

A New Look at Exchange Rate Volatility and Trade Flows

Peter B. Clark, Natalia Tamirisa, and Shang-Jin Wei,
with Azim Sadikov and Li Zeng



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Foreword

This study examines the effect of exchange rate volatility on trade, and was prepared in response to a request to the IMF from the Director General of the World Trade Organization (WTO). The IMF produced a study in 1984 for the General Agreement on Tariffs and Trade (GATT) on this subject. Since then, there have been major developments in the world economy, some perhaps having exacerbated fluctuations in exchange rates whereas others likely having reduced the impact of volatility on trade. It is therefore appropriate to revisit the issue some 20 years later.

Overall, there is no robust evidence of a large negative effect of exchange rate volatility on trade. This suggests that, from the perspective of enhancing trade, exchange rate volatility is not likely to be a major policy concern. This does not rule out the possibility that a large exchange rate volatility could affect an economy through other channels.

This study was prepared by a team led by Peter B. Clark and Shang-Jin Wei and consisted of Natalia Tamirisa, Azim Sadikov (summer intern), and Li Zeng (research assistant). It has benefited from comments from Mary Amiti, Giovanni Dell’Ariccia, Raghuram Rajan, Stephen Tokarick, Management, and various departments of the IMF, as well as from Marc Auboin, Richard Eglin, and other staff of the WTO. Miklos Koren, Andrew Rose, Adam Szeidl, and Silvana Tenreyro generously shared their data. Marlene George, Celia Burns, and Laura Leon provided able assistance. Gail Berre of the External Relations Department edited the paper and coordinated the production of the publication. The views expressed are those of the authors and do not necessarily reflect the views of national authorities or IMF Executive Directors.

Raghuram G. Rajan
Economic Counsellor and Director
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I Overview

In 1984 the IMF produced a study for the General Agreement on Tariffs and Trade (GATT) on the impact of exchange rate volatility on world trade. That study was motivated by an increase in protectionist pressures, large exchange rate movements among the major currencies, and a significant slowdown in world trade. Some of these developments have reappeared. For example, the growth in world exports of goods and services declined sharply in 2001–03 from the double-digit pace in 2000, and the exchange value of the U.S. dollar fluctuated fairly sharply during 2002–03. The 1984 study also reflected a desire to take stock of the implications for currency volatility and trade resulting from the shift from largely fixed to floating rates among the major currencies after the breakdown of the Bretton Woods system in 1971–73. Because there have been other major developments in the international monetary system since then, it is appropriate to revisit the issues addressed in that study some 20 years later.

Some of these developments would appear to have exacerbated fluctuations in exchange rates. The liberalization of capital flows in the last 30 years and the enormous increase in the scale and variety of cross-border financial transactions have clearly increased the magnitude of exchange rate movements in those countries with underdeveloped capital markets and those where there is not yet a track record of consistently stable economic policies.¹ Currency crises in emerging markets, which have become more frequent in the last two decades, are especially notable cases of large exchange rate volatility.² This has been of particular concern to developing countries and emerging market economies. In addition, the transition to a market-based system in Central and Eastern Europe often involves major adjustments in the international value of these economies' currencies.

Other changes in the world economy may have reduced the impact of exchange rate volatility. The pro-

liferation of financial hedging instruments over the last 20 years could reduce firms' vulnerability to the risks arising from volatile currency movements. In addition, for multinational firms fluctuations in different exchange rates may have offsetting effects on their profitability. As a growing fraction of international transactions is undertaken by these multinational firms, exchange rate volatility may have a declining impact on world trade.

On balance, it is not clear whether the major changes in the world economy over the past two decades have operated to reduce or increase the extent to which international trade is adversely affected by fluctuations in exchange rates. One aspect of this issue is the extent to which such volatility itself has changed, and another is the degree to which firms are sensitive to exchange rate risk and can take steps to mitigate it at low cost. It is therefore necessary to examine new empirical evidence on this issue.

There are a number of differences between the current study and the earlier one. To begin with, the country coverage is considerably broader. In IMF (1984) the analysis was focused almost exclusively on the G-7 countries. This reflected the view that fluctuations in the major currencies were the most important factor for the environment within which other countries have to plan their policies.³ While these currencies are the most important to the functioning of the international monetary system, fluctuations in many other exchange rates are also relevant for systemic reasons as well as for their implications for the other countries themselves. Therefore, this study takes a more comprehensive view of the subject and covers the exchange rates of all IMF members for which data are available.

The study also explores a range of different exchange rate volatility measures. Moreover, aside from examining aggregate trade, the study divides all products into two groups—differentiated and homogeneous products—and tests whether volatility has a differentiated effect on them.

Given the large number of countries in the data set, it is possible to estimate the degree to which volatility has

¹Some aspects of these developments have recently been analyzed in Prasad and others (2003).

²Issues related to balance of payments adjustments in response to capital account crises were discussed in a recent note to the WTO prepared by IMF staff. (See World Trade Organization, 2003.)

³For a recent analysis of the impact of G-3 exchange rate volatility on developing countries, see "How Concerned Should Developing Countries Be About G-3 Exchange Rates" in IMF (2003a).

a differential effect depending on whether the country is advanced or developing. The estimation techniques are also quite different, as recent theoretical advances in gravity-equation specification are employed to assess more accurately the impact of exchange rate volatility on trade.

Finally, following the work of Rose (2000), the study looks at the effect of common currency arrangements on trade. This is a related yet distinct issue from the impact of exchange rate volatility because a currency union is more than just an elimination of exchange rate volatility among members. It reduces other transaction costs relevant to trade and provides a commitment device for macroeconomic policies.

Anticipating some of the findings below, this study shows that while exchange rate fluctuations have increased in times of currency and balance of payments crises during the 1980s and 1990s, there does not appear to have been any increase, on average, in such volatility between the 1970s and the 1990s. It is also noteworthy that an exchange rate regime that is classified as pegged does not necessarily have lower overall exchange rate volatility than an arrangement that permits some degree of rate flexibility. Pegging to an anchor currency still leaves a country exposed to fluctuations in the anchor against other currencies, and a peg that becomes misaligned can subsequently generate exchange market pressures and large, discrete changes in currency values, and hence volatility.

A review of the theoretical literature since the 1984 study has, if anything, reinforced the conclusion that there is no unambiguous relationship between exchange rate volatility and trade flows. The general presumption that trade is adversely affected by an increase in exchange rate fluctuations depends on a number of specific assumptions and does not necessarily hold in all cases, especially in general equilibrium models, where other variables change along with exchange rates. These models show that exchange rate volatility is the result of the volatility in underlying shocks to the economy and the policy regime, which deter-

mines how the shocks are reflected in exchange rates and other variables.

For the world as a whole, there is no obvious association between periods of low exchange rate volatility and periods of fast growth in trade. In other words, at an aggregate level there is no evidence of a negative effect of exchange rates on world trade. Once one examines the data on trade and exchange rate volatility at a bilateral level, a negative relationship between the two is borne out by some of the empirical evidence in this study. This negative relationship, however, is not robust to a more general specification of the equation linking bilateral trade to its determinants that embodies the recent theoretical advances in a gravity model. Thus, if there is a negative impact of exchange rate volatility on trade, it is not likely to be quantitatively large and the effect is not robust.

These findings suggest that, from the perspective of promoting world trade, exchange rate volatility is probably not a major policy concern. Note that this does not imply necessarily that exchange rate fluctuations should be viewed with equanimity. For example, currency crises—special cases of exchange rate volatility—have required painful adjustments in output and consumption. In this case, however, what is important is not that measures need to be taken to moderate currency fluctuations directly, but that appropriate policies need to be pursued in order to avoid the underlying causes of large, unpredictable, and damaging movements in exchange rates.

There are a number of aspects related to exchange rate volatility that are not covered in this study. It does not deal with determining the level of exchange rates nor with choosing the optimal exchange rate arrangement, e.g., fixed versus floating.⁴

Section II reviews the relevant theoretical and empirical literature over the last two decades. Section III describes the recent history of exchange rate volatility in different parts of the world. Section IV presents some new evidence on the effect of exchange rate volatility on trade, and Section V offers concluding remarks.

⁴For an extensive analysis of the performance of alternative exchange rate regimes, see Rogoff and others (2004).

II A Brief Review of the Theoretical and Empirical Literature

Since the appearance of the 1984 IMF study on the effects of exchange rate volatility on trade, two survey papers covering the literature on this topic have appeared, Côté (1994) and McKenzie (1999). In addition, the U.K. Treasury recently commissioned a number of studies (U.K. Treasury, 2003) and invited submissions from numerous academics to provide data for an assessment of the desirability of joining EMU. Therefore, it is not necessary to present a comprehensive discussion of the many contributions to the field. Rather, the focus here will be on certain key issues that explain why it has been difficult to reach clear-cut conclusions on the impact of exchange rate variability on trade flows. The study will also focus on some of the more recent work in the area. The two aforementioned surveys conclude that, from a theoretical perspective, there is no unambiguous response in the level of trade to an increase in exchange rate volatility because differing results can arise from plausible alternative assumptions and modeling strategies. The same ambiguity pervades much of the empirical literature, which may reflect the lack of clear-cut theoretical results as well as the difficulty in arriving at an appropriate proxy for exchange rate risk. Nonetheless, some recent studies, as well as some of the evidence presented here, appear to suggest that the data support a negative relationship.

