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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
IMF Research Department

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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 proliferation 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 differential effect on them.

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

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

[2]Issues 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.)

[3]For 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 determines 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.

[4]For 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,

[5]For 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 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:

[6]See Frankel and Wei (1993), Wei (1999), Dell'Ariccia (1999), Rose (2000), and Tenreyro (2003).

[7]See, 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).

[8]In 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.

[9]Parsley 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

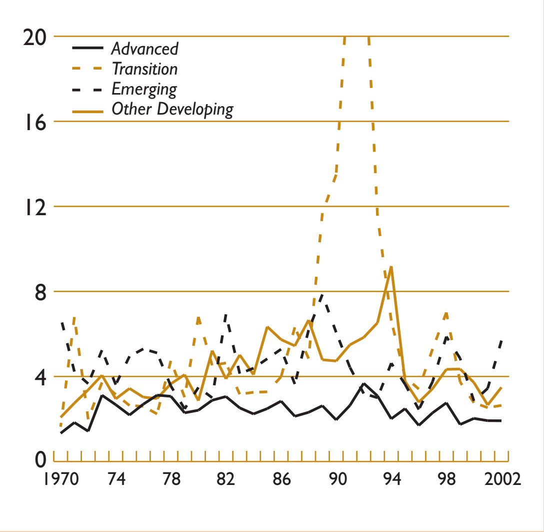
It is useful to begin the analysis of exchange rate volatility over time and across countries by examining the evolution of fluctuations in exchange rates for broad groups of countries as shown in Figure 3.1.[11] This shows the short-run effective volatility since 1970 of exchange rates reported in the IMF's *International Financial Statistics (IFS),* converted to real terms using consumer prices for advanced, transition, emerging market, and developing economies.[12] As

[10]See, for example, Brodsky (1984), Kenen and Rodrik (1986), Frankel and Wei (1993), Dell'Ariccia (1999), Rose (2000), and Tenreyro (2003).

[11]Figure 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.

[12]The 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.

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.

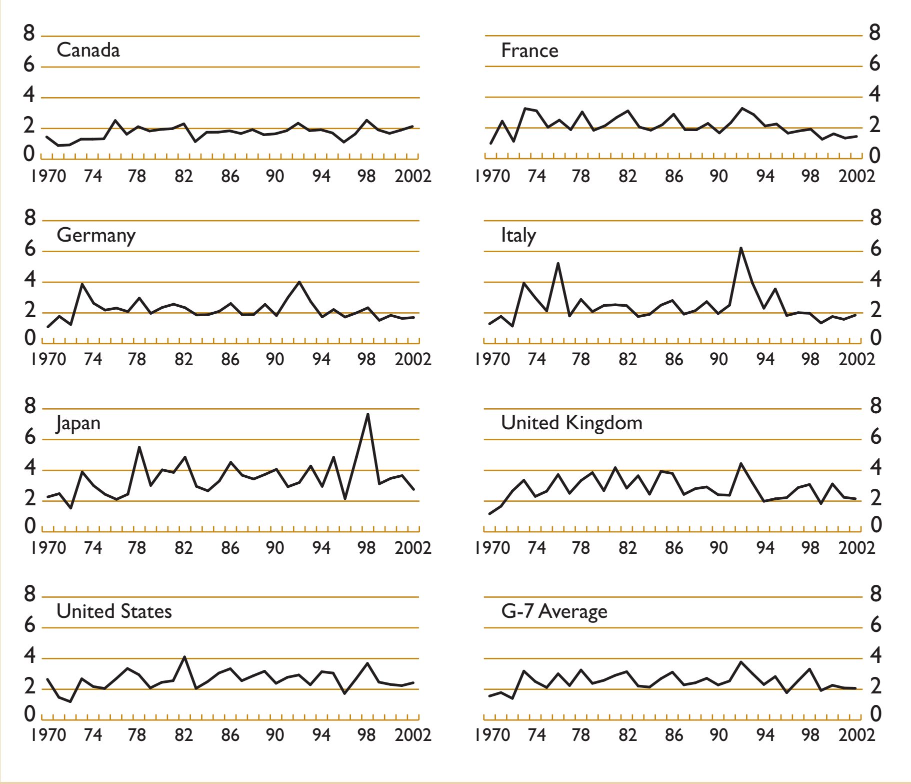
First, looking at the how variability has changed over the sample period, it is noteworthy that there is no obvious trend increase over time. In the first three years of the sample period 1970–72, lower-than-average effective volatility is evident for the advanced economies, which reflects the fixed-rate 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 analytical 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

[13]The 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)

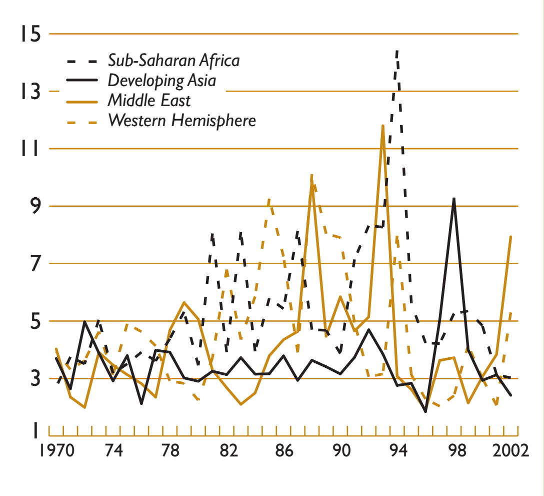
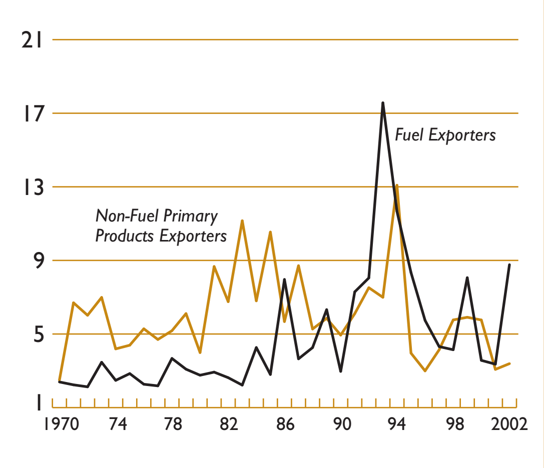


Figure 3.4. Short-Run Effective Volatility of the Real Exchange Rate in Two Developing Country Groups by Source of Export Earnings
(In percent)



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

[14] As 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.

[15] The 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)

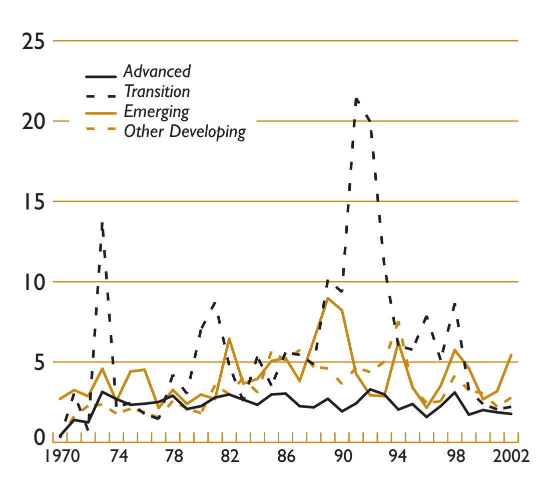
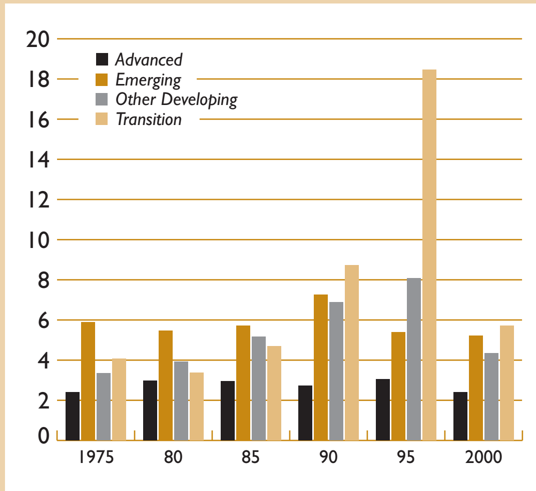


Figure 3.6. Long-Run Effective Volatility of the Real Exchange Rate by Major Country Groups
(In percent)



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-

[16]It 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.

[17]The 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)

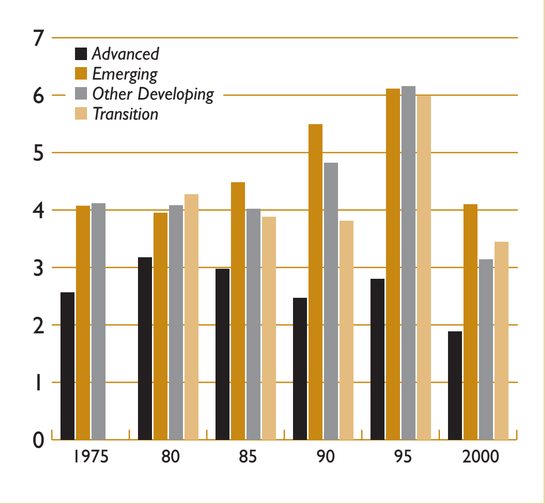
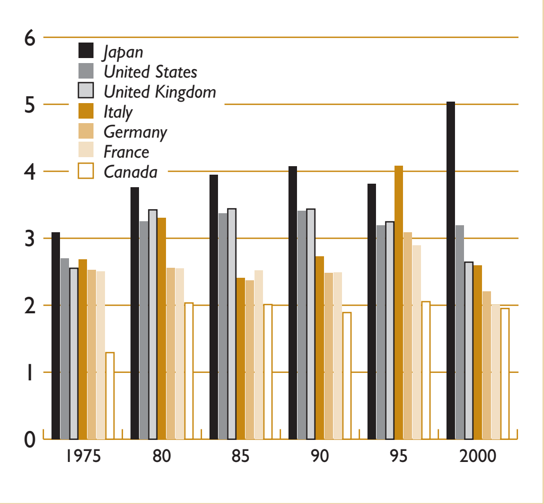


Figure 3.8. Long-Run Effective Volatility of the Real Exchange Rate in the G-7 Countries
(In percent)



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.

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

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 Ötker-Robe (2002).

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

[19]The 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 Regime[1]

Official IMF Classification[2]

Country Groups	Peg	Limited Flexibility	Managed Floating	Freely Floating
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]

Country Groups	Peg	Limited Flexibility	Managed Floating	Freely Floating	Freely Falling
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

[1]Based on a sample of 150 countries for the period 1970–2001.
[2]Based on the IMF's annual publication *Exchange Arrangements and Exchange Restrictions,* various issues.
[3]Based on Reinhart and Rogoff (2002).

