supply of money falls and the decline in output is permanent. These arguments ignore the direct relative price effect of a decline in the price of exports in terms of imports, which reduces the trade deficit and shifts the IS to the right.

Summary

This paper examines the relationship between economic fluctuations and terms of trade disturbances in the context of a stochastic intertemporal equilibrium model of a small open economy. The analysis aims to establish whether terms of trade shocks can account for a significant part of observed output variability, and whether the intertemporal equilibrium approach can explain the positive response of the trade balance to an improvement in the terms of trade--the Harberger-Laursen-Metzler effect--and fluctuations in real exchange rates of the magnitude observed in the past two decades.

The model's equilibrium co-movements, computed using recursive numerical simulation methods, reproduce many of the characteristics of recent economic fluctuations in the Group of Seven and 23 developing countries. In particular, a Harberger-Laursen-Metzler effect, which is stronger in industrial countries, and substantial deviations from purchasing power parity, which are larger in developing economies, are observed. The results also show that the model explains more than 50 percent of the observed variability of output in industrial countries. The intertemporal and intratemporal income and substitution effects that interact in the model to produce these results are examined by analyzing sensitivity to changes in the model's parameters and by constructing impulse response functions for the alternative parameter specifications.

The results of this analysis suggest that, despite the unquestionable role of nominal disturbances in explaining some aspects of the business cycle, terms of trade and productivity shocks themselves play an important role. Even when no market failure, no imperfections of capital markets, and no barriers to capital mobility are evident, small open economies may experience significant fluctuations in economic activity, the external balance, and the real exchange rate simply as the optimal response of economic agents to disturbances affecting export and import prices.

Contents

IMF WORKING PAPER

WP/92/93

INTERNATIONAL MONETARY FUND

Research Department

The Terms of Trade and Economic Fluctuations

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Authorized for distribution by Peter Wickham

November 1992

Abstract

A three-good, stochastic intertemporal equilibrium model of a small open economy is used to examine the link between terms of trade and business cycles. Equilibrium co-movements of model economies representing industrial and developing countries are computed and compared with the stylized facts of 30 countries. The results show that terms-of-trade shocks account for half of observed output variability and that the model mimics the Harberger-Laursen-Metzler effect and produces large deviations from purchasing power parity. The elasticity of substitution between tradable and nontradable goods and the persistence of the shocks play a key role in producing these results.

JEL Classification Numbers:
E3, F3, F4

1/ Helpful comments by Dave Backus, Guillermo Calvo, Mary Finn, Jeremy Greenwood, Jonathan Ostry, Assaf Razin, Carmen Reinhart, Lars Svensson, Linda Tesar and Peter Wickham are gratefully acknowledged. Suggestions by seminar participants at the International Monetary Fund, and the 1992 North American Summer Meeting and Latin American Meeting of the Econometric Society are also acknowledged.