Theoretical Aspects of the Relationship Between Exchange Rate Volatility and Trade

It is useful to begin with the example of a rudimentary exporting firm to illustrate how (real) exchange rate volatility can affect the level of its exports. The simplest case, described by Clark (1973), considers a competitive firm with no market power, producing only one commodity sold entirely to one foreign market, and that does not import any intermediate inputs. The firm is paid in foreign currency and converts the proceeds of its exports at the current exchange rate, which varies in an unpredictable fashion because there are no hedging possibilities by assumption, such as through forward contracts. Moreover, because of

costs involved in adjusting the scale of production, the firm must make timely production decisions in advance of any subsequent exchange rate movements. Therefore, it cannot alter its output in response to favorable or unfavorable shifts in the profitability of its exports arising from these movements. In this situation, the variability in the firm's profits arises solely from the exchange rate. Also, where the managers of the firm are adverse to risk, greater volatility in the exchange rate—with no change in its average level—leads to a reduction in output, and hence in exports, in order to reduce the exposure to risk. This basic model has been elaborated by a number of authors, such as Hooper and Kohlhagen (1978), who reach the same conclusion of a clearly negative relationship between exchange rate volatility and the level of trade.

This strong conclusion, however, rests on a number of simplifying assumptions. First, it is assumed that there are no hedging possibilities either through the forward exchange market or through offsetting transactions. For advanced economies, where there are well-developed forward markets, specific transactions can be easily hedged, thus reducing exposure to unforeseen movements in exchange rates.⁵

Moreover, there are numerous possibilities for reducing exposure to the risk of adverse exchange rate fluctuations other than forward currency markets. The key point is that for a multinational firm engaged in a wide variety of trade and financial transactions across a large number of countries, there are manifold opportunities to exploit offsetting movements in currencies and other variables. For example, there is a clear tendency for exchange rates to adjust to differences in inflation rates, and recent evidence suggests that such adjustments may be quicker than indicated by earlier studies. Thus, if exports are priced in a foreign currency that is depreciating, the loss to the exporter from the declining exchange rate is at least partly offset by the higher foreign-currency export price (Cushman,

⁵For an analysis of the effects of forward cover on the level of trade, see Ethier (1973), Kawai and Zilcha (1986), and Viaene and de Vries (1992). Wei (1999), however, does not find empirical support for the hypothesis that the availability of hedging instruments reduces the impact of exchange rate volatility on trade.

1983 and 1986). In a similar vein, as noted by Clark (1973), to the extent that an exporter imports intermediate inputs from a country whose currency is depreciating, there will be some offset to declining export revenue in the form of lower input costs. In addition, when a firm trades with a large number of countries, the tendency for some exchange rates to move in offsetting directions will provide a degree of protection to its overall exposure to currency risk. Finally, as analyzed by Makin (1978), a finance perspective suggests that there are many possibilities for a multinational corporation to hedge foreign currency risks arising from exports and imports by holding a portfolio of assets and liabilities in different currencies.

One reason why trade may be adversely affected by exchange rate volatility stems from the assumption that the firm cannot alter factor inputs in order to adjust optimally to movements in exchange rates. When this assumption is relaxed and firms can adjust one or more factors of production in response to movements in exchange rates, increased variability can in fact create profit opportunities. This situation has been analyzed by Canzoneri and others (1984), De Grauwe (1992), and Gros (1987). The effect of such volatility depends on the interaction of two forces at work. On the one hand, if the firm can adjust inputs to both high and low prices, its expected or average profits will be larger with greater exchange rate variability because it will sell more when the price is high and vice versa. On the other hand, to the extent that there is risk aversion, the higher variance of profits has an adverse effect on the firm and constitutes a disincentive to produce and to export. If risk aversion is relatively low, the positive effect of greater price variability on expected profits outweighs the negative impact of the higher variability of profits, and the firm will raise the average capital stock and the level of output and exports. In a more general setting that analyzes the behavior of a firm under uncertainty, Pindyck (1982) has also shown that, under certain conditions, increased price variability can result in increased average investment and output as the firm adjusts to take advantage of high prices and to minimize the impact of low prices.

One aspect of the relationship between trade and exchange rate volatility that must be mentioned is the role of “sunk costs.” Much of international trade consists of differentiated manufactured goods that typically require significant investment by firms to adapt their products to foreign markets, to set up marketing and distribution networks, and to set up production facilities specifically designed for export markets. These sunk costs would make firms less responsive to short-run movements in the exchange rate because they would tend to adopt a wait-and-see approach, stay in the export market as long as they can recover their variable costs, and wait for a turnaround in the exchange rate to recoup their sunk costs. Following the

finance literature on real options, McDonald and Siegel (1986), Dixit (1989), and Krugman (1989) have explored the implications of sunk costs in the context of an “options” approach, which has been applied by Franke (1991) and Sercu and Vanhulle (1992). The key idea is that an exporting firm can be viewed as owning an option to leave the export market, and a firm not currently exporting can be regarded as owning an option to enter the foreign market in the future. The decision to enter or exit the export market involves considering explicit fixed and variable costs—but also the cost of exercising the option to enter or leave the market. The greater the volatility in exchange rates, the greater the value of keeping the option; hence the larger the range of exchange rates within which the firm delays action by staying in the export market or staying out if it has not yet entered. This suggests that increased exchange rate volatility would increase the inertia in entry and exit decisions.

In most theoretical models, that which is being studied is the volatility of the real exchange rate, as opposed to that of the nominal exchange rate. The two are distinct conceptually but do not differ much in reality: prices of goods tend to be sticky in local currency in the short-to-medium run. In this case, real and nominal exchange rate volatilities are virtually the same for practical purposes. For this reason, after reviewing the literature on the effect of real exchange rate volatility, this study does not present a separate discussion on the effect of nominal exchange rate volatility. The exceptions are episodes of high inflation, when nominal exchange rate volatility tends to be bigger than real exchange rate volatility. For this reason, the empirical analysis that will be presented later examines explicitly whether or not real versus nominal exchange rate volatilities have different effects on trade.

Up to this point, the discussion of the impact of volatility on trade has been within a partial equilibrium framework, i.e., the only variable that changes is some measure of the variability of the exchange rate; all other factors that may have an influence on the level of trade are assumed to remain unchanged. Those developments that are generating the exchange rate movements, however, are likely to affect other aspects of the economic environment, which will in turn have an effect on trade flows. Thus, in a general equilibrium framework it is important to take account of the interaction of all the major macroeconomic variables to get a more complete picture of the relationship between exchange rate variability and trade.

Such an analysis has been provided recently by Bacchetta and Van Wincoop (2000). They develop a simple, two-country general equilibrium model, where uncertainty arises from monetary, fiscal, and technology shocks, and they compare the level of trade and welfare for fixed and floating exchange rate arrangements. They reach two main conclusions. First, there

is no clear relationship between the level of trade and the type of exchange rate arrangement. Depending on the preferences of consumers regarding the tradeoff between consumption and leisure, as well as the monetary policy rules followed in each system, trade can be higher or lower under either exchange rate arrangement. As an example of the ambiguity of the relationship between volatility and trade in a general equilibrium environment, a monetary expansion in a country would depreciate its exchange rate causing it to reduce its imports, but the increased demand generated by the monetary expansion could offset part or all of the exchange rate effect. Thus, the nature of the shock that causes the exchange rate change can lead to changes in other macroeconomic variables that offset the impact of the movement in the exchange rate. Second, the level of trade does not provide a good index of the level of welfare in a country, and thus there is no one-to-one relationship between levels of trade and welfare in comparing exchange rate systems. In their model, the authors determine trade by the certainty equivalent of a firm's revenue and costs in the home market relative to the foreign market, whereas the welfare of the country is determined by the volatility of consumption and leisure.

Obstfeld and Rogoff (1998) also provide an analysis of the welfare costs of exchange rate volatility. They extend the "new open-economy macroeconomic model" to an explicitly stochastic environment, where risk has an impact on the price-setting decisions of firms and, hence, on output and international trade flows. They provide an illustrative example whereby reducing the variance of the exchange rate to zero by pegging the exchange rate could result in a welfare gain of up to one percent of GDP. Bergin and Tchakarov (2003) provide an extension of this type of model to more realistic situations involving incomplete asset markets and investment by firms. They are able to calculate the effects of exchange rate uncertainty for a wide range of cases and find that the welfare costs are generally quite small, on the order of one-tenth of one percent of consumption. They explore the implications of two cases, however, where risk does matter quantitatively, on the order of the effect in the example cited above by Obstfeld and Rogoff: first, where consumers exhibit considerable persistence in their patterns of consumption, such that welfare is adversely affected by sudden changes in consumption; and second, where asset markets are asymmetric in that there is only one international bond, such that the country without its own bond is adversely affected.

Finally, Koren and Szeidl (2003) develop a model that brings out clearly the interactions among macroeconomic variables. They show that what matters is not the unconditional volatility of the exchange rate as a proxy for risk, as used in many empirical papers in the literature, but rather that exchange rate uncertainty

should influence trade volumes and prices through the covariances of the exchange rate with the other key variables in the model. In this general equilibrium context, they stress that it is not uncertainty in the exchange rate per se that matters, but rather whether this uncertainty magnifies or reduces a firm's other risks on the cost and demand side, and ultimately whether it exacerbates or moderates the risk faced by consumers.

Empirical Results on the Relationship Between Exchange Rate Volatility and Trade

The early empirical work on the effect of exchange rate variability on trade surveyed in the 1984 IMF study did not yield consistent results, with much of the work yielding little or no support for a negative effect. For example, the early work by Hooper and Kohlhagen (1978) used the model of Ethier (1973) for traded goods and derived equations for export prices and quantities in terms of the costs of production, reflecting both domestic and imported inputs, other domestic prices, domestic income, and capacity utilization. Exchange rate risk was measured by the average absolute difference between the current period spot exchange rate and the forward rate of the last period, as well as by the variance of the nominal spot rate and the current forward rate. The authors examined the impact of exchange rate volatility on aggregate and bilateral trade flow data for all G-7 countries except Italy. In terms of the effect of volatility on trade flows, they found essentially no evidence of any negative effect. Cushman (1983) uses a model similar to that of Hooper and Kohlhagen but extends the sample size and uses real as opposed to nominal exchange rates. Of 14 sets of bilateral trade flows between industrial countries, he found a negative and significant effect of volatility for six cases. Finally, IMF (1984) uses a simplified version of Cushman's model to estimate bilateral exports between the G-7 countries from the first quarter of 1969 to the fourth quarter of 1982, with real GNP, the real bilateral exchange rate, relative capacity utilization, and variability measured as the standard deviation of the percentage changes in the exchange rate over the preceding five quarters. In only two cases did variability have a significantly negative coefficient, while positive coefficients were significant in several cases.