Table 3.5. Real Effective Volatility Across Regimes and Time Periods[1]

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

[1]Based on a sample of 150 countries for the period 1970–2001.
[2]Based on the IMF's annual publication *Exchange Arrangements and Exchange Restrictions.*
[3]Based 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 provides 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

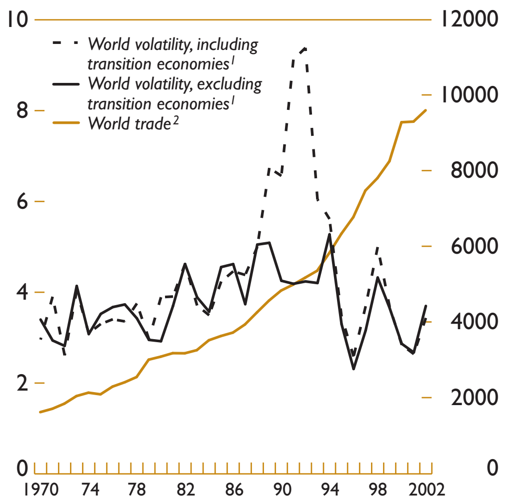
It is instructive to look at the time paths of world trade and exchange rate volatility and examine if there is any obvious negative association between the two. Figure 4.1 shows the evolution of world trade since 1970 together with the average real effective volatility for all countries in the sample. 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

[20]Data 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



[1]Volatility is measured as the unweighted average of the real exchange rate volatility of the countries in the sample (left scale, in percent).
[2]World trade is measured as the average of the volume of world exports and imports in billions of 1995 U.S. dollars (right scale).

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.

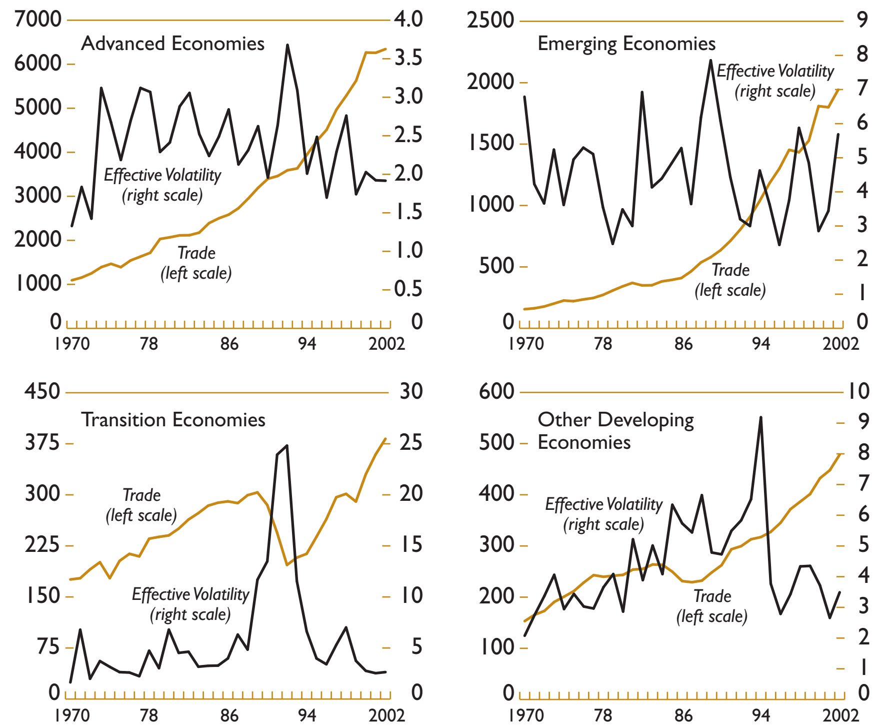
The Conceptual Framework for Analyzing the Volatility Effect in Trade

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

Figure 4.2. Effective Volatility of the Real Exchange Rate and Trade by Major Country Groups[1]

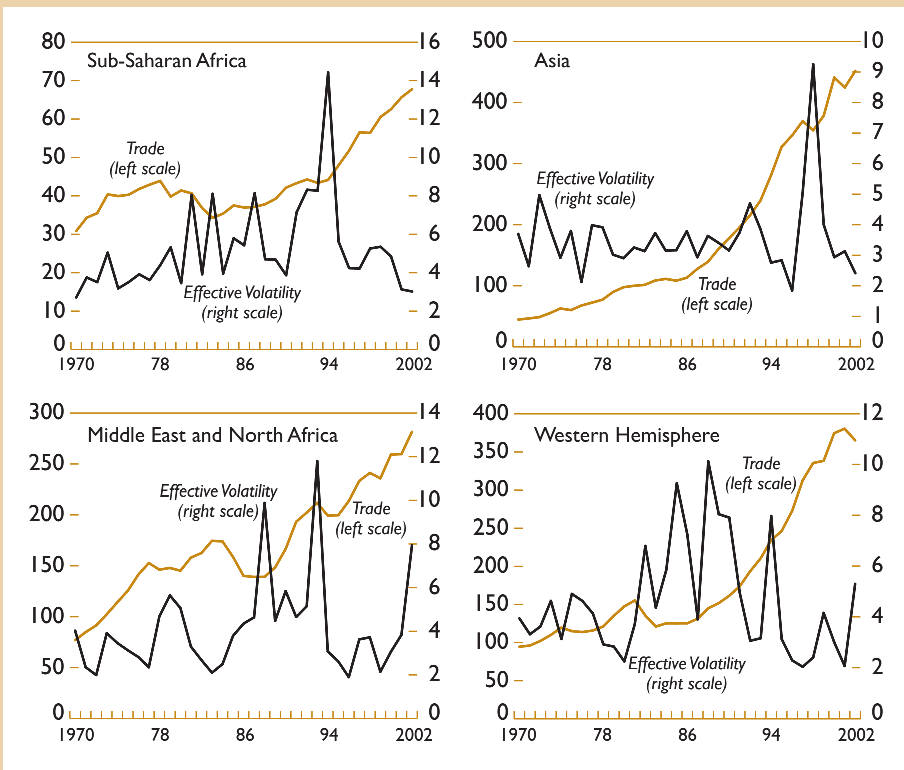


[1]Trade is in billions of 1995 U.S. dollars; volatility is average of real exchange rate volatility.

and income shares of *all* the trading partners. In other words, the multilateral resistance effects are catch-all expressions that summarize the effects on a given bilateral trade from differential, possibly unobserved, trade costs between this country pair and all other trading partners. The gravity equation can then be interpreted as indicating that bilateral trade depends on the bilateral trade barrier between the two countries in question, relative to the two countries' multilateral resistance indices: for a given bilateral trade barrier between the two countries, higher barriers between them and their other trading partners would reduce the relative price of goods traded between them, thus raising bilateral trade. In empirical applications, the multilateral resistance indices can be conveniently proxied by country effects (fixed or time varying). Also included are time effects in the model to control for time-specific factors, such as world business cycles, global shocks, etc.

The second building block is the measure of exchange rate volatility. The focus of the benchmark model is on the long-run measure of *IFS*-based real exchange rate volatility. Its value in any given year, *t,* is calculated as the standard deviation of the first-difference of the monthly natural logarithm of the bilateral real exchange rate in the five years preceding year *t,* which is a conventional measure most commonly used in the current literature on the subject. To check the robustness of results, alternative—yet analogously calculated—measures of exchange rate volatility are examined: long-run *IFS*-based nominal exchange rate volatility; short-run, contemporaneous *IFS*-based real and nominal exchange rate volatility; and the short- and long-run volatility of real parallel market rates using data from Reinhart and Rogoff (2002). Also considered as an additional robustness analysis are the conditional volatilities of real exchange rates, which are estimated using a GARCH (1, 1) model. To ensure the stationarity of the GARCH model, countries with hyperinflation episodes, extreme exchange rate fluctuations, and/or incomplete data are excluded, focusing the estimation on 124 industrial, developing, emerging, and transition economies.

Figure 4.3. Effective Volatility of the Real Exchange Rate and Trade of Developing Countries by Region[1]



[1]Trade is in billions of 1995 U.S. dollars; volatility is average of real exchange rate volatility.

The third building block for the model is the consideration of different country groups and different types of trade. An analysis of the exchange rate volatility effect was conducted separately for industrial countries and developing countries. The separate effects of exchange rate volatility are allowed for, depending on the type of product trade—differentiated or homogeneous. The classification of products into differentiated and homogenous varieties follows the strategy in Rauch (1999). Conceptually, Rauch first identifies two types of homogenous products: those traded on an organized exchange (commodities) and those whose prices are reported regularly in a professional trade publication (referenced price products). All other products are then defined as differentiated products.

What the Data Tell Us

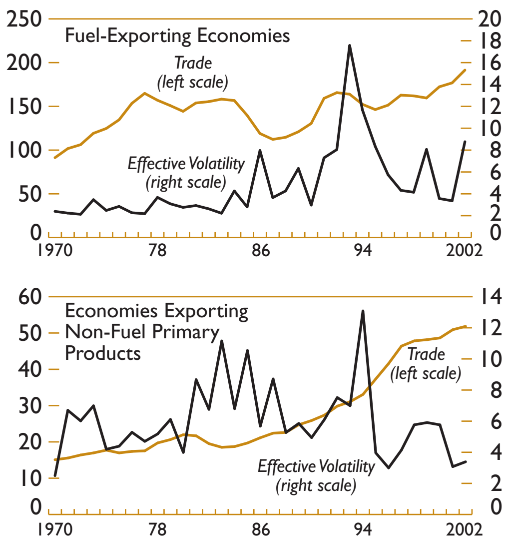
The gravity model performs well empirically, yielding precise and generally reasonable estimates. The coefficient on distance is negative and statistically significant, while the coefficient on the economic mass is positive and statistically significant. Most other control variables are also mostly significant and have the expected signs.

Does Exchange Rate Volatility Hamper Trade?

As a benchmark specification using country and time-fixed effects, one finds that the long-run real exchange rate volatility has a statistically significant negative effect on trade (Table 4.1, column 1, row 1). If exchange rate volatility were to rise by one standard deviation (from 0.12 to 0.15, for example, in the sample), trade would fall by about 7 percent (Table 4.1, column 2, row 1).[21] This effect is comparable to the estimates found by previous studies, e.g., Rose (2000) and Tenreyro (2003).

[21]This impact is computed as the estimated coefficient in the regression equation multiplied by one standard deviation of the volatility measure, multiplied by 100 to convert to percent.

Figure 4.4. Effective Volatility of the Real Exchange Rate and Trade of Developing Countries by Type of Export[1]



[1]Trade is in billions of 1995 U.S. dollars; volatility is average of real exchange rate volatility.

Is the Negative Effect on Trade Robust to Alternative Ways of Controlling for Factors Other Than Bilateral Exchange Rate Volatility?

The answer is no. On the one hand, a negative effect is still observed when controlling for unobservable cultural, economic, historical, geographical, and other factors specific to a given pair of countries rather than individual countries (Table 4.1, column 1, row 2). On the other hand, no negative effect is found when country-specific effects are allowed to vary over time, as appears justified theoretically, given the dynamic nature of multilateral resistance. Indeed, in some cases this specification could even result in a positive coefficient (Table 4.1, column 1, row 3). While this does not necessarily imply that volatility promotes trade, it suggests that the finding of a negative effect of exchange rate volatility on trade is not robust.

A note of caution is in order here. Recent developments in the theoretical foundation of a gravity specification suggest that it is important to include time-varying country-fixed effects in order to fully absorb the multilateral resistance effects. Otherwise, one might misattribute to exchange rate volatility those effects on bilateral trade that should have been attributed to other factors. At the same time, it should be noted that part of the forces underlining bilateral exchange rate volatility is time varying and country specific. The inclusion of the time-varying, country-fixed effects could also overcorrect. For example, an unexpected increase in one country's money supply could raise all the bilateral exchange rate volatility involving that country. Even if this increase in volatility depresses all bilateral trade involving that country, a specification that controls for the country's time-varying fixed effects would not be able to reveal a negative effect of exchange rate volatility on trade. This qualification should be kept in mind in interpreting the result.

Sorting Out Causality

To the extent that countries implement policies aimed at lowering exchange rate volatility in order to increase

Table 4.1. Effect of Long-Run Real Exchange Rate Volatility on Aggregate Trade[1]

Model Specification	Not Controlling for Joint Causality Between Trade and Exchange Rates (1)	Implied Percentage Change in Trade by One Standard Deviation Increase in Volatility (2)	Controlling for Joint Causality Between Trade and Exchange Rates (3)	Implied Percentage Change in Trade by One Standard Deviation Increase in Volatility (4)
With country- and time-fixed effects	–2.37* (0.67)	–6.64	–22.64* (12.50)	–63.39
With country-pair and time-fixed effects	–2.40* (0.47)	–6.72	–6.49 (6.24)	–18.17
With time-varying country effects	2.89* (1.78)	8.09	–23.82 (28.87)	–66.70
With country- and time-fixed effects on the full sample	–1.16 (0.22)	–8.82	. . .	. . .

[1]Standard errors are in parentheses. An asterisk denotes significance at the 90 percent level or higher. For details, see Appendix Tables A9 and A10.

bilateral trade, the model considered so far would suffer from an endogeneity bias. Two instrumental variable approaches are used to control for this possibility: that proposed by Frankel and Wei (1993), whereby the volatility in the relative quantity of money is used as an instrumental variable for exchange rate volatility; and that implemented by Tenreyro (2003), which relates the exchange rate volatility to the propensity of countries to adopt a common currency anchor. Neither of these approaches is perfect, and each has its advantages: the Frankel-Wei approach appeals to the monetary theory of exchange rate determination and is simple and easy to implement, while the Tenreyro approach appeals to the optimal currency framework, as described in Alesina, Barro, and Tenreyro (2002). There is no significant effect of exchange rate volatility on trade in the models with country-pair and time-varying country effects (Table 4.1, column 3, row 2 and column 3, row 3). The negative volatility effect found in the model with constant country effects, however, survives (Table 4.1, column 3, row 1).

Does the Conclusion Change When Alternative Measures of Volatility Are Employed?

The short answer is no. Table 4.2 reports results from the same regression, which includes our standard long-run measure together with all three alternative measures of exchange rate volatility (as differences from the long-run real *IFS*-based measure). The short-run volatility in the real exchange rate appears to discourage trade, albeit to a smaller extent than the long-run volatility. The volatility in the parallel market exchange rates has a similar effect on trade as the volatility in the *IFS*-reported exchange rates, but only in the long run. As shown in Appendix Tables A11 and A12, the volatilities of the nominal and real exchange rates are highly correlated and thus have similar effects on trade. In addition, conditioning the measure of exchange rate volatility on historical information using the GARCH approach, instead of the simple statistical measure of volatility, also preserves the negative relationship with trade. As in Table 4.1, when time-varying country fixed effects are controlled for, there is no longer evidence of a negative and significant association between volatility and trade.

Does Exchange Rate Volatility Have a Different Effect on Trade in Differentiated or Homogeneous Products?

Recent developments in the economics of trade suggest that a given increase in transaction costs (of which exchange rate volatility is a component) could have a larger, negative effect on trade in differentiated products than on trade in homogenous products. But, as with aggregate trade, the estimation results show that this theoretical prior is not robust. When country and time effects are controlled for separately, exchange rate volatility indeed has a negative effect on trade in differentiated products, but not on trade in homogenous products (Table 4.3, column 1). When, however, time-varying country fixed effects are included (Table 4.3, column 3), the conclusion is overturned, as in the aggregate trade model.

Do Members in Currency Unions Trade More?

The core results confirm the finding of Rose (2000) that common currency arrangements triple trade. Apparently,

Table 4.2. Alternative Measures of Exchange Rate Volatility[1]

Model Specification	Long-Run Real Exchange Rate Volatility (1)	Short-Run Real Exchange Rate Volatility[2] (2)	Long-Run Real Parallel Market Exchange Rate Volatility[2] (3)	Short-Run Real Parallel Market Exchange Rate Volatility[2] (4)
With country- and time-fixed effects	−3.92* (1.3)	−2.72* (1.04)	−1.20* (0.63)	−0.55 (0.73)
Implied percentage change in trade by one standard deviation increase in volatility	−10.98	−6.80	−6.48	−2.15
With country-pair and time-fixed effects	−4.72* (0.76)	−4.15* (0.55)	−0.42 (0.34)	−1.14* (0.41)
Implied percentage change in trade by one standard deviation increase in volatility	−13.22	−10.38	−2.27	−4.45
With time-varying country effects	7.52* (3.89)	6.70* (3.24)	−2.20 (2.71)	−1.55 (2.8)
Implied percentage change in trade by one standard deviation increase in volatility	21.06	16.75	−11.88	−6.05

[1]Standard errors are indicated in parentheses. An asterisk denotes significance at the 90 percent level or higher. For details, refer to Appendix Tables A11, A12, and A13.
[2]In excess of long-run real official exchange rate volatility.

Table 4.3. Effect of Exchange Rate Volatility on Trade in Different Types of Products[1]

Model Specification	With Country and Time Effects (1)	Implied Percentage Change in Trade by One Standard Deviation Increase in Volatility (2)	With Time-Varying Country Effects (3)	Implied Percentage Change in Trade by One Standard Deviation Increase in Volatility (4)
Trade in homogeneous products	–0.59 (2.12)	–1.65	–2.97 (4.39)	–8.32
Trade in differentiated products	–2.89* (1.66)	–8.09	0.98 (3.06)	2.74

[1]Standard errors are indicated in parentheses. An asterisk denotes significance at the 90 percent level or higher. For details, refer to Appendix Table A14.

the trade-enhancing benefits of currency unions exceed by far gains from a reduction in exchange rate volatility and are preserved over time (Appendix Tables A9 and A11). They are also robust to controlling for time-varying country effects, but break down in a model with country-pair fixed effects (Appendix Table A12). This suggests that currency union membership may be correlated with other country-pair characteristics. Once these characteristics are controlled for by the inclusion of country-pair fixed effects, there is no additional trade-promoting effect from currency unions.

Does the Volatility Effect Differ Across Country Groups?

In principle, the effects could be different. Foreign exchange markets are typically less developed and less liquid in developing countries, thereby limiting firms' opportunities for hedging foreign exchange risk. Indeed, volatile exchange rates are more likely to be associated with the smaller trade of developing countries than with trade among advanced economies in the specification with country-fixed effects. The negative effect disappears for both country groups, however, when country effects are time varying (Appendix Table A15). As hedging instruments become more readily available for the currencies of industrial countries, one might expect that their trade would be less affected by exchange rate volatility. Wei (1999), however, finds little support for the hypothesis that the growing availability of hedging instruments is responsible for the small impact of volatility on trade.

On balance, for both aggregate and disaggregated trade there is empirical evidence pointing to a generally small negative effect of exchange rate volatility on trade. But this evidence is not overwhelming and not robust across different empirical specifications.

V Summary and Concluding Remarks

This study provides a much more comprehensive analysis of exchange rate volatility and trade than the previous IMF analysis. It examines exchange rate variability over the past 30 years for all countries for which data are available and employs state-of-the-art statistical techniques to test the natural presumption that volatility in exchange rates reduces the level of international trade.

In terms of observed variability, the analysis here shows that, while exchange rate fluctuations have increased in times of currency and balance of payments crises, there has been no clear increase in exchange rate volatility between the 1970s and the 1990s on average. It is not surprising that the currencies of the advanced economies have had lower average volatility than other country groups. Nonetheless, many transition, emerging market, and developing countries have recently exhibited exchange rate variability on a par—or close to—that of many advanced economies.

In terms of the impact of exchange rate volatility on trade flows, the current study does not find a robust negative effect. To be more precise, the study reports some evidence that is consistent with a negative effect of volatility on trade; however, such a relationship is not robust to certain reasonable perturbation of the specification. Specifically, when time-varying, country-fixed effects are allowed—which are suggested by recent theoretical work on the gravity model specification—the analysis does not reveal a negative association between volatility and trade.

The lack of a robustly negative impact of exchange rate volatility on trade may well reflect the ambiguity of the theoretical results in the general equilibrium models. These models show that exchange rate variability is the result of the volatility of the underlying shocks to technology, preferences, and policies, for example, as well as the overall policy regime. Changes in the volatility of the exchange rate may reflect changes in the volatility of the underlying shocks and/or changes in the policy regime. For example, trade liberalization undertaken together with a move to greater exchange rate flexibility could well be associated with increased trade flows as well as increased exchange rate volatility. This possibility is a reason for the ambiguity of the theoretical results as well as the difficulty in finding consistent and robust empirical results regarding the impact of volatility on trade. An additional implication is that the empirical results do not provide clear policy guidance. Even if such volatility were associated with reduced trade flows, this does not necessarily mean that trade would expand if the authorities stabilized the exchange rate in the face of shocks that occur.

These considerations suggest that there are no strong grounds upon which to take measures to reduce exchange rate movements from the perspective of promoting trade flows. Note that this does not rule out the possibility that exchange rate fluctuations may affect an economy through other channels. For example, currency crises—special cases of exchange rate volatility—have required painful adjustments in output and consumption. In this case, however, appropriate policies are those that help to avoid the underlying causes of large and unpredictable movements in exchange rates, rather than measures to moderate currency fluctuations directly for the purpose of enhancing trade.

Appendix: Determining Whether Countries with Stable Exchange Rates and a Common Currency Trade More

While there is some evidence of a negative effect of exchange rate volatility on trade, it is not robust to variations in specification. This is true both for aggregate trade as well as for trade in homogeneous and differentiated products separately. Therefore, the overall message from the empirical analysis is that, if exchange rate volatility depresses trade, the effect is unlikely to be quantitatively large. The basis for these conclusions is discussed in more detail, below.

The Gravity Model: An Empirical Analysis

The empirical analysis in this study is based on the standard gravity framework, whereby trade between two countries is modeled as a function of incomes (economic mass) of these countries and the distance between them. The framework has proved to be robust and successful in a wide variety of empirical applications. Moreover, the gravity model has strong foundations in international trade theories, from those based on country differences in factor endowments or technology to models of increasing returns to scale and monopolistic competition. Entering incomes in the product form is well established theoretically in the trade literature.[22]

Besides the economic mass and distance, the empirical specifications of the gravity model typically control for other factors augmenting or reducing 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 have been found to be statistically significant determinants of trade in various empirical applications. The model also controls typically for the level of economic development, which is expected to have a positive effect on trade because more-developed countries tend to specialize and trade more. With all of these by now fairly standard explanatory variables included in the gravity equation as controls, the focus of interest here is on the introduction of alternative measures of exchange rate variability to see to what extent this particular variable may affect transaction costs and thereby affect the level of bilateral trade between two trading partners.