A number of factors may have contributed to the lack of robust findings in this early work. First, as noted above, theoretical considerations do not provide clear support for the conventional assumption that exchange rate volatility has a negative impact on the level of trade. Second, the sample period over which exchange rates showed significant variation was relatively short. Finally, the specification of the estimating equations

was typically rather crude, consisting of a few macro variables from standard trade equations in use at the time.

McKenzie (1999) surveys a large number of empirical papers on the topic, most of which appeared after the IMF study. He stresses the point made above that, at a theoretical level, models have been constructed that lead to negative or positive effects of variability on trade, and that a priori there is no clear case that one model is superior to another. His survey of the empirical work leads to the same mixed picture of results, with many studies finding no significant effect or, where significant, no systematic effect in one direction or the other. He finds, however, that the most recent contributions to the literature have been more successful in obtaining a statistically significant relationship between volatility and trade, which he attributes to more careful attention to the specification of the estimation technique and the measure of volatility used. Similarly, U.K. Treasury (2003) cites a number of recent studies—De Grauwe (1987), Rose (2000), Dell’Ariccia (1999), Anderton and Skudelny (2001), Arize (1998), and Fountas and Aristotelous (1999)—that find a negative link, but these effects are not very large: complete elimination of volatility would raise trade by a maximum of 15 percent compared to the consensus estimate of the effect as typically less than 10 percent.

Recent work on this topic employing the gravity model has found some significant evidence of a negative relationship between exchange rate variability and trade.⁶ The gravity equation has been used widely in empirical work in international economics and has been highly successful in explaining trade flows.⁷ In its basic form, the gravity model shows bilateral trade flows between countries as depending positively on the product of their GDPs and negatively on their geographical distance from each other. Countries with larger economies tend to trade more in absolute terms, while distance can be viewed as a proxy for transportation costs, which act as an impediment to trade. In addition, population is often included as an explanatory variable as an additional measure of country size. In many applications, a host of dummy variables are added to account for shared characteristics that would increase the likelihood of trade between two countries, such as common borders, common language, and membership in a free trade association. To this basic equation researchers add some measure of exchange rate variability to see if this proxy for exchange rate risk has a separate, identifiable effect on trade

⁶See Frankel and Wei (1993), Wei (1999), Dell’Ariccia (1999), Rose (2000), and Tenreiro (2003).

⁷See, for example, McCallum (1995) and Coe and others (2002). For discussions of the gravity equation, see Deardorff (1998), Anderson and van Wincoop (2003), and Annex D in U.K. Treasury (2003).

flows after all other major factors have been taken into account.

The work by Dell’Ariccia (1999) provides a systematic analysis of exchange rate volatility on the bilateral trade of the 15 EU members at that time and Switzerland over the 20-year period from 1975 to 1994, using four different measures of exchange rate uncertainty: the standard deviation of the first difference of the logarithm of the monthly bilateral nominal exchange rate, that of the real exchange rate, the sum of the squares of forward errors, and the percentage difference between the maximum and minimum of the nominal spot rate. In the basic regressions, exchange rate volatility has a small but significantly negative impact on trade: eliminating volatility to zero in 1994 would have increased trade by an amount ranging from 10 to 13 percent, depending on the particular measure of variability.⁸ The results for both nominal and real variability are very close, which is not surprising given that in the sample the two exchange rate measures are highly correlated.

Dell’Ariccia then goes on to take account of the simultaneity bias that can result from central banks’ attempts to stabilize their exchange rates with their main trading partners. If they were successful, there would be a negative association between exchange rate variability and the level of trade, but it would not reflect causation from the former to the latter. He first uses an instrument (the sum of squares of the three-month logarithmic forward error) for the measures of exchange rate volatility to account for possible endogeneity in this variable. The results confirm the negative relationship between volatility and trade, with the magnitude of the effect about the same as before. In addition, he uses both fixed effects and random effects estimation methods to account for the simultaneity bias. In this case, the effect is still significant, but the magnitude is much smaller: total elimination of exchange rate volatility in 1994 would have increased trade by only 3–4 percent.

Rose (2000) also employs the gravity approach and uses a very large data set involving 186 countries for the five years 1970, 1975, 1980, 1985, and 1990. His main objective in the paper is to measure the effect of currency unions on members’ trade—an issue that is dealt with at length below—but he also uses his model to test for the effects of exchange rate volatility on trade. His primary measure of volatility is the standard deviation of the first difference of the monthly logarithm of the bilateral nominal exchange rate, which is computed over the five years preceding the year of estimation. In his benchmark results using the pooled data, he finds a small but significant negative effect:

⁸In 1994, the average standard deviation of the monthly nominal exchange rate change was roughly 5.5 percent, and over the sample period the annual average bilateral trade growth was 3.5 percent.

reducing volatility by one standard deviation (7 percent) around the mean (5 percent) would increase bilateral trade by about 13 percent, which is similar to the finding of Dell’Ariccia described above.⁹ This result is robust when using three alternative measures of volatility, but not when the standard deviation over the previous five years of the *level* of the exchange rate is used. When random effects are incorporated in the estimation, however, the magnitude of the effect of volatility on trade is reduced to about a third of the benchmark estimate, or roughly 4 percent. Thus the estimation results of Rose and Dell’Ariccia appear to be quite consistent.

A recent paper by Tenreyro (2003) casts some doubt, however, on the robustness of these results. She uses a gravity equation similar to that of Rose for a broad sample of countries, using annual data from 1970 to 1997. The measure of volatility is the same as that employed by Rose, except that the standard deviation of the log change in monthly exchange rates is measured only over the current year. Her main objective is to address several estimation problems in previous studies on the effect of volatility on trade. When these problems are not addressed and the ordinary least squares method is used, she finds a small effect:

reducing volatility from its sample mean of about 5 percent to zero results in an increase in trade of only 2 percent. When the more appropriate method is used, but without taking account of endogeneity, eliminating exchange rate uncertainty leads to an estimated 4 percent increase in trade. When endogeneity is taken into account through the use of instruments, however, volatility has an insignificant effect on trade: a result that is robust on the choice of instruments.

Finally, it should be noted that there has been some recent work looking at the effects of exchange rate volatility on disaggregated trade flows. Broda and Romalis (2003) find that volatility decreases trade in differentiated products relative to trade in commodities, although the effect is rather small: eliminating all real exchange rate volatility would increase trade in manufactures by less than 5 percent and total trade by less than 3 percent. They note, however, that some countries with particularly volatile exchange rates, especially developing countries, would experience a more pronounced increase in trade. Koren and Szeidl (2003) also use disaggregated data and find small effects: eliminating exchange rate variability would result in a change in export prices of only a few percentage points.

⁹Parsley and Wei (2001) look at the effect of reducing nominal exchange rate variability on relative price variability across countries and find that reducing the former diminishes the latter. They also find, however, a much stronger effect arising from participation in a hard peg, such as a currency union, which is consistent with Rose’s finding of a large impact of a currency union on trade.

III Recent History and Geography of Exchange Rate Volatility

Measuring Exchange Rate Volatility

In the voluminous literature on exchange rate volatility and trade, there is no consensus on the appropriate method for measuring such volatility. This lack of agreement reflects a number of factors. As noted in the section below, there is no generally accepted model of firm behavior that is subject to risk arising from fluctuations in exchange rates and other variables. Consequently, theory cannot provide definitive guidance as to which measure is most suitable. Moreover, the scope of the analysis will dictate to some extent the type of measure used. If the focus is on advanced countries, then one could take into account forward markets for the assessment of exchange rate volatility on trade, whereas this would not be possible if the analysis extended to a large number of developing countries. In addition, one needs to consider the time horizon over which variability is to be measured, as well as whether it is unconditional volatility or the unexpected movement in the exchange rate relative to its predicted value that is the relevant measure. Finally, the level of aggregation of trade flows being considered will also play a role in determining the appropriate measure of the exchange rate to be used.

This study provides a comprehensive picture of volatility in exchange rates across the entire IMF membership for which data are available. In the empirical analysis, the paper starts with an examination of the relationship between aggregate exchange rate volatility and aggregate trade. Recognizing the limitations of looking at the aggregate data, the study then turns to analyzing the effect of exchange rate volatility on trade across different country pairs and over time. Methodologically, the switch to bilateral trade and volatility allows one to better control a variety of factors other than volatility that could affect trade. As a consequence, the chance to detect an effect of exchange rate volatility on trade improves. Given this methodological approach, the basic building block in the analysis is the volatility in the exchange rate between the currencies of each pair of countries in the sample. For the descriptive part of the study below, which looks at the exchange rate volatility facing a country as a whole, it is necessary to aggregate the bilateral volatilities using trade shares as weights to obtain what is referred to as the

“effective volatility” of a country’s exchange rates. This ensures that the measures of volatility in the descriptive and econometric parts of the study are fully consistent.

Such a measure of effective volatility presupposes that the exchange rate uncertainty facing an individual firm is an average of the variability of individual bilateral exchange rates (Lanyi and Suss, 1982). If a trading firm engages in international transactions with a wide range of countries, however, any tendency for exchange rates to move in offsetting directions would reduce the overall exposure of the firm to exchange rate risk. This would argue for using the volatility of a country’s effective exchange rate as the measure of exchange rate uncertainty facing a country. This would seem particularly appropriate for advanced economies, where much trade is undertaken by diversified multinational corporations. This was the approach taken in the original IMF study, which focused almost exclusively on the G-7 countries. The present study, however, covers nearly all developing countries, where the role of diversified firms is less pronounced. For this reason, as well as for consistency with the econometric analysis below, effective volatility is used in the descriptive part of the study.

It is important to realize that the degree of exchange rate variability to which a country is exposed is not necessarily closely related to the type of exchange rate regime it has adopted. A country may peg its currency to an anchor currency but will float against all other currencies if the anchor does as well. Thus, as with effective exchange rates, effective volatility is a multi-dimensional concept (Polak, 1988). Pegging can reduce nominal exchange rate volatility vis-à-vis one trading partner, but it can by no means eliminate overall exchange rate variability. This is shown below, where measured volatility is related to two different classifications of a country’s exchange rate arrangement.

The choice between using nominal and real exchange rates depends in part on the time dimension that is relevant for the economic decision being taken. In the short run, where costs of production are known and export and import prices have been determined, the exchange rate exposure of a firm is a function of the nominal exchange rate. The decision to engage in international transactions, however, stretches over a longer

period of time, during which production costs and export and import prices in foreign currency will vary. From this perspective, exchange rates measured in real terms are appropriate. Nonetheless, as nominal and real exchange rates tend to move closely together, given the stickiness of domestic prices, the choice of which one to use is not likely to affect significantly measured volatility or the econometric results. Still, real rates are preferable on theoretical grounds and are used in the benchmark measures of volatility below. Consumer prices are used to construct the real rates because they are the most widely available measures of domestic prices. As a robustness check, results using nominal exchange rates are also reported.

While exchange rates are often highly volatile, the extent to which they are a source of uncertainty and risk depends on the degree to which exchange rate movements are foreseen. When hedging instruments are available, the predicted part of exchange rate volatility can be hedged away and hence may not have much effect on trade. This suggests that the appropriate measure of risk should be related to deviations between actual and predicted exchange rates. One possibility along these lines would be to use the forward rate as a prediction of the future spot rate and to use the difference between the current spot rate and the previous period forward rate as an indicator of exchange rate risk. One problem with this approach is that the forward rate is not a good predictor of future exchange rates. In addition, quotations are available only for the major currencies. More generally, there are a wide variety of methods—ranging from structural models to time series equations using autoregressive conditional heteroskedasticity (ARCH)/generalized ARCH (GARCH) approaches, for example—that could be used to generate predicted values of exchange rates (McKenzie, 1999). As pointed out by Meese and Rogoff (1983), however, there are inherent difficulties in predicting exchange rates. Therefore, this study adopts the approach followed in much of the work on the topic and uses a measure of the observed variability of exchange rates as the benchmark. GARCH estimates are included as an alternative measure of volatility.

The most widely used measure of exchange rate volatility is the standard deviation of the first difference of logarithms of the exchange rate.¹⁰ This measure has the property of being equal to zero if the exchange rate follows a constant trend, which presumably could be anticipated and therefore would not be a source of uncertainty. Following the practice in most other studies, the change in the exchange rate is computed over

one month using end-of-month data. The standard deviation is calculated over a one-year period as an indicator of short-run volatility, as well as over a five-year period to capture long-run variability.

Finally, it is useful to take note of the role of currency invoicing here. Very often trade between a pair of countries, especially between two developing countries, is not invoiced in the currency of either country. Instead, a major currency—especially the U.S. dollar—is often used as the invoicing currency. It might appear that the volatility of the exchange rate between the currencies of the two trading partners is not the relevant volatility to consider. For example, if Chinese exports to India are invoiced in U.S. dollars, it might seem that the Chinese exporters would only care about the fluctuations between the U.S. dollar and the Chinese yuan, but not between the Indian rupee and the Chinese yuan. This view, however, is not correct. Any fluctuation between the Chinese yuan and the Indian rupee, holding constant the Chinese yuan/U.S. dollar rate, must reflect fluctuations in the Indian rupee/U.S. dollar rate. As the latter could affect the Indian demand for Chinese exports, fluctuations in the Chinese yuan/Indian rupee exchange rate would also affect Chinese exports to India even if the trade is invoiced in U.S. dollars. Generally speaking, the choice of invoicing currency does not alter the effect of exchange rate volatility on trade.

Comparisons Using the Benchmark Measure of Volatility

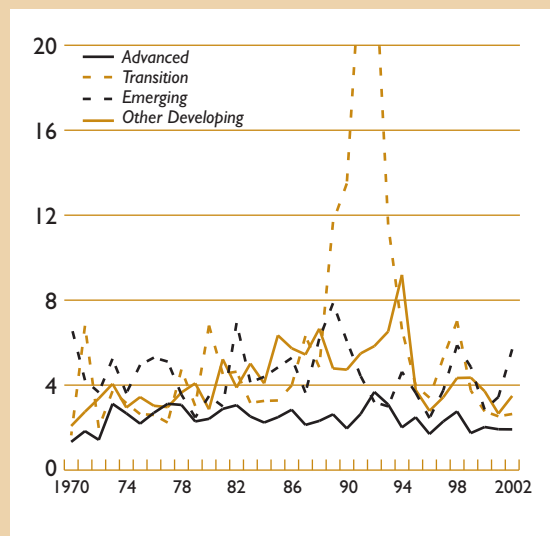
It is useful to begin the analysis of exchange rate volatility over time and across countries by examining the evolution of fluctuations in exchange rates for broad groups of countries as shown in Figure 3.1.¹¹ This shows the short-run effective volatility since 1970 of exchange rates reported in the IMF's *International Financial Statistics (IFS)*, converted to real terms using consumer prices for advanced, transition, emerging market, and developing economies.¹² As

¹¹Figure 3.1 shows equal-weighted averages of the effective volatilities of the exchange rates of the countries in each group, as each individual country is viewed as the unit of interest. Alternatively, one could weight the effective volatility of each country by its trade share. This weighted-average volatility was computed for each group, and the results are not markedly different from what is shown in Figure 3.1.

¹²The list of countries in each group is given in Appendix Table A1. The list of advanced countries follows that in the *World Economic Outlook*, Table A in the Statistical Appendix, except that the four newly industrialized Asian economies are included in the group of emerging markets. The transition economies comprise the countries in transition in Table A. The group of emerging market economies is a fairly narrow list of 20 countries. All other countries are included in the list of developing countries.

¹⁰See, for example, Brodsky (1984), Kenen and Rodrik (1986), Frankel and Wei (1993), Dell'Araccia (1999), Rose (2000), and Tenreiro (2003).

Figure 3.1. Short-Run Effective Volatility of the Real Exchange Rate by Country Groups
(In percent)



noted in Section I, there were several developments in the international monetary system over this period, including crises in emerging market economies, capital account liberalization, and the breakup of the former Soviet Union, all of which tended to be associated with an increase in exchange rate volatility.

First, looking at the how variability has changed over the sample period, it is noteworthy that there is no obvious trend increase over time. In the first three years of the sample period 1970–72, lower-than-average effective volatility is evident for the advanced economies, which reflects the fixed-rate system of most of these countries. Since then, the exchange rates of these countries have exhibited greater volatility, but not markedly so. In fact, the average effective volatility from 1991–2002 is about the same as in 1970–80. There is also no clear upward trend in exchange rate volatility in emerging market economies and developing countries over the entire period. While transition economy exchange rates exhibited much greater variability on average in the 1990–2002 period, this reflects the very large change in exchange rates associated with the breakup of the former Soviet Union and the shift to market economies from 1989 to 1993. The unprecedented high level of volatility during these years was a reflection by and large of adjustments in real exchange rates that were needed to accommodate the structural transformation of these economies. These adjustments now appear to be essentially complete, and in recent years (1999–2002)

the effective volatility in their real exchange rates has been less than that of emerging and developing countries.

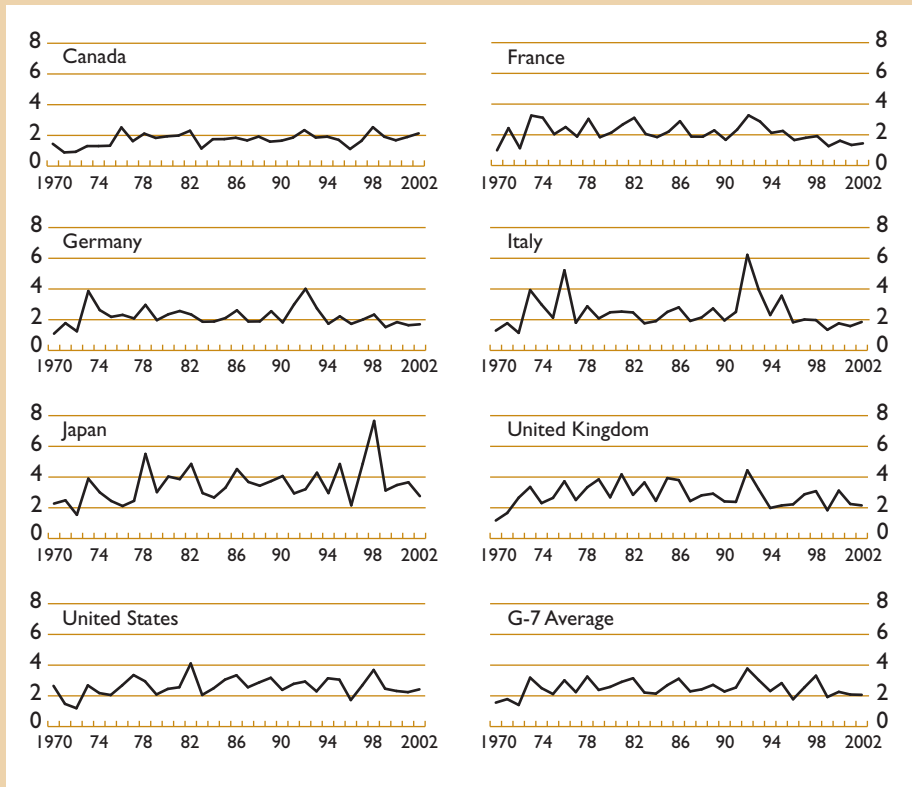
Second, looking across the major country groupings, it is not surprising that measured volatility is lowest for the advanced economies. This reflects the fact that these countries trade relatively more with each other and that their bilateral exchange rates with each other tend to exhibit smaller fluctuations than with other countries, as discussed below. The lower volatility within the group arises presumably from the greater stability in the economic policies of the advanced economies, as well as from their ability to adjust relatively smoothly to shocks. In addition, the foreign exchange markets in which these currencies are traded are very large and liquid, with instruments available to hedge volatility that enable these markets to clear quickly, thereby dampening potentially large fluctuations in exchange rates.