To control for remoteness or multilateral resistance effects, country-specific fixed effects are included in the model. The concept of multilateral resistance was proposed by Anderson and Van Wincoop (2003) and is defined as a function of unobservable equilibrium price indices that depend on all bilateral trade barriers and income shares of the trading partners. The gravity equation can then be interpreted as indicating that bilateral trade depends on the bilateral trade barriers between the two countries in question, relative to the product of their multilateral resistance indices. For a given bilateral trade barrier between the two countries, higher barriers between them and their other trading partners would reduce the relative price of goods traded between them, thus raising bilateral trade. In empirical applications, the multilateral resistance indices can be conveniently proxied by country-specific fixed effects. The model also includes time effects to control for time-specific factors, such as global business cycles, oil price shocks, etc., so that the intercept in the model is allowed to change both across countries and over time. In addition, as an experiment, time-varying, country-fixed effects have been included, which is more general than including time dummies and country-fixed effects separately. The time-varying, country-fixed effects are arguably more consistent with the notion of a time-varying multilateral resistance emphasized in recent trade theories. At the same time, part of the forces underlying bilateral exchange rate volatility is time varying and country specific. The inclusion of the time-varying, country-fixed effects could also overcorrect. For example, an unexpected increase in one country's money supply could raise all the bilateral exchange rate volatility involving that country. Even if this increase in volatility depresses all bilateral trade involving that country, a specification that controls for that country's time-varying fixed effects would not be able to capture a negative effect

[22]See Anderson (1979), Helpman and Krugman (1985), Bergstrand (1985), Deardorff (1998), and Anderson and van Wincoop (2003).

of exchange rate volatility on trade. This qualification must be kept in mind in interpreting the result.

It is useful to note that up until very recently the literature that fits a gravity model to trade data seldom included any type of country-fixed effects. It is still rarer to include time-varying, country-fixed effects. Augmenting the empirical trade equation with various kinds of fixed effects may be considered one of the value-added aspects of this paper from a methodological point of view.

Aggregate Trade

The benchmark panel specification for the analysis of aggregate trade is similar to that used by Rose (2002). The model using ordinary least squares with robust standard errors is estimated based on the log-linear transformation:

$$\begin{aligned} ltrade_{ijt} = {} & \beta_0 + \beta_1 lrgdp_{ijt} + \beta_2 lrgdppc_{ijt} + \beta_3 lareap_{ij} \\ & + \beta_4 ldist_{ij} + \beta_5 lreal_{ijt} + \beta_6 custrict_{ijt} \\ & + \beta_7 comlang_{ij} + \beta_8 island_{ij} + \beta_9 landl_{ij} \\ & + \beta_{10} border_{ij} + \beta_{11} comcol_{ij} + \beta_{12} curcol_{ijt} \\ & + \beta_{13} colony_{ij} + \beta_{14} comctry_{ij} + \beta_{15} fta_{ijt} \\ & + \beta_{16} gsp_{ijt} + \beta_{17} onein_{ijt} + \beta_{18} bothin_{ijt} \\ & + \Gamma fe + \Phi te_{ij} + \varepsilon_{ij}, \end{aligned}$$

where $ltrade_{ijt}$ denotes the logarithm of the real value of aggregate bilateral trade between country i and j at time t; $lrgdp_{ijt}$ is the logarithm of the product of real GDPs of countries i and j at time t; $lrgdppc_{ijt}$ is the logarithm of the product of real GDP per capita of countries i and j at time t; $lareap_{ij}$ is the logarithm of the product of the land areas of countries i and j; $ldist_{ij}$ is the logarithm of distance between i and j; $lreal_{ijt}$ is the long-run real *IFS*-based measure of volatility in the bilateral exchange rate of countries i and j at time t; and $custrict_{ijt}$ is a dummy variable taking the value of 1, if countries i and j share a common currency at time t, and zero otherwise. The coefficients of interest are those on the measure of exchange rate volatility, $lreal_{ijt}$, and the currency union dummy, $custrict_{ijt}$.

Other variables control for various cultural, geographical, and historical factors: $comlang_{ij}$ is a dummy taking the value of 1 if i and j have a common language; $island_{ij}$ is the number of islands and $landl_{ij}$ is the number of landlocked countries in the country pair; $border_{ij}$ is a dummy taking a value of 1 when i and j share a common border; $comcol_{ij}$ is a dummy taking a value of 1 if after 1945 i and j were colonies with the same colonizer; $curcol_{ijt}$ is a dummy taking the value of 1 if i was a colony of j at time t, or vice versa; $colony_{ij}$ is a dummy taking a value of 1 if i ever colonized j, or vice versa; and $comctry_{ij}$ is a dummy taking a value of 1 if i and j belong to the same nation.

There are also several controls for trade policy factors:[23] fta_{ijt} is a dummy variable if i and j are members in the same regional trading arrangement; gsp_{ijt} is a dummy taking the value of 1 if i was a Generalized System of Preferences beneficiary of j or vice versa at time t; and $onein_{ijt}$ and $bothin_{ijt}$ are dummies taking a value of 1 if either i or j, or both, were members of GATT/WTO at time t. Finally, the vectors fe and te denote country- and year-specific dummies. The error term ε_{ijt} is assumed to be well behaved.

Disaggregated Trade

For the analysis of disaggregated trade, two equations are considered separately for trade in differentiated products and in homogenous products, which are estimated by the Seemingly Unrelated Regressions (SUR) technique. This specification allows the parameters on the same variables to be different for different types of trade, while the error terms for a given country pair are correlated in the two equations.

A few comments are needed to clarify the less familiar analysis of disaggregated trade. Higher exchange rate volatility can be viewed as an increase in a type of transaction cost in international trade. More concretely, it may add noise to the price signal, and hence make it more difficult and more costly for buyers and sellers in the international market to find the right match for trading goods. A given increase in search costs, however, could play a different role in the overall transaction costs for trade in homogeneous products versus differentiated products. For homogeneous products, such as wheat, an importer is not concerned with who the producer is because the products are easily comparable, and price is the primary decision factor. On the other hand, heterogeneous products, such as digital cameras or tennis shoes, tend to be branded because there are additional characteristics other than price that would affect an importer's purchase decision. For even more differentiated products, such as machine tools, again price would not necessarily be the key factor affecting the purchase decision.

Noting the difference in search costs in international trade for these two types of goods, Rauch (1999) presented some evidence suggesting that a given increase in transaction costs has a bigger negative effect on the volume of trade in differentiated products than in homogeneous products. He did not look into the effect of exchange rate volatility on trade, however. Extending his logic, one might hypothesize that a given increment

[23]Bilateral tariff and nontariff barriers are excluded from the model due to unavailability of data.

in exchange rate volatility would also dampen trade in differentiated products more than trade in homogenous products. A recent paper by Broda and Romalis (2003) contains a theoretical model that *assumes* (as opposed to *derives*) this difference in the effects of exchange rate volatility. The authors also report some empirical evidence demonstrating that exchange rate volatility deters trade in differentiated products more than trade in homogenous products. Their regression specification, however, does not include as control variables most of the usual country-pair characteristics described above. Given that many developing countries are striving to move toward producing and exporting more differentiated products, it is interesting to test this hypothesis using a regression specification similar to that used for the analysis of aggregate trade.

Data and Sources

Aggregate Trade

Estimating the aggregate trade model requires data on total bilateral trade, incomes, population, distance, as well as geographical, cultural, and historical information. The study uses a panel data set that covers 178 IMF member countries every fifth year from 1975 to 2000.[24] Summary statistics and correlations for the data set are presented in Appendix Table A16. The list of countries in the sample is presented in Appendix Table A1.

The data set is an updated version of Rose's data set. To extend the data to 2000, the bilateral trade data series are constructed exactly following Rose's study: bilateral merchandise trade data are from the IMF's *Direction of Trade Statistics.* Bilateral trade is measured in U.S. dollars as total trade (exports plus imports) between the two countries in question, deflated by the U.S. Consumer Price Index (1982–83 prices) for urban areas (available from *www.freelunch.com*). Real GDP and population data come exclusively from the World Bank's *World Development Indicators.*[25]

The benchmark model focuses on the long-run measure of *IFS*-based real exchange rate volatility calculated as the standard deviation of the first-difference of the monthly natural logarithm of the bilateral real exchange rate in the five years preceding year *t.* The monthly bilateral exchange rates are obtained from the *IFS.* To obtain exchange rates for each European Monetary Union member currency for the years 1999 and 2000, the euro exchange rates were converted using the irrevocably fixed conversion rates obtained from the official European Central Bank website. Real exchange rates are constructed by using consumer prices from the *IFS.*

To check the robustness of results, alternative, yet analogously calculated, measures of exchange rate volatility were examined: long-run, *IFS*-based nominal exchange rate volatility; short-run, contemporaneous *IFS*-based real and nominal exchange rate volatility; and short-run and long-run volatility of real parallel market rates, data for which come from Reinhart and Rogoff (2002). For more details on these measures of exchange rate volatility, see Section III of this study.

As part of the robustness analysis, the conditional volatilities of the exchange rates estimated using a GARCH (1, 1) were considered.[26] The underlying equation for the model is an ARIMA (0, 1, 0) process of the exchange rates (in the logarithmic form), which implies that the log difference of the exchange rates is a random walk with drift. This model yields an estimate of volatility that is the standard deviation of the error term in the underlying equation, conditional upon historical information from all previous months in the five-year period. The last estimated conditional standard deviation of each country pair is used as the approximation of the conditional volatility at the beginning of next period. For example, the conditional volatility of 1975 equals the estimated conditional standard deviation for December 1974 in the GARCH regressions.

The GARCH regressions on the monthly exchange rates are run for six five-year panels, with the first one being 1970–74 and the last one being 1995–99. In each five-year panel, exchange rate data are further grouped into three categories—those of developed country pairs, of developing country pairs, and of country pairs between developed and developing countries—which bring the total number of GARCH regressions to 15. To ensure that the estimated coefficients satisfy the stationarity conditions,[27] we exclude countries with hyperinflation episodes and countries with extreme exchange rate fluctuations, defined as a change in the log exchange rate in absolute value in any month exceeding a threshold of 1, or $|[d \log(exrt)]_t| > 1$. The

[24]A key regressor in the analysis is long-run exchange rate volatility, which is constructed from five-year intervals. When trade is sampled every fifth year, exchange rate volatility can then be constructed from non-overlapping five-year periods.

[25]In contrast, Rose uses several sources: *World Development Indicators,* Penn World Tables, and *International Financial Statistics.* WTO and Free Trade Agreement dummies for 2000 are extended based on the information available from the WTO official website (*www.wto.org*).