Figure 3.2 shows the same measure of volatility for the G-7 countries individually, as well as for the group as a whole. While variability is, on average, very similar to that for advanced countries as a whole, there are notable differences. The high average volatility for Japan, at 3.50 percent, is double that of Canada, at 1.75 percent. This latter low figure would appear to reflect the close integration of the Canadian and U.S. economies, as well as the strategy of the Canadian authorities to avoid large swings in the Canadian-U.S. dollar exchange rate over part of the sample period. Also noteworthy is the increased volatility for France, Germany, and Italy surrounding the turmoil in the exchange rate mechanism of the European monetary system in 1991–93 (which also affected the United Kingdom in 1992), as well as a noticeable reduction in effective volatility in the exchange rates of these three countries with the introduction of the euro in 1999.

To illustrate the reasons for the relatively low effective volatility of the advanced economies, it is useful to decompose the variability in their exchange rates into the contributions of each of the major country groups. This is done in Table 3.1 for the G-7 countries. First, the table decomposes the effective volatility of each of the G-7 into the share of volatility from each group for the years 1970, 1980, 1990, and 2000, so that the row sum equals the overall effective volatility for that country, shown in the last row. It is clear that with two exceptions, Japan and the United States in 1970, the largest component of volatility is that arising from the exchange rates of the other advanced economies. This reflects, in part, the fact that the trade weights of the industrial countries are very high, as well as the lower volatility of the individual bilateral exchange rates among the advanced countries. This is shown in the second portion of the table, which gives the volatility of the exchange rates of the G-7 within each of the major country groupings, computed with the trade weights summing to unity for each group. It shows that, with only a few exceptions, the volatility of the exchange rates of the G-7 with other

Figure 3.2. Short-Run Effective Volatility of the Real Exchange Rate for the G-7 Countries

(In percent)



advanced economies was less than that of the G-7 exchange rates with the other country groups.

As noted above, of the major country groups, the transition economies have had the highest level of exchange rate variability, which was associated with the breakup of the former Soviet Union. Data for this group are shown only starting in 1988 because most of these countries did not exist in the 1970s and 1980s. Only starting in 1995 are data available for all 22 transition countries, and over the period 1995–2002 the exchange rate volatility of this group was comparable to that of emerging market economies and developing countries. Volatility in these latter two groups, while on average not quite double that of the advanced countries for the period as a whole, nonetheless declined between the 1980s and 1990s, especially for the emerging market economies.

Some additional detail is shown in Figure 3.3, which gives a geographic breakdown of developing countries (WEO classification), and in Figure 3.4 for two ana-

lytical groups, fuel exporters and exporters of non-fuel primary products.¹³ Among the geographic regions, sub-Saharan Africa (excluding South Africa and Nigeria) shows the highest average level of volatility of real exchange rates over the sample period, although this may reflect the unusually high 14.5 percent figure in 1994, which is related in large part to the dramatic devaluation of the CFA franc that year. By contrast, the developing countries in Asia have exhibited fairly consistently below-average volatility, especially if one excludes the exceptionally high degree of variability associated with the Asian crisis in 1997–98. For the developing countries in the Western Hemisphere, exchange rate fluctuations have been below average, except for the turbulence associated with the lost decade of the 1980s. Regarding the analytic groupings shown in Figure 3.4, fuel exporters have experienced increasing exchange

¹³The list of countries in each group is given in Appendix Table A2.

Table 3.1. Short-Run Effective Volatility of Real IFS Exchange Rates in G-7 Countries by Major Country Groups

Country	Year	Advanced Economies	Transition Economies	Emerging Economies	Other Countries	Total Effective Volatility
Decomposition of Volatility						
United States	1970	0.616	0.005	1.808	0.101	2.529
United States	1980	1.751	0.021	0.364	0.321	2.457
United States	1990	1.397	0.045	0.648	0.283	2.372
United States	2000	1.385	0.028	0.811	0.111	2.335
United Kingdom	1970	0.602	0.006	0.321	0.176	1.105
United Kingdom	1980	1.957	0.029	0.251	0.415	2.651
United Kingdom	1990	1.827	0.061	0.301	0.208	2.396
United Kingdom	2000	2.569	0.085	0.334	0.132	3.119
France	1970	0.427	0.008	0.263	0.200	0.899
France	1980	1.213	0.049	0.239	0.520	2.020
France	1990	0.951	0.109	0.254	0.244	1.558
France	2000	0.998	0.090	0.302	0.224	1.614
Germany	1970	0.523	0.022	0.360	0.115	1.019
Germany	1980	1.353	0.143	0.347	0.365	2.209
Germany	1990	0.964	0.283	0.347	0.130	1.724
Germany	2000	1.102	0.228	0.401	0.117	1.847
Italy	1970	0.624	0.044	0.407	0.180	1.255
Italy	1980	1.355	0.136	0.355	0.575	2.421
Italy	1990	0.950	0.258	0.361	0.334	1.903
Italy	2000	0.908	0.218	0.386	0.260	1.772
Canada	1970	1.144	0.002	0.261	0.041	1.448
Canada	1980	1.706	0.006	0.140	0.090	1.943
Canada	1990	1.384	0.022	0.199	0.054	1.660
Canada	2000	1.443	0.008	0.197	0.039	1.687
Japan	1970	0.663	0.002	1.315	0.170	2.150
Japan	1980	1.885	0.009	1.173	0.898	3.966
Japan	1990	2.354	0.029	1.343	0.351	4.077
Japan	2000	1.789	0.036	1.465	0.229	3.519
Volatility Within Groups						
United States	1970	0.806	1.358	11.589	1.318	2.529
United States	1980	2.913	6.231	1.565	1.972	2.457
United States	1990	2.134	11.444	2.409	3.882	2.372
United States	2000	2.478	2.346	2.236	1.670	2.335
United Kingdom	1970	0.767	1.200	3.286	1.570	1.105
United Kingdom	1980	2.442	6.656	3.739	3.256	2.651
United Kingdom	1990	2.137	8.954	3.660	3.709	2.396
United Kingdom	2000	3.162	3.079	2.909	2.905	3.119
France	1970	0.496	1.525	6.524	2.164	0.899
France	1980	1.571	7.338	4.467	3.094	2.020
France	1990	1.130	10.462	4.268	2.764	1.558
France	2000	1.220	2.444	3.979	3.237	1.614
Germany	1970	0.606	1.414	5.756	1.921	1.019
Germany	1980	1.644	7.666	5.095	4.048	2.209
Germany	1990	1.141	8.243	4.228	3.331	1.724
Germany	2000	1.453	2.059	3.938	3.989	1.847
Italy	1970	0.758	1.574	6.205	2.169	1.255
Italy	1980	1.786	7.381	4.836	3.844	2.421
Italy	1990	1.152	8.950	4.969	4.532	1.903
Italy	2000	1.220	2.516	3.893	3.721	1.772
Canada	1970	1.224	2.058	6.704	1.622	1.448
Canada	1980	1.907	6.210	2.208	2.215	1.943
Canada	1990	1.514	14.301	3.018	3.009	1.660
Canada	2000	1.597	2.342	2.496	2.721	1.687
Japan	1970	0.988	1.680	5.766	1.699	2.150
Japan	1980	3.748	6.892	4.227	4.119	3.966
Japan	1990	3.852	10.566	4.320	4.663	4.077
Japan	2000	3.502	3.389	3.552	3.455	3.519

Figure 3.3. Short-Run Effective Volatility of the Real Exchange Rate in Developing Countries Grouped by Geographic Region
(In percent)

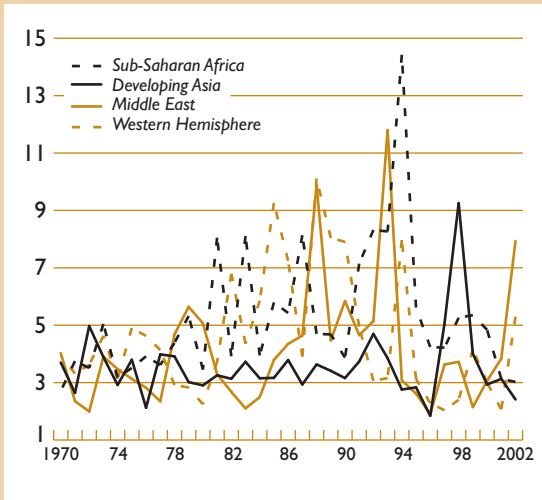
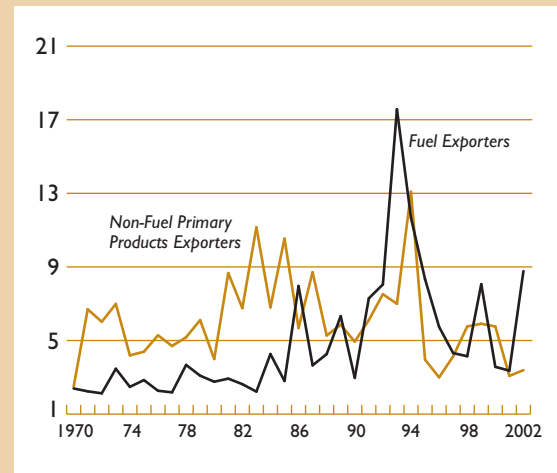


Figure 3.4. Short-Run Effective Volatility of the Real Exchange Rate in Two Developing Country Groups by Source of Export Earnings
(In percent)



rate volatility over the sample period, and exporters of non-fuel primary products have had the highest average level of real exchange volatility over the entire period, which likely reflects the effects of movements in the terms of trade of these countries.

The average figures for the country groups embody wide variations in the level of exchange rate volatility of the individual countries in each group. It is therefore useful to examine the variation across the members in each group. This is done in Table 3.2, which presents figures for the average effective volatility of real exchange rates over the entire sample period 1970–2002 for the five countries with the highest and lowest volatilities.¹⁴ As expected, the dispersion of exchange rate volatility across the advanced economies is quite low, compared with the other groups. It is noteworthy, however, that Japan has the highest measured volatility in this group, with another G-7 country—the United Kingdom—ranking fifth. The dispersion is much higher within the other country groups.

Table 3.3 provides information on the frequency (number of years) that each country appeared in the top five or bottom five in terms of effective real exchange rate volatility. This indicates which countries

exhibited persistently high or low variability over the sample period. The results are often similar to what is shown in Table 3.2; for example, Japan is in the top five advanced economies in 30 out of the 33 years in the sample. Similarly, in the emerging markets group, Argentina is in the top five in 20 of the 33 years.¹⁵

Alternative Measures of Volatility

It is useful to compare the benchmark measure of volatility with a number of alternatives. Figure 3.5 provides figures for the short-run effective volatility of the *nominal* official exchange rate. A comparison with Figure 3.1 shows that, while there are no major differences between these two measures, generally real exchange rate volatility is somewhat higher than nominal volatility. This is particularly the case in 1970, when fixed nominal rates were more widespread and inflation differentials generated larger movements in real

¹⁴As noted above, the group of transition countries only attained its full complement of 22 in 1995, and so the ranking is only relevant for the 1990s.

¹⁵The results for Myanmar in Table 3.3 need to be interpreted with caution, given that the bulk of trade appears to occur at the unofficial parallel market rate. Only public sector enterprises, accounting for about 30 percent of reported trade, conduct transactions at the official rate. The parallel market rate, as reported by Reinhart and Rogoff (2002), however, exhibits somewhat greater volatility than the official rate.

Table 3.2. Average Effective Volatility Ranking, 1970–2002

Advanced (Avg = 2.42)		Emerging (Avg = 4.43)		Other (Avg = 4.59)		Sub-Sahara (Avg = 5.89)		Developing Asia (Avg = 3.66)	
Top Five (Avg = 3.21)		Top Five (Avg = 6.70)		Top Five (Avg = 16.05)		Top Five (Avg = 15.46)		Top Five (Avg = 5.44)	
Japan	3.50	Argentina	9.36	Angola	27.32	Angola	27.32	Afghanistan, I.S. of	6.82
Israel	3.48	Chile	6.52	Zambia	15.59	Zambia	15.59	Maldives	5.73
Australia	3.23	Mexico	5.92	Nicaragua	13.51	Congo, Dem. Rep. of	13.07	Lao People's Dem. Rep	5.43
New Zealand	3.03	Peru	5.89	Congo, Dem. Rep. of	13.07	Uganda	10.77	Indonesia	4.87
United Kingdom	2.81	Uruguay	5.80	Uganda	10.77	Sudan	10.53	Sri Lanka	4.37
Bottom Five (Avg = 1.78)		Bottom Five (Avg = 2.33)		Bottom Five (Avg = 1.30)		Bottom Five (Avg = 2.60)		Bottom Five (Avg = 2.43)	
Austria	1.64	Panama	1.89	Réunion	1.08	Mali	2.16	Tonga	2.19
Canada	1.76	Singapore	2.17	Martinique	1.20	Liberia	2.63	Bangladesh	2.23
Bel_Lux	1.77	China, Hong Kong SAR	2.38	Aruba	1.33	Cape Verde	2.72	Malaysia	2.40
Netherlands	1.81	Malaysia	2.40	Guiana, French	1.34	Mauritius	2.72	Fiji	2.55
Denmark	1.91	Thailand	2.80	China, Macao	1.55	Cameroon	2.75	Thailand	2.80
Middle East and Turkey (Avg = 4.28)		Western Hemisphere (Avg = 4.54)		Fuel-Exporting (Avg = 6.18)		Non Fuel-Exporting (Avg = 6.15)			
Top Five (Avg = 6.65)		Top Five (Avg = 9.55)		Top Five (Avg = 11.25)		Top Five (Avg = 11.65)			
Iran, I.R. of	8.39	Nicaragua	13.51	Angola	27.32	Zambia	15.59		
Lebanon	8.27	Bolivia	10.26	Iran, I.R. of	8.39	Congo, Dem. Rep. of	13.07		
Yemen, Republic of	6.07	Argentina	9.36	Equatorial Guinea	7.86	Uganda	10.77		
Syrian Arab Republic	5.48	Suriname	8.11	Nigeria	6.61	Bolivia	10.26		
Turkey	5.04	Chile	6.52	Yemen, Republic of	6.07	Ghana	8.56		
Bottom Five (Avg = 2.46)		Bottom Five (Avg = 2.11)		Bottom Five (Avg = 2.67)		Bottom Five (Avg = 2.90)			
Malta	2.15	Panama	1.89	Bahrain, Kingdom of	2.22	Mali	2.16		
Bahrain, Kingdom of	2.22	Netherlands Antilles	2.13	Kuwait	2.51	Liberia	2.63		
Kuwait	2.51	Bahamas, The	2.14	Saudi Arabia	2.58	Solomon Islands	3.10		
Saudi Arabia	2.58	Barbados	2.14	Oman	2.93	Guyana	3.30		
Yemen, Republic of	2.85	Dominica	2.24	Gabon	3.13	Côte d'Ivoire	3.31		

Table 3.3. Number of Years in Average Effective Volatility Ranking 1970–2002

Advanced		Emerging		Developing		Sub-Sahara		Developing Asia	
Frequency in Top Five		Frequency in Top Five		Frequency in Top Five		Frequency in Top Five		Frequency in Top Five	
Japan	28	Argentina	21	Congo, Dem. Rep. of	17	Congo, Dem. Rep. of	23	Sri Lanka	22
Australia	21	Uruguay	21	Sudan	13	Sudan	21	Myanmar	21
Israel	18	Turkey	14	Angola	9	Ghana	11	Pakistan	19
New Zealand	16	Chile	14	Bolivia	9	Angola	10	Samoa	17
United Kingdom	15	Indonesia	13	Ghana	8	Uganda	9	Indonesia	16
Frequency in Bottom Five		Frequency in Bottom Five		Frequency in Bottom Five		Frequency in Bottom Five		Frequency in Bottom Five	
Austria	28	Panama	22	Martinique	25	Cameroon	24	Malaysia	28
Belgium Luxembourg	28	Singapore	21	Guiana, French	22	Gabon	16	Thailand	23
Canada	19	Malaysia	18	Réunion	20	Côte d'Ivoire	13	Fiji	22
Netherlands	17	Venezuela, Rep. Bol.	18	Netherlands Antilles	14	Madagascar	12	Philippines	13
Denmark	13	Mexico	17	Bahamas, The	9	Mauritius	12	Samoa	12
Middle East and Turkey		Western Hemisphere		Fuel-Exporting		Non Fuel-Exporting			
Frequency in Top Five		Frequency in Top Five		Frequency in Top Five		Frequency in Top Five			
Turkey	30	Argentina	19	Nigeria	25	Congo, Dem. Rep. of	24		
Syrian Arab Republic	29	Paraguay	15	Iran, I.R. of	20	Bolivia	12		
Egypt	24	Chile	14	Algeria	19	Ghana	12		
Iran, I.R. of	19	Haiti	11	Venezuela, Rep. Bol.	16	Sierra Leone	11		
Jordan	17	Bolivia	11	Angola	12	Burkina Faso	11		
Frequency in Bottom Five		Frequency in Bottom Five		Frequency in Bottom Five		Frequency in Bottom Five			
Malta	32	Netherlands Antilles	20	Kuwait	25	Côte d'Ivoire	19		
Bahrain, Kingdom of	26	Panama	16	Bahrain, Kingdom of	24	Rwanda	17		
Kuwait	23	Bahamas, The	13	Gabon	23	Togo	15		
Saudi Arabia	21	Mexico	13	Venezuela, Rep. Bol.	22	Liberia	15		
Egypt	12	Trinidad and Tobago	12	Saudi Arabia	21	Bolivia	15		

Figure 3.5. Short-Run Effective Volatility of the Nominal Exchange Rate by Major Country Groups

(In percent)