[26]As an alternative to estimating volatility using parametric models such as GARCH, Andersen and others (2001) propose examining the realized volatility directly, which has the advantage of being model independent. This approach, however, is very data intensive and thus cannot be implemented in this study.

[27]The estimated coefficients of the regressions ensure that all time-varying variance (σ^2_t) processes are stable. Furthermore, the results of nine regressions satisfy the sufficient conditions that will guarantee the GARCH processes to be covariance stationary (see Greene, 2000, p. 802).

threshold amounts to a monthly appreciation of over 170 percent or a monthly depreciation of over 60 percent.[28] In addition, in each panel the series length of the exchange rate for each country pair is required to be greater than or equal to 30. This process produces 124 countries in total for the estimation sample, which are used throughout the study.[29]

Disaggregated Trade

For disaggregated trade, data on the value of bilateral imports for 98 industries are obtained from the United Nations' COMTRADE database and cover 39 countries (see Appendix Table A17) during the period 1975–2000. Import data are disaggregated at the Standard International Trade Classification (SITC) four-digit level, rev. 1, and are deflated by the U.S. urban Consumer Price Index (1982–84 prices).

The classification of products into differentiated and homogenous varieties follows the strategy in Rauch (1999). Conceptually, Rauch identifies first two types of homogenous products, those traded on an organized exchange (commodities) and those whose prices are reported regularly in a professional trade publication (referenced-price products). All other products are then defined as differentiated products. Rauch implemented the classification on SITC, rev. 2, industries.

There were instances when the classification for a given product was ambiguous. Hence, Rauch produced two separate classification systems: one, conservative aggregation, attributed all ambiguous products to the homogeneous category, and the other, liberal aggregation, attributed all ambiguous products to the differentiated category. Rauch provides an appendix that lists the classification results of all SITC, rev. 2, industries at the four-digit level. This study uses a concordance from SITC, rev. 1, to SITC, rev. 2 (available from *www.nber.org*), and then applies the Rauch classification to the data. To minimize the impact of misclassified products on the conclusions, all products whose classifications are ambiguous are excluded, and only those products whose degrees of classification are relatively clear are used. That leaves 81 industries for which the classification is relatively unambiguous; 22 of these are classified as homogeneous, and the remaining 59 are classified as differentiated products. The classification lists are presented in Appendix Table A18.

The series for bilateral imports of homogeneous products are obtained by summing sectoral import data across all sectors classified as homogeneous for a given country pair in a given year. Bilateral imports of differentiated products are constructed similarly. GDP and GDP per capita data are from the World Bank Indicators database. All other variables are from the aggregate trade data set described above.

Appendix Table A16 presents some summary statistics on the two types of products in the sample over the years. As can be seen, the total value of trade in differentiated products has been more than twice that of trade in homogeneous products in the sample. There is a modest increase in the share of trade in differentiated products in total trade in the sample, to 83 percent in 2000 from 75 percent in 1975.

Key Findings

The gravity model performs well empirically, yielding precise and generally reasonable estimates (Appendix Table A9) that are broadly consistent with the results of other papers employing a gravity model using trade data. The coefficient on distance is negative and statistically significant, ranging around –1.50 across the different variations of the model. The coefficient on the economic mass is positive and in general statistically significant, ranging from 0.83 in the model with time-varying fixed effects estimated on a sample excluding high-inflation countries, to 0.06 in the same model including such countries. The high sensitivity of the coefficient for the economic mass to the inclusion of high-inflation countries suggests that high-inflation episodes tend to distort economic relations between trade and other behavioral and policy variables, indirectly justifying the exclusion of such countries from the sample on which baseline regressions are estimated in this study.

Other control variables are also significant for the most part and have the expected signs. For example, a common language, Free Trade Agreement membership, Generalized System of Preference relationship, being a colonizer and a colony, and colonization by the same country all have a positive and statistically significant effect on trade. The role of some controls, however, is sensitive to the specification of the model. For example, the level of economic development, as measured by the real GDP per capita, has a positive and statistically significant effect on trade only in the model that includes high-inflation countries and time-varying country effects (Appendix Table A9, column 5). World Trade Organization membership is positive and statistically significant in most specifications, on balance suggesting that it has a trade-enhancing effect over and above other factors.

[28]The following countries are excluded from all regressions: Angola, Argentina, Armenia, Azerbaijan, Bolivia, Brazil, Bulgaria, Chile, Democratic Republic of the Congo, Republic of Congo, Dominican Republic, Ghana, Honduras, Iran, Israel, Lithuania, Mexico, Nicaragua, Nigeria, Peru, Romania, Sudan, Suriname, Tajikistan, Turkmenistan, Uganda, Ukraine, Yugoslavia, Zambia. For regressions using 1995–99 data, five more countries are excluded: Belarus, Indonesia, Sierra Leone, Sri Lanka, and República Bolivariana de Venezuela.

[29]Owing to missing data, the number of countries in the estimation samples for different years is less than 124.

Main Results of the Effect of Exchange Rate Volatility on Trade

Some benchmark results of using the gravity equation to estimate the effect of exchange rate variability on aggregate trade are given in Appendix Table A9. These equations use the standard measure of volatility, i.e., that of the long-run real *IFS* exchange rate, the coefficient of which is shown in the first row of the table.[30] As shown in column 1, which uses both time- and country-fixed effects, there is a statistically significant negative impact on the level of trade.[31] This impact can be computed as the effect of increasing volatility by one standard deviation around its mean, which implies a reduction in trade flows of almost 7 percent.[32] Employing this same specification but using the full sample of countries, as shown in column 4, the estimated reduction in trade generated by a one standard deviation increase in volatility generates a reduction in trade of somewhat over 9 percent.[33] These estimates are comparable to those found by other authors using the same methodology, e.g., Rose (2000), who estimates a reduction of 13 percent, and Tenreyro (2003), who makes estimates ranging from 4–8 percent.

An alternative specification is used in the results reported in column 2 of Appendix Table A9, where individual country-fixed effects are replaced with country *pair*–fixed effects. The main advantage of this approach is that it allows one to control for unobserved cultural, economic, historical, geographical, and other factors that are specific to a given pair of countries.[34] Omitting such factors may bias the estimation results if they are correlated with other regressors in the model. An F-test indicates that the estimated coefficients for the country-pair fixed effects are jointly significant. It turns out that there is very little effect on the coefficient of exchange rate volatility, which is essentially the same as in column 1 of the same table.[35]

[30]Appendix Table A11 reports the effects of alternative measures of exchange rate variability.

[31]This equation was also estimated without country-fixed effects, and an F-test confirmed that the inclusion of such effects is warranted.

[32]This impact is computed as the estimated coefficient in the regression equation multiplied by one standard deviation of the volatility measure, multiplied by 100 to convert to percent.

[33]While the coefficient of volatility in this regression is about one-half that in column 1, the standard deviation of volatility is over twice as large, as shown in Appendix Table A16, with the overall result being a somewhat bigger trade impact. Given that the larger sample includes countries with substantial exchange rate changes, this is not at all surprising.

[34]In this specification, distance, land area, and other time-invariant bilateral variables become redundant in regressions with country pair–fixed effects and therefore are excluded from the regression.

[35]As discussed below, however, this is not true for all of the other estimated coefficients and, in particular, for the dummy variable for a common currency union.

The finding of a negative impact of exchange rate volatility, however, is not evident in a more general specification in which country- and time-fixed effects are replaced with time-varying fixed effects. Allowing for time variation in country-fixed effects is more consistent with the theoretical concept of multilateral resistance proposed by Anderson and van Wincoop (2003) because such multilateral resistance indices are likely to vary over time. Moreover, an F-test comparing the two specifications indicates that the latter is preferred on statistical grounds. As shown in Appendix Table A9, column 3, this modification of the model results in a positive estimated impact of exchange rate volatility on trade (but not significant at the 90 percent confidence level). Using the time-varying country effects approach for the full sample, as reported in column 5, the estimated effect of volatility is negative and the same size as in column 4, but not statistically different from zero.

What might account for the difference in the results? One possible explanation runs as follows: time-varying country-fixed effects in principle control for all unidentified time-varying factors that are country specific, including the effective, i.e., overall exchange rate volatility for each of the trading partners in question. Indeed, when one includes the measure of effective volatility (at the country level, as opposed to bilateral level) in the basic model with time-invariant country effects,[36] the coefficient on this measure of effective volatility is negative and statistically significant, while the coefficient on the bilateral measure of exchange rate volatility becomes positive and similar in magnitude to that in the model with time-varying fixed effects. This shows that the negative effect of bilateral volatility on trade is not robust to controlling for broader aspects of exchange rate volatility and, more generally, for all aspects of multilateral resistance.

These benchmark results show that there is evidence of a negative effect of exchange rate volatility on the level of trade, but the magnitude of the estimated impact appears to be small. This finding is not robust to the choice of estimation technique, however. In particular, the negative effect disappears in a general model that controls for time-varying factors that are country specific and is in line with the most recent theoretical work on the gravity model of trade. This disparity in the findings characterizes not only the above results using the benchmark measure of exchange rate volatility for aggregate trade, but also the results reported below that use alternative measures of volatility, look at different country groupings and different types of traded goods, and use alternative estimation techniques that attempt to control for the possibility that exchange rate volatility is not exogenous. Thus, to

[36]See Appendix Table A13, column 4.

anticipate the overall conclusion, while there is evidence that increased exchange rate variability reduces the volume of international trade, this finding depends on the particular estimation technique employed, so that it cannot be considered an overwhelmingly robust empirical result.

Alternative Measures of Volatility

The estimated impact of alternative measures of volatility on trade, using time- and individual country-fixed effects, is reported in Appendix Table A11. When one includes in column 1 a measure of the short-run real exchange rate volatility in the model as the difference from the long-run real volatility,[37] short-run volatility can be seen as having an additional dampening effect on trade over and above the negative effect arising from the long-run volatility. The magnitude of this additional effect is about half of the long-run volatility effect. This finding could be interpreted as indicating that trading firms form their expectations of the future exchange rate volatility based on both historical and contemporaneous volatility.

The volatility in the parallel market exchange rate has a broadly similar effect on trade as the volatility in the official *IFS*-based exchange rate. Appendix Table A11, columns 2 and 3, reports regressions where the volatility measures based on the parallel market rates are included as differences from the *IFS*-based volatility measures, in addition to the official volatility measures. The coefficient on the long-run parallel market volatility is negative and statistically significant, about the same as the coefficient on the official exchange rate volatility in column 2, but about one-third the size in column 3. In the short run, however, the volatility of the parallel market exchange rate does not appear to affect trade.[38] These results suggest that parallel market rates are also relevant for trade transactions in addition to the official exchange rates.[39]

Given that nominal and real exchange rates are highly correlated, it is probably not too surprising that their volatilities have similar effects on trade. In Appendix Table A11, column 4, the coefficient on the nominal exchange rate volatility (–2.60) is close to that on the real exchange rate volatility (–2.37) in Appendix Table A9, column 1.

So far, this study has considered a simple statistical measure of exchange rate volatility. This is now replaced with a conditional measure of exchange rate volatility, as estimated from a GARCH model (Appendix Table A11, column 5). The coefficient of the conditional volatility measure is virtually identical to that of the unconditional measure (–2.20 versus –2.37). Irrespective of whether one assumes that trading firms condition their expectations on the available historical information (GARCH) or that they project volatility using a simple statistical approach, exchange rate volatility has a statistically significant negative effect on trade of a broadly similar magnitude. In terms of the impact of exchange rate volatility on the level of trade, the estimates are comparable to those discussed above in connection with the benchmark results. They range from a low of about 5 percent for the GARCH estimate of volatility (column 5), to 25 percent for the combined effect of short- and long-run real official volatilities.

These results using various measures of exchange rate volatility are broadly robust to an alternative model specification where country fixed effects are replaced with country-*pair* effects (Appendix Table A12). The estimated coefficient of volatility is consistently negative, in nearly all cases statistically significant, and tends to be somewhat higher.[40] As a consequence, the impact of higher exchange rate volatility on trade is also larger, ranging from a reduction of 8 percent for the long-run nominal exchange rate to a decline of 26 percent for the combined impact of short- and long-run real official rates.

When country-fixed effects and time effects are replaced with time-varying country effects, however (Appendix Table A13), this modification of the model reverses the impact of the study's standard measures of bilateral exchange rate volatility on trade in the long and short run—it becomes positive and statistically significant—and the effect of parallel market volatility becomes insignificant. This lack of robustness to alternative specifications is in line with that discussed above in connection with the results for the benchmark measure of volatility. With this particular model, increased exchange rate variability now has an estimated *positive* impact on trade, ranging from 10 percent (column 4) to 34 percent (column 3).

[37]Short-run volatility is not strongly correlated with long-run volatility in the sample: the correlation coefficient is 0.38.

[38]When the alternative measures of exchange rate volatility are included as separate regressors in the gravity equation, the estimated coefficients are similar to those reported above and are statistically significant, except for the volatility of the short-run parallel rate.

[39]It is also worth noting that the *IFS*-based exchange rates used in the benchmark regressions are not only official rates but also include market and principal rates. The exchange rates in *IFS* are classified into three broad categories, reflecting the role of the authorities in the determination of exchange rates and/or the multiplicity of exchange rates in a country. The market rate is used to describe exchange rates determined largely by market forces: the official rate is used to describe an exchange rate determined by the authorities, sometimes in a flexible manner. For countries maintaining multiple exchange arrangements, the rates are labeled principal rate, secondary rate, and tertiary rate. The official rate is included in the series only if neither the market nor the principal rate is available. The *IFS*-based measures are thus reasonably well correlated with parallel market rates, with the coefficient of correlation of 0.65.

[40]Again, when the alternative measures of volatility are entered in the equation by themselves, the coefficients are similar to those reported in Appendix Table A12 and are statistically significant.

It should be noted, however, that the equation results reported in column 4 of Appendix Table A13 include the effective or overall exchange rate volatility of a country that is used in Section III. Because bilateral trade flows are the dependent variable, the sum of the effective volatilities of the country pairs is used as the regressor. The idea in this specification is to examine the effect of bilateral exchange rate volatility *relative to* the aggregate measure of volatility, which is a component of the multilateral resistance to trade mentioned above. One would expect that an increase in the variability of the bilateral exchange rate between two countries would have a negative effect on their bilateral trade, and that an increase in the variability of all other exchange rates would tend to raise trade between the two countries in question; as such trade would become relatively less risky. In fact, the empirical results are counter to this expectation. Nonetheless, the net impact of a one standard deviation increase in volatility is a reduction in trade of about 13 percent because the negative effect of the higher effective volatility more than offsets the positive effect of the rise in bilateral volatility.[41]

Controlling for Endogeneity of Exchange Rate Volatility

So far, exchange rate volatility has been assumed to be exogenous to trade. This assumption, however, may not be warranted: to the extent that countries implement policies aimed to lower exchange rate volatility in order to increase their trade, the baseline equation would suffer from endogeneity bias. Two instrumental variable approaches were used to control for this possibility:[42] that proposed by Frankel and Wei (1993), whereby the volatility in the relative quantity of money is an instrumental variable for exchange rate volatility, and that proposed by Tenreyro (2003), which relates exchange rate volatility to the incidence and the propensity of countries' to share a common anchor. Neither of these instruments is perfect, but each has its advantages: the Frankel-Wei approach is simple and easy to implement, while that of Tenreyro's instrumental variable appeals to the modern optimal currency framework of Alesina, Barro, and Tenreyro (2002).

Controlling for endogeneity using the Frankel-Wei instrumental variable approach (see first panel of Appendix Table A10) modifies the basic results of the role of exchange rate volatility. While the coefficient on exchange rate volatility remains negative in every specification, it is statistically significant only in the equation with country and time effects for both real and nominal exchange rates. In these two cases, the estimated coefficients are much larger than those reported above. The negative trade effects are also considerably larger—about 90 percent for the real rate and 125 percent for the nominal exchange rate—which seems implausible compared to the findings described above.

The results using the Tenreyro instrumental variable approach are reported in the second and third panels of Appendix Table A10. When the instrumental variable is the dummy for a common anchor, the coefficients on the exchange rate volatility measure become statistically insignificant across all specifications. When the propensity to share a common anchor is used as an instrumental variable, these coefficients are negative in all specifications and statistically significant in the specifications with both country- and time-fixed effects, and with time-varying fixed effects. In both cases, the estimated coefficients are extremely large, implying reductions in trade ranging from 115 percent to 265 percent (column 1) for a one standard deviation increase in volatility. These are far beyond any other estimates in this paper or in the literature, and, as such, should probably be viewed as outliers.

Several reasons may account for differences in the magnitude and sign of these coefficients on the volatility measure and those obtained by Tenreyro. The most important one is that in her regressions volatility appears as log (1 + standard deviation of the exchange rate), whereas the regressions of this study include just the volatility or the standard deviation of the exchange rate for consistency with the benchmark OLS estimations and instrumental variable regressions of Frankel and Wei (1993). The specification of this study differs from Tenreyro in other respects as well: common language and border dummies considered significant are included in the logit regressions estimating the propensity to adopt a common anchor; the study controls for whether or not the trading partners are related as a colony and a colonizer, as well as WTO membership, common colonizer status, and whether or not the trading partners are island economies; and trade between the two countries, rather than just bilateral exports, are used as the left hand–side variable.

[41]In estimating the equation in column 4 of Appendix Table A13, country-fixed effects are included in the model instead of time-varying country effects, on the assumption that the impact of effective volatility would be largely absorbed by the time-varying country dummies. When this same equation was estimated with time-varying country effects instead of the time- and country-fixed effects used in column 4, however, the results were very similar, with a significant negative impact on trade somewhat higher at 19 percent.

[42]An alternative third instrumental variable approach, based on Devereux and Lane (2003), combines the factors underlying the optimal currency area theory with the factors underlying financial links to explain the volatility of the bilateral exchange rate for trading partners. While appealing conceptually, this approach is highly data intensive and was not implemented due to the unavailability of data.

Differentiation Across Country Groups

Findings indicate that across countries the impact of exchange rate volatility on trade is not uniform. In particular, volatile exchange rates appear to be more damaging for trade among developing countries than for trade among advanced economies. As shown in Appendix Table A15, column 1, the coefficients on the exchange rate volatility measures interacted with dummies for trade among advanced and developing countries (denoted by NS) and among developing countries (denoted by SS) and are negative and statistically significant; their net magnitude is –2.23 and –3.22, respectively. This is consistent with the possibility that developing countries are less able to manage currency risk. Foreign exchange markets are typically nascent and less liquid in developing countries, limiting firms' opportunities for hedging foreign exchange risk. With time-varying fixed effects, shown in column 2, however, there is essentially no impact of volatility on trade flows among NS and SS.

Do Members of Currency Unions Trade More?

The main results of this study confirm the remarkable finding of Rose (2000) that common currency arrangements triple trade (Appendix Table A9, column 1), as the coefficient on the currency union dummy is comparable to that found in his paper. The trade-enhancing benefits of currency unions appear to exceed by far the gains from a substantial reduction in exchange rate volatility, although, as discussed above, the instrumental variable (IV) estimation results also indicate a very large benefit in trade gains arising from a decline in volatility.

While the trade-enhancing effect of a common currency is robust to controlling for time-varying fixed effects (Appendix Table A13, columns 1 and 5), it breaks down in a model with country-pair fixed effects (Appendix Table A9, column 2, and Appendix Table A13, columns 1, 4, and 5), in line with the findings in Pakko and Wall (2001). The statistical insignificance of the currency union dummy in the model with country-pair effects—which Rose (2002) did not use in his analysis—suggests that the trade-enhancing effect of a common currency found in specifications omitting country-pair effects reflects an estimation bias because the omitted factors apparently are correlated with trade volume and with the likelihood that countries use a common currency (for example, common history or institutional and regulatory similarities among countries that are members in a currency union). Of course, currency unions have country-pair characteristics that evolve slowly over time. It would thus appear that the power of a test for the effect of currency unions on trade becomes much weaker when country-pair fixed effects are included.

Moreover, the beneficial effect of a common currency on trade is not uniform across country groupings because it appears to be limited to currency unions among developing countries. When the currency union dummy is interacted with the dummy for the developing country pairs, the coefficient on this product term is positive and significant, while the general currency union dummy becomes negative and statistically significant, suggesting that currency unions other than those among developing countries impair trade between them (Appendix Table A15). This result suggests that currency unions may have a large positive impact on trade only in cases where transaction costs are high, where policy credibility problems are acute, or where hedging opportunities are limited.

Disaggregated Trade: Does Exchange Rate Volatility Have a Different Effect on Trade in Differentiated Versus Homogeneous Products?

The finding that the negative effect of exchange rate volatility on trade is not robust also carries over when looking at disaggregated trade. As discussed in the text, recent developments in the economics of trade suggest that a given increase in transaction costs (of which exchange rate volatility is a component) could have a larger negative effect on trade in differentiated products than on trade in homogenous products. The evidence for this possibility is examined in this subsection.

In the first specification (reported in the first two columns of Appendix Table A14), the study estimates a system of two equations by the SUR technique with time- and country-fixed effects. In this case, the coefficients on exchange rate volatility are negative in both equations, and the volatility effect is statistically significant only in the equation on trade in differentiated products. In other words, consistent with the conjecture above, exchange rate volatility has a negative effect on trade in differentiated products, but not on trade in homogenous products. This conclusion, however, is not robust. In the last two columns of Appendix Table A14, when time-varying, country-fixed effects are included (which are more general than the inclusion of a combination of time- and country-fixed effects and are dictated by the recent theory underlying the gravity specification used here), the conclusion is overturned. More precisely, the coefficients on exchange rate volatility are not statistically different from zero for trade both in differentiated and in homogenous products. As extensions, the study also examines the effects of short-run exchange rate volatility and volatility of the parallel market exchange rate: the results are qualitatively the same as described above.