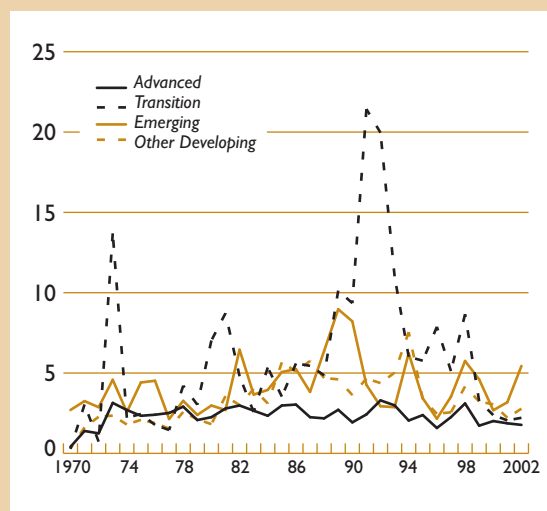
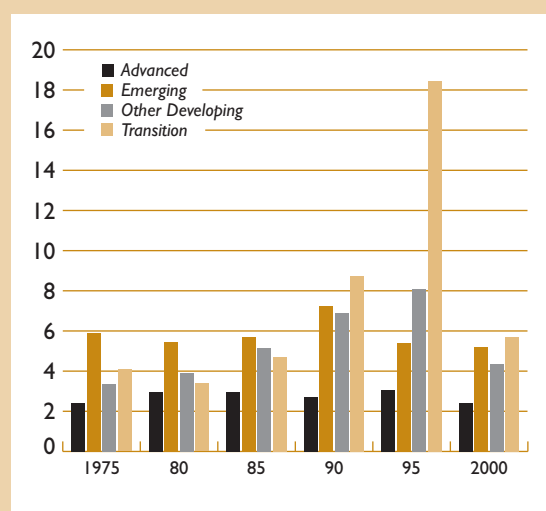


Figure 3.6. Long-Run Effective Volatility of the Real Exchange Rate by Major Country Groups

(In percent)



rates.¹⁶ Lower volatility in nominal exchange rates is also more pronounced among developing countries over the entire sample period, which would appear to reflect the fear of floating described by Reinhart and Rogoff (2002).

Figure 3.6 shows the longer-run measure of exchange rate volatility—namely, the standard deviation of monthly log differences in exchange rates calculated over the five years preceding the year in question. As one would expect, the measured volatility is larger than the average of the short-run volatilities over the same years. Figure 3.7 shows a measure of conditional volatility—namely, that estimated for each currency, assuming it follows a GARCH process. The underlying idea is that part of the volatility can be forecasted, based on past values of the exchange rate, and firms engaged in trade would naturally make an effort to develop such a forecast. Figure 3.7 plots the conditional—or forecasted—exchange rate volatility (for a description of this methodology, see the appendix). A comparison with Figure 3.6 shows that this

measure is in general somewhat lower than the standard measure, which is particularly the case for the transition economies in 1995. Figure 3.8 gives the long-run volatility for the G-7 countries.

Up to this point, exchange rates in the *IFS*, i.e., those compiled and reported by the authorities to the IMF, have been used in the analysis. Recently, however, attention has focused on the classification of exchange rate regimes and the appropriateness of using these exchange rates as the basis for such a classification. In particular, Reinhart and Rogoff (2002) have put together an extensive data set for 153 countries of monthly parallel exchange rates that are market determined going back to 1946. They find striking and widespread differences between the official *de jure* regime, as reported in the IMF’s *Annual Report on Exchange Rate Arrangements and Exchange Restrictions (AREAER)*, and that implied by the information they gathered on actual *de facto* exchange rate practices.¹⁷ As the exchange rates reported by Reinhart and Rogoff may be more representative of the price of foreign exchange at which international trade transac-

¹⁶It is also interesting to note that the introduction of the European Monetary Union (EMU) in 1999 reduced, but by no means eliminated, effective nominal exchange rate volatility of its three G-7 members. Average nominal effective volatility from 1995–98 before the EMU was 1.91, 2.07, and 2.34 percent, in France, Germany, and Italy, respectively, whereas in 1999–2002, their average effective nominal volatility was 1.41, 1.68, and 1.63 percent, respectively.

¹⁷The correspondence between the official IMF and the Reinhart/Rogoff “Natural” regime classifications is shown in Appendix Table A3. Also shown are the distributions of the major country groups by type of exchange rate regime for the IMF classification (Appendix Table A4) and for the Natural classification (Appendix

Figure 3.7. Long-Run Effective Conditional Volatility of the Real Exchange Rate by Major Country Groups

(In percent)

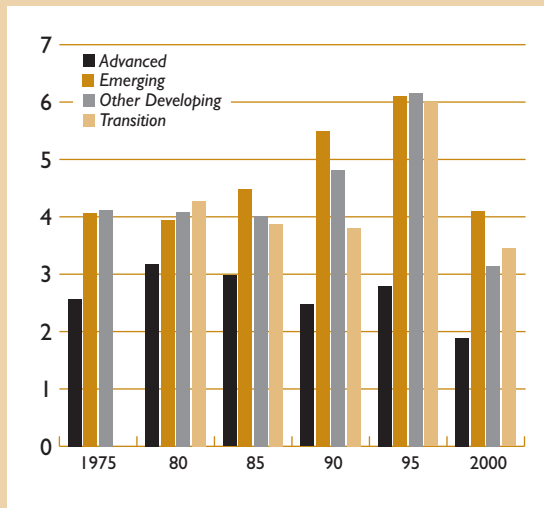
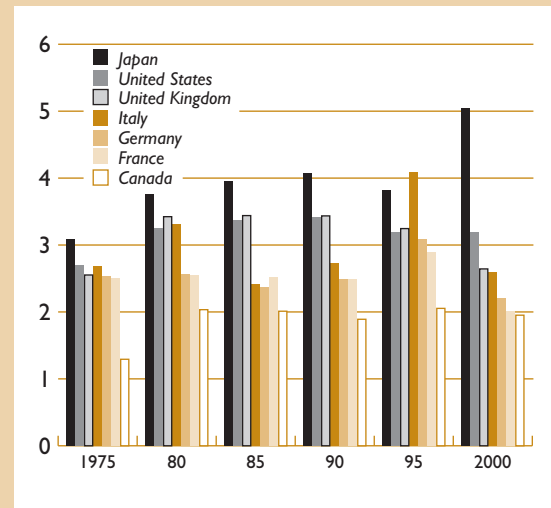


Figure 3.8. Long-Run Effective Volatility of the Real Exchange Rate in the G-7 Countries

(In percent)



tions were conducted, it would also appear worthwhile to calculate exchange rate volatility using these market-determined rates.

In order to compare the volatility implied by both *IFS* and market-determined rates, it is necessary to use the same set of countries. Because the usable data for real market-determined rates are significantly smaller (from 107 countries) than what is available for real *IFS* rates (from 172 countries), the benchmark measure of volatility for the latter had to be recomputed.¹⁸ This is shown in Appendix Table A7, where the sample period extends only through 1998 because of data limitations. Comparing the benchmark measure of exchange rate volatility with the same measure, but using the larger sample of countries, the evolution of exchange rate volatility over time and between major country groupings is quite similar. The difference in measured volatility for the same country group reflects only the difference in the sample of countries and the fact that the variability of the currencies of the countries included in the larger sample is not the same as that of the currencies in the smaller sample.

Table A5). It should be noted that since 1998, the IMF's *AREAER* reports exchange rate classifications that are based on *de facto*, rather than *de jure* exchange rate arrangements. For an analysis that applies retroactively to the *de facto* classification back to 1990, see Bubula and Ötger-Robe (2002).

¹⁸The list of countries in each group is given in Appendix Table A6.

Appendix Table A8 shows the benchmark measure of volatility using parallel market exchange rates, which can be compared directly with Appendix Table A7, as both use the same list of countries. It is immediately clear that, in almost all cases, the volatility of parallel market rates is larger than that of *IFS* rates.¹⁹ This is true for advanced countries as well. Even though there are unlikely to be significant differences between *IFS* and market quotations for the bilateral rates between advanced countries, there would tend to be much larger differences for the bilateral rates between the advanced economies and countries in other groups. The only exceptions occur in 1991, 1992, 1997, and 1998 for transition economies, when movements in *IFS* rates exceeded those in parallel market rates. It should be noted, however, that the difference between the two measures of volatility declined from the 1970s to the 1990s for all the country groups except emerging markets, where there was a slight increase. This largely reflects the fact that, except for transition economies, the effective volatility of the market exchange rate declined between the 1970s and the 1990s, whereas the volatility

¹⁹The behavior of the two measures of volatility is quite different; the average of the simple correlation coefficient between the official and the parallel real exchange rate volatility measure for each bilateral exchange rate over the entire sample was 0.58. The correlation coefficient between the two measures of one-year volatility in the nominal exchange rate was even lower at 0.45.

Table 3.4. Real Effective Volatility Across Country Groups by Type of Exchange Rate Regime¹

		Official IMF Classification ²			
Peg		Limited Flexibility	Managed Floating	Freely Floating	
Country Groups					
Advanced	2.14	2.07	2.81	2.94	
Emerging	3.74	2.28	4.30	6.90	
Transition	5.73	—	4.56	6.37	
Developing	4.35	2.94	4.95	6.47	

		Natural Classification ³				
Peg		Limited Flexibility	Managed Floating	Freely Floating	Freely Falling	
Country Groups						
Advanced	1.81	2.37	2.81	3.09	4.76	
Emerging	2.98	2.81	4.02	4.66	8.31	
Transition	3.75	3.11	3.48	11.15	9.95	
Developing	3.28	3.16	4.53	5.26	13.47	

¹Based on a sample of 150 countries for the period 1970–2001.

²Based on the IMF's annual publication *Exchange Arrangements and Exchange Restrictions*, various issues.

³Based on Reinhart and Rogoff (2002).