Thus, the overall conclusion on disaggregated trade is the same as that for aggregated trade: namely, the evidence is not overwhelmingly robust to indicate that exchange rate volatility has a negative effect on trade. Using an array of alternative formulations involving different measures of exchange rate volatility, estimation techniques, different country groupings, and disaggregation by type of product, one does find fairly systematic evidence of a negative effect of volatility on trade. Once one takes into account other factors that would affect trade in a more general model involving the time-varying multilateral resistance as emphasized by recent trade theory, however, this negative effect disappears. Thus, whether or not one finds evidence that exchange rate volatility depresses the volume of trade and has a larger negative effect on differentiated than on homogeneous products, depends on the particular methodology used in the estimation.

Statistical Appendix

Table A1. List of Countries in Major Country Groupings

Advanced Economies	Transition Economies	Emerging Economies	Rest of the World
Australia	Albania	Argentina	Afghanistan, I.S. of
Austria	Armenia	Brazil	Algeria
Belgium	Azerbaijan	Chile	Angola
Canada	Belarus	China, P.R.	Antigua and Barbuda
Cyprus	Bulgaria	China, P.R., Hong Kong SAR	Aruba
Denmark	Croatia	Colombia	Bahamas, The
Finland	Czechoslovakia	Ecuador	Bahrain, Kingdom of
France	Czech Republic	Indonesia	Bangladesh
Germany	Estonia	Korea	Barbados
Greece	Georgia	Malaysia	Belize
Iceland	Hungary	Mexico	Benin
Ireland	Kazakhstan	Panama	Bolivia
Israel	Kyrgyz Republic	Peru	Burkina Faso
Italy	Latvia	Philippines	Burundi
Japan	Lithuania	Singapore	Cambodia
Luxembourg	Macedonia, FYR	South Africa	Cameroon
Netherlands	Moldova	Thailand	Cape Verde
New Zealand	Mongolia	Turkey	Central African Rep.
Norway	Poland	Uruguay	Chad
Portugal	Romania	Venezuela, Rep. Bol.	China, P.R., Macao SAR
Spain	Russia		Congo, Dem. Rep. of
Sweden	Serbia and Montenegro		Congo, Republic of
Switzerland	Slovak Republic		Costa Rica
United Kingdom	Slovenia		Côte d'Ivoire
United States	Ukraine		Djibouti
			Dominica
			Dominican Republic
			Egypt
			El Salvador
			Equatorial Guinea
			Ethiopia
			Fiji
			Gabon
			Gambia, The
			Ghana
			Grenada
			Guatemala
			Guiana, French
			Guinea-Bissau
			Guyana
			Haiti
			Honduras
			India
			Iran, I.R. of
			Iraq
			Jamaica
			Jordan

Table A1. *(concluded)*

Advanced Economies	Transition Economies	Emerging Economies	Rest of the World
			Kenya Kuwait Lao People's Dem. Rep. Lebanon Liberia Libya Madagascar Malawi Maldives Mali Malta Martinique Mauritania Mauritius Morocco Mozambique Myanmar Nepal Netherlands Antilles Nicaragua Niger Nigeria Oman Pakistan Papua New Guinea Paraguay Qatar Réunion Rwanda St. Kitts and Nevis St. Lucia St. Vincent and the Grenadines Samoa Saudi Arabia Senegal Seychelles Sierra Leone Solomon Islands Sri Lanka Sudan Suriname Syrian Arab Republic Tanzania Togo Tonga Trinidad and Tobago Tunisia Uganda Vanuatu Vietnam Yemen, Republic of Zambia Zimbabwe

Table A2. List of Countries in Regional Groups of Developing Countries and by Source of Export Earnings

Sub-Saharan Africa[1]	Developing Asia	Middle East and Turkey	Western Hemisphere	Fuel Exporters	Nonfuel Primary Product Exporters
Angola	Afghanistan, I.S. of	Bahrain, Kingdom of	Antigua and Barbuda	Algeria	Afghanistan, I.S. of
Benin	Bangladesh	Egypt	Argentina	Angola	Bolivia
Burkina Faso	Cambodia	Iran, I.R. of	Bahamas, The	Bahrain, Kingdom of	Burkina Faso
Burundi	Fiji	Iraq	Barbados	Congo, Republic of	Burundi
Cameroon	Indonesia	Jordan	Belize	Equatorial Guinea	Chad
Cape Verde	Lao People's Dem. Rep.	Kuwait	Bolivia	Gabon	Chile
Central African Rep.	Malaysia	Lebanon	Brazil	Iran, I.R. of	Congo, Dem. Rep. of
Chad	Maldives	Libya	Chile	Iraq	Côte d'Ivoire
Congo, Dem. Rep. of	Myanmar	Malta	Colombia	Kuwait	Ethiopia
Congo, Republic of	Nepal	Oman	Costa Rica	Libya	Ghana
Côte d'Ivoire	Pakistan	Qatar	Dominica	Nigeria	Guinea-Bissau
Djibouti	Papua New Guinea	Saudi Arabia	Dominican Republic	Oman	Guyana
Equatorial Guinea	Philippines	Syrian Arab Republic	Ecuador	Qatar	Liberia
Ethiopia	Samoa	Turkey	El Salvador	Saudi Arabia	Malawi
Gabon	Solomon Islands	Yemen, Republic of	Grenada	Venezuela, Rep. Bol.	Mali
Gambia, The	Sri Lanka		Guatemala	Yemen, Republic of	Mauritania
Ghana	Thailand		Guyana		Niger
Guinea-Bissau	Tonga		Haiti		Papua New Guinea
Kenya	Vanuatu		Honduras		Rwanda
Liberia	Vietnam		Jamaica		Sierra Leone
Madagascar			Mexico		Solomon Islands
Malawi			Netherlands Antilles		Togo
Mali			Nicaragua		Uganda
Mauritania			Panama		Zambia
Mauritius			Paraguay		Zimbabwe
Mozambique			Peru		
Niger			St. Kitts and Nevis		
Rwanda			St. Lucia		
Senegal			St. Vincent & Grenadines		
Seychelles			Suriname		
Sierra Leone			Trinidad and Tobago		
Sudan			Uruguay		
Tanzania			Venezuela, Rep. Bol. de		
Togo					
Uganda					
Zambia					
Zimbabwe					

[1] Excludes Nigeria and South Africa.

Table A3. Correspondence Between the Official/IMF and Natural Regime Classification, 1970–2001[1]

Natural Classification[3]	Official IMF Classification[2]				
	Peg	Limited Flexibility	Managed Floating	Freely Floating	Total
Peg	84.29 53.53	8.17 46.61	5.00 8.48	2.54 5.18	100 35.33
Limited Flexibility	34.86 16.13	8.82 36.65	35.84 44.28	20.48 30.42	100 25.74
Managed Floating	55.10 22.58	1.23 4.52	24.60 26.92	19.07 25.08	100 22.8
Freely Floating	12.58 1.01	16.98 12.22	1.26 0.27	69.18 17.80	100 4.46
Freely Falling	32.21 6.75	0 0	35.82 20.05	31.97 21.52	100 11.67
Total	55.64 100	6.20 100	20.84 100	17.33 100	100 100

Note: The top member in each classification is the row percentage, and the bottom number is the column percentage.
[1]The statistics are derived from a sample of 150 countries.
[2]Based on the IMF's *Annual Report on Exchange Arrangements and Exchange Restrictions.*
[3]Based on Reinhart and Rogoff (2002).

Table A4. Official Classification of the Distribution of Exchange Rate Regimes Across Country Groups, 1970–2001[1]

Country Groups	IMF Classification[2]				
	Peg	Limited Flexibility	Managed Floating	Freely Floating	Total
Advanced	32.32 11.31	25.46 87.33	13.72 13.27	28.50 33.08	100 19.82
Emerging	39.52 11.50	0.63 1.81	43.97 35.33	15.87 15.31	100 16.47
Transition	35.06 4.39	0 0	34.32 11.86	30.63 12.71	100 7.09
Developing	72.84 72.81	1.11 10.86	14.32 39.54	11.73 38.90	100 56.62
Total	56.64 100	5.78 100	20.50 100	17.08 100	100 100

Note: The top number in each classification is the row percentage, and the bottom number is the column percentage.
[1]The above statistics are derived from a sample of 150 countries.
[2]Based on the IMF's *Annual Report on Exchange Arrangements and Exchange Restrictions.*

Table A5. Natural Classification of the Distribution of Exchange Rate Regimes Across Country Groups, 1970–2001[1]

	Natural Classification[2]					
Country Groups	Peg	Limited Flexibility	Managed Floating	Freely Floating	Freely Falling	Total
Advanced	26.82 15.16	40.63 33.30	17.71 16.31	11.98 57.14	2.86 5.14	100 20.65
Emerging	26.41 12.44	24.84 16.97	24.53 18.82	2.97 11.80	21.25 31.78	100 17.21
Transition	13.81 2.72	25.00 7.15	19.03 6.12	3.73 6.21	38.43 24.07	100 7.21
Developing	46.35 69.68	19.53 42.58	23.98 58.75	1.96 24.84	8.17 39.02	100 54.93
Total	36.54 100	25.19 100	22.43 100	4.33 100	11.51 100	100 100

Note: The top number in each classification is the row percentage, and the bottom number is the column percentage.
[1]The above statistics are derived from a sample of 150 countries.
[2]Based on Reinhart and Rogoff (2002).

Table A6. List of Countries in the Real Parallel Exchange Rate Data Set

Advanced Economies	Transition Economies	Emerging Economies	Rest of the World
Australia	Belarus	Argentina	Afghanistan, I.S. of
Austria	Bulgaria	Brazil	Algeria
Belgium	Czech Republic	Chile	Bangladesh
Canada	Estonia	China, P.R.	Benin
Cyprus	Hungary	China, P.R., Hong Kong SAR	Bolivia
Denmark	Latvia	Colombia	Burundi
Finland	Lithuania	Ecuador	Congo, Dem. Rep. of
France	Poland	Indonesia	Costa Rica
Germany	Romania	Korea	Dominican Republic
Greece	Russia	Malaysia	Egypt
Iceland	Serbia and Montenegro	Mexico	El Salvador
Ireland	Ukraine	Peru	Ethiopia
Israel		Philippines	Gambia, The
Italy		Singapore	Ghana
Japan		South Africa	Guatemala
Netherlands		Thailand	Guyana
New Zealand		Turkey	Haiti
Norway		Uruguay	Honduras
Portugal		Venezuela, Rep. Bol.	India
Spain			Iran, I.R. of
Sweden			Iraq
Switzerland			Jamaica
United Kingdom			Jordan
United States			Kenya
			Kuwait
			Lao People's Dem. Rep.
			Lebanon
			Liberia
			Libya
			Madagascar
			Malawi
			Malta
			Mauritania
			Mauritius
			Morocco
			Myanmar
			Nepal
			Nicaragua
			Nigeria
			Pakistan
			Paraguay
			Saudi Arabia
			Sierra Leone
			Sri Lanka
			Suriname
			Syrian Arab Republic
			Tanzania
			Tunisia
			Uganda
			Vietnam
			Zambia
			Zimbabwe