Table 3.5. Real Effective Volatility Across Regimes and Time Periods¹

		Official IMF Classification ²			
		1970–80	1981–90	1991–2001	1970–2001
Peg		3.12	4.96	4.11	3.99
Limited flexibility		2.13	2.20	2.13	2.15
Managed floating		4.93	4.75	4.18	4.43
Freely floating		3.05	6.95	5.01	5.22

		Natural Classification ³			
		1970–80	1981–90	1991–2001	1970–2001
Peg		2.80	3.17	3.03	2.98
Limited flexibility		2.58	2.97	2.88	2.83
Managed floating		3.48	4.27	4.16	4.02
Freely floating		3.32	4.11	4.64	4.26
Freely falling		7.99	13.04	9.31	10.56

¹Based on a sample of 150 countries for the period 1970–2001.

²Based on the IMF's annual publication *Exchange Arrangements and Exchange Restrictions*.

³Based on Reinhart and Rogoff (2003).

of the *IFS* rate increased for transition and developing economies, remained almost unchanged for advanced countries, but decreased for emerging market economies.

In comparing the volatility of currencies across countries, it is relevant to consider the type of exchange rate regime because this would likely have a bearing on the degree of variability of a country's currency against other currencies. This is done in Table 3.4, which shows the real effective exchange rate volatility across country groupings in terms of both the official IMF exchange rate classification as well as the Reinhart-Rogoff Natural classification. It is noteworthy that a currency classified as pegged is by no means insulated from exchange rate fluctuations. Indeed, the average effective volatility of freely floating advanced countries (2.94 percent with the IMF classification and 3.09 percent with the Natural classification) is less than the average volatility of pegged currencies of other country groups, except for the emerging market

countries in the Natural classification. Also, looking across types of currency regimes within country groupings, limited flexibility confers less exchange rate volatility than pegged, except for the advanced countries under the Natural classification; and managed floating is not associated with a great deal more volatility than pegged regimes. Only freely floating and freely falling regimes have distinctly greater average volatility; the latter category in the Natural classification includes those countries that had annual inflation rates exceeding 30 percent, which not surprisingly caused considerable exchange rate volatility.

Table 3.5 shows how effective volatility has varied over time by exchange rate regime. Again, limited flexibility is associated with less variability than a pegged regime. If one ignores the 1970s, when the major industrial countries were pegged early in the decade, volatility declined from the 1980s to the 1990s, except in the category freely floating in the Natural classification.

IV New Evidence on the Effect of Exchange Rate Volatility on Trade

As discussed in Section II, theoretical models do not point unambiguously to a negative effect of exchange rate volatility on trade. Moreover, empirical analysis in the existing literature has not uncovered a strong causal impact that is consistently negative. In the empirical analysis reported in this section, there is no obvious negative relationship between aggregate exchange rate volatility and aggregate trade. Turning to bilateral trade, there is some evidence that exchange rate volatility tends to reduce trade. This negative effect, however, is not robust to alternative ways of controlling for factors that could affect trade. The key findings of this empirical analysis are summarized below, and the appendix describes the statistical results in more detail.

The objective of the empirical analysis is to examine the role of exchange rate volatility in trade in a comprehensive manner. Compared to the existing academic literature and the 1984 IMF paper on the topic, the contribution of this analysis lies in exploring the effect of exchange rate volatility on trade along several dimensions:

- by the type of exchange rate volatility: examining a range of different exchange rate volatility measures—short- and long-run, real and nominal, official, *IFS* based and parallel market based, and conditional and unconditional;
- by country group: testing if the impact of exchange rate volatility differs across country groupings, including industrial and developing countries; and
- by the type of trade: examining the impact not only on aggregate but also on sectoral trade, which allows one to test if the effect of exchange rate volatility varies in direction and magnitude across different types of goods. The role of exchange rate volatility has not yet been explored extensively using disaggregated trade data.

In addition to the disaggregation of the volatility effect, tests were conducted to determine its robustness to alternative ways of controlling for joint causality between trade and exchange rates and for trade-related factors other than exchange rate volatility. Finally, while the focus is on exchange rate volatility, this pro-

vides an opportunity to revisit a related topic, the role of a common currency in enhancing trade flows, and to explore the robustness of the finding by Rose (2002) that this positive effect is very large.

Aggregate Volatility and Aggregate Trade—A First Look

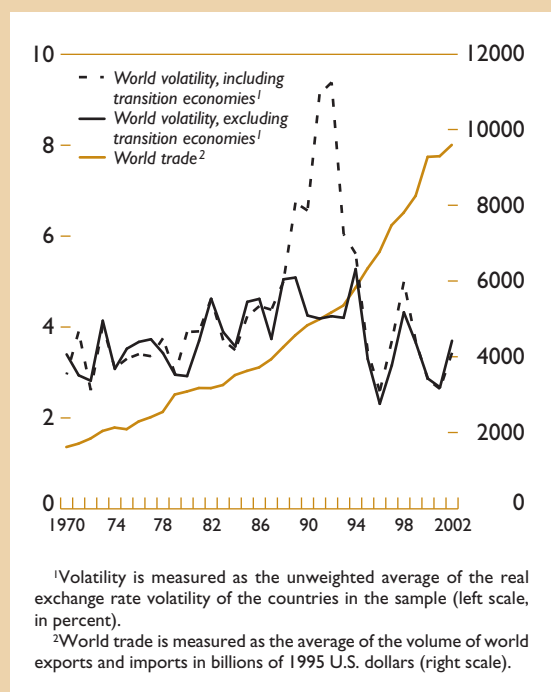
It is instructive to look at the time paths of world trade and exchange rate volatility and examine if there is any obvious negative association between the two. Figure 4.1 shows the evolution of world trade since 1970 together with the average real effective volatility for all countries in the sample. There is a clear bulge in exchange rate volatility from 1989 to 1993, which reflects the large fluctuations in the currencies of a number of transition economies during this period in the aftermath of the breakup of the Soviet Union.²⁰ If one excludes transition economies from the measure of world currency volatility, the bulge disappears. What then appears is an upward trend in average volatility from the early 1970s through the end of the 1980s, but a general moderation in the overall level of currency volatility since then.

In comparison, world trade has increased steadily since 1970, and the growth rate is much more smooth than that of exchange rate volatility. Looking at the movement of world trade and aggregate volatility over time, there does not appear to be any clear relationship between them. Therefore, at the aggregate level there is no evidence of a negative effect of real exchange rate volatility on trade.

It may be useful to examine the relationship between the two by breaking down the sample by major country groups (Figure 4.2) and developing countries

²⁰Data for transition countries are not reported before 1988 because most of these countries did not exist before 1991. Data are available for Yugoslavia only from 1970 and for Hungary beginning in 1976. The effective volatilities for the major country groupings shown in Figures 4.2–4.4 do include, however, the available bilateral exchange rate data for transition countries, weighted by appropriate trade shares.

Figure 4.1. Effective Volatility of the Real Exchange Rate and World Trade



by geographic region (Figure 4.3) and by type of export (Figure 4.4). In some of the sub-samples and for some of the years, there appears to be a negative association between exchange rate volatility and the level of trade in certain country groupings. This is most evident in the case of transition economies in 1990–94 (lower left graph of Figure 4.2), the Asian crisis in 1997–98 (upper right graph of Figure 4.3), and economies exporting non-fuel primary products in the early 1980s (lower graph of Figure 4.4). This negative association may not reflect a causal relationship, however, but rather a manifestation of the effects of a common set of factors that both raise currency volatility and reduce trade. For example, the Asian crisis led to a large decline in the imports of the affected countries and major movements in their exchange rates, but the fall in domestic demand was the most important factor reducing import volumes—not currency volatility. Similarly, the breakup of the Soviet Union caused widespread dislocations in many transition economies, resulting in substantial falls in output and trade and huge changes in many exchange rates that were part and parcel of the transition process.

In order to estimate the specific impact of exchange rate volatility on trade flows, it is necessary to take account of the separate effects of a myriad of factors

that determine the level of exports and imports. The following moves away from aggregate trade and discusses a methodology that exploits the much richer variations in the data on bilateral trade and bilateral exchange rates, which in turn permit the identification of the distinct contribution of volatility on trade.

The Conceptual Framework for Analyzing the Volatility Effect in Trade

To investigate the effect of exchange rate volatility on trade, there are several building blocks to consider. First, there are factors other than exchange rate volatility that affect trade, and it is important to account for them in a way that is consistent with economic theory. Otherwise, one runs the risk of misattributing the effect of these other factors to exchange rate volatility. Second, the measure of exchange rate volatility should be conceptually reasonable. Third, it may be useful to allow exchange rate volatility to have different effects on different types of trade or trade in different country groupings. These building blocks are explained in turn.

As part of the first building block, one must account for the determinants of trade patterns other than exchange rate volatility in a modified gravity model. This model relates trade between a given pair of countries to characteristics of each of the two countries and the characteristics of their relationship to each other. The characteristics that are most important—to which the model owes its name—are the economic mass (i.e., GDP) and the distance between the countries. In addition, the empirical specifications of the gravity model typically control for other factors that augment or reduce trade, such as land areas, cultural similarity, geographical position, historical links, and preferential trading arrangements, all of which tend to affect the transaction costs relevant for bilateral trade and which have been found to be statistically significant determinants of trade in various empirical applications. Typically, the model also controls for the level of economic development, which is expected to have a positive effect on trade because the more developed countries tend to specialize and trade more (e.g., Frankel and Wei, 1993). The gravity model has been empirically successful in terms of its ability to explain a large part of the variations in the observed trade patterns. It also has the merit of being grounded in international trade theories, ranging from those based on country differences in factor endowments or technology to models of increasing returns to scale and monopolistic competition.

A relatively recent development in the theoretical foundation of the gravity model emphasizes “remoteness” or “multilateral resistance” effects. These effects were proposed by Anderson and van Wincoop (2003) and are defined as a function of unobservable equilibrium price indices that depend on bilateral trade barriers