Table A7. Short-Run Effective Volatility of Real *IFS* Exchange Rate: Smaller Sample of Major Country Groups

Year	G-7	Advanced Economies	Transition Economies	Emerging Market Economies	Other Countries of the World
1970	1.39	1.17	1.56	6.15	1.82
1971	1.75	1.93	6.34	1.99	2.33
1972	1.76	1.63	2.41	4.17	3.68
1973	2.84	2.73	3.26	6.82	4.17
1974	2.26	2.35	3.05	3.89	3.08
1975	1.71	1.77	1.94	4.89	3.21
1976	2.38	2.25	2.42	4.70	2.86
1977	1.98	2.40	1.86	4.97	2.74
1978	2.41	2.20	3.21	2.81	3.47
1979	1.94	1.78	2.31	2.18	4.12
1980	2.01	1.84	5.83	2.71	2.73
1981	2.28	2.23	3.89	3.01	5.47
1982	2.67	2.61	4.33	6.46	4.04
1983	1.97	2.05	3.34	3.65	5.68
1984	1.79	1.96	3.61	3.84	4.16
1985	2.47	2.38	4.23	4.24	7.52
1986	2.49	2.39	4.48	4.49	6.61
1987	1.96	1.90	6.49	3.03	5.75
1988	1.96	1.90	4.60	5.27	8.56
1989	2.12	2.19	11.71	7.37	5.18
1990	2.10	1.81	13.55	4.68	5.04
1991	2.03	2.03	22.04	3.45	4.89
1992	3.02	2.84	27.35	2.78	5.17
1993	2.49	2.41	6.52	2.48	6.29
1994	1.73	1.62	7.23	3.60	7.22
1995	2.66	2.23	4.53	3.54	3.15
1996	1.33	1.33	3.56	1.87	2.25
1997	2.16	2.00	5.78	3.55	3.19
1998	2.55	2.29	8.43	5.02	3.74
1970–80	2.04	2.01	3.11	4.11	3.11
1981–90	2.18	2.14	6.83	4.62	5.87
1991–98	2.25	2.09	8.83	3.29	4.47
1970–98	2.14	2.08	7.46	4.04	4.55

Table A8. Short-Run Effective Volatility of Real Parallel Exchange Rate: Smaller Sample of Major Country Groups

Year	G-7	Advanced Economies	Transition Economies	Emerging Market Economies	Other Countries of the World
1970	2.27	1.88	4.87	8.47	4.15
1971	2.01	2.43	5.58	4.75	4.93
1972	2.32	2.27	3.97	4.98	5.57
1973	4.02	4.06	4.48	7.51	6.95
1974	6.00	6.18	6.71	5.74	8.10
1975	2.78	4.14	4.81	4.87	6.57
1976	3.95	4.26	5.58	7.15	6.01
1977	2.90	3.83	6.83	6.31	6.49
1978	4.29	4.58	7.88	4.54	6.44
1979	3.34	3.59	9.47	3.17	6.96
1980	3.37	3.55	9.86	4.14	8.50
1981	4.39	4.83	7.32	6.28	10.01
1982	4.24	4.67	7.13	9.61	9.65
1983	3.71	4.70	6.59	9.42	7.87
1984	3.88	4.49	7.82	6.60	7.67
1985	3.58	3.69	8.30	8.14	10.15
1986	3.53	3.72	10.67	6.60	8.52
1987	2.89	2.94	7.53	7.52	9.09
1988	2.78	2.79	8.48	7.27	12.42
1989	3.17	3.35	16.16	9.64	8.47
1990	2.83	2.71	13.76	10.88	6.32
1991	2.71	2.91	10.16	4.92	6.71
1992	3.64	3.66	15.18	4.84	6.40
1993	3.71	4.65	8.15	3.94	6.80
1994	2.09	1.89	6.04	4.43	6.33
1995	3.13	2.74	6.23	3.57	4.49
1996	1.89	1.83	4.57	2.50	3.58
1997	2.63	2.51	8.57	3.87	4.79
1998	3.03	2.70	6.96	5.26	3.98
1970–80	3.39	3.71	6.85	5.59	6.50
1981–90	3.50	3.79	9.99	8.22	9.02
1991–98	2.86	2.86	7.86	4.17	5.37
1970–98	3.28	3.49	8.23	6.08	7.02

Table A9. The Role of Exchange Rate Volatility in Trade: Main Results

Variable	Country FE + Time FE (1)	Country Pair FE + Time FE (2)	Time-Varying Country Effects (3)	Country FE + Time FE with Full Sample (4)	Time-Varying Country Effects with Full Sample (5)
Long-run volatility of real official exchange rate	–2.37	–2.40	2.89	–1.16	–1.17
	(0.67)	(0.47)	(1.78)	(0.22)	(0.83)
Dummy for common currency union	1.35	0.25	1.43	1.35	1.30
	(0.14)	(0.38)	(0.14)	(0.12)	(0.12)
Log of real GDP product	0.20	0.49	0.83	0.10	0.06
	(0.13)	(0.10)	(0.19)	(0.11)	(0.27)
Log of real per capita GDP product	–0.06	–0.25	0.07	0.00	0.83
	(0.12)	(0.09)	(0.22)	(0.10)	(0.28)
Log of distance	–1.52		–1.54	–1.50	–1.50
	(0.02)		(0.02)	(0.02)	(0.02)
Common language dummy	0.25		0.26	0.36	0.36
	(0.05)		(0.05)	(0.04)	(0.04)
Common border dummy	–0.12		–0.11	0.36	0.35
	(0.10)		(0.10)	(0.08)	(0.08)
Number of landlocked countries in the country pair	0.11		–1.37	0.28	–0.22
	(0.50)		(0.39)	(0.32)	(0.47)
Number of island countries in the country pair	2.54		0.86	2.12	–0.11
	(0.36)		(0.77)	(0.27)	(0.4)
Log of area product	0.52		–0.03	0.56	0.16
	(0.08)		(0.18)	(0.07)	(0.14)
Dummy for same colonizer after 1945	0.70		0.72	0.59	0.61
	(0.07)		(0.07)	(0.06)	(0.06)
Dummy for both currently being colonies	0.31	0.21	–1.12	0.59	–1.05
	(0.47)	(0.98)	(0.16)	(0.44)	(0.14)
Dummy for common nation	0.83		2.33	0.57	2.29
	(0.57)		(0.37)	(0.53)	(0.33)
Dummy for being colonizer and colony to each other	1.46		1.45	1.31	1.29
	(0.07)		(0.07)	(0.06)	(0.06)
Dummy for common Free Trade Agreement membership	0.28	0.25	0.27	0.39	0.40
	(0.08)	(0.10)	(0.08)	(0.06)	(0.07)
Dummy for one in World Trade Organization	0.26	0.10	1.80	0.22	2.03
	(0.12)	(0.10)	(0.55)	(0.09)	(0.49)
Dummy for both in World Trade Organization	0.43	0.22	3.52	0.41	4.01
	(0.14)	(0.10)	(1.10)	(0.11)	(0.97)
Dummy for Generalized System of Preferences	0.63	0.45	0.59	0.71	0.67
	(0.03)	(0.09)	(0.03)	(0.03)	(0.03)
Time-fixed effects	Yes	Yes	No	Yes	No
Country-fixed effects	Yes	No	No	Yes	No
Country pair–fixed effects	No	Yes	No	No	No
Time-varying country effects	No	No	Yes	No	Yes
Number of observations	16,238	16,238	16,238	26,267	26,267
R-squared	0.79	0.49	0.81	0.75	0.77
Root mean squared errors	1.64		1.60	1.76	1.71

Note: FE = fixed effects. Numbers in parentheses are standard errors.

Table A10. Controlling for Endogeneity of Exchange Rate Volatility

Variable	Real Exchange Rate (1)	Real Exchange Rate (2)	Real Exchange Rate (3)	Nominal Exchange Rate (4)	Nominal Exchange Rate (5)	Nominal Exchange Rate (6)
Relative Money Supply as Instrumental Variable[1]						
Long-run volatility of real official exchange rate	–22.64	–6.49	–23.82			
	(12.5)	(6.24)	(28.87)			
Long-run volatility of nominal official exchange rate				–25.98	–7.78	–17.92
				(14.50)	(7.52)	(21.72)
Log of real GDP product	0.37	0.52	0.44	0.62	0.60	0.45
	(0.2)	(0.12)	(0.41)	(0.31)	(0.16)	(0.40)
Log of real per capita GDP product	–0.25	–0.28	0.35	–0.52	–0.36	0.41
	(0.19)	(0.12)	(0.35)	(0.32)	(0.17)	(0.41)
Log of distance	–1.52		–1.52	–1.49		–1.52
	(0.04)		(0.09)	(0.06)		(0.08)
Common language dummy	0.27		0.27	0.22		0.26
	(0.06)		(0.10)	(0.08)		(0.10)
Common border dummy	–0.08		–0.12	–0.10		–0.12
	(0.12)		(0.14)	(0.12)		(0.14)
Number of landlocked countries in the country pair	–1.41		–1.38	–1.86		–1.16
	(0.56)		(0.39)	(0.72)		(0.51)
Number of island countries in the country pair	1.76		–1.64	1.36		–0.87
	(0.70)		(2.79)	(0.91)		(1.87)
Log of area product	0.44		0.54	0.31		0.43
	(0.11)		(0.60)	(0.16)		(0.46)
Dummy for same colonizer after 1945	0.78		0.79	0.70		0.76
	(0.09)		(0.13)	(0.12)		(0.16)
Dummy for being colonizer and colony to each other	1.33		1.33	1.32		1.31
	(0.08)		(0.08)	(0.09)		(0.08)
Dummy for common Free Trade Agreement membership	0.27	0.23	0.26	0.30	0.24	0.29
	(0.09)	(0.11)	(0.13)	(0.09)	(0.11)	(0.10)
Dummy for one in World Trade Organization	0.14	–0.02	–1.77	0.16	–0.02	–0.65
	(0.16)	(0.11)	(3.83)	(0.16)	(0.11)	(2.48)
Dummy for both in World Trade Organization	0.11	0.12	–3.63	0.10	0.11	–1.41
	(0.29)	(0.15)	(7.69)	(0.30)	(0.16)	(5.01)
Dummy for Generalized System of Preferences	0.66	0.44	0.63	0.65	0.43	0.63
	(0.03)	(0.11)	(0.04)	(0.03)	(0.11)	(0.03)
Time-fixed effects	Yes	Yes	No	Yes	Yes	No
Country-fixed effects	Yes	No	No	Yes	No	No
Country pair–fixed effects	No	Yes	No	No	Yes	No
Time-varying country effects	No	No	Yes	No	No	Yes
Number of observations	14,343	14,343	14,343	14,343	14,343	14,343
R-squared	0.77	0.48	0.80	0.76	0.46	0.80
Root mean squared errors	1.71		1.62	1.74		1.62

Table A10. *(continued)*

Variable	Real Exchange Rate (1)	(2)	(3)	Nominal Exchange Rate (4)	(5)	(6)
Common Anchor Dummy as Instrumental Variable[2]						
Long-run volatility of real official exchange rate	−10.62 (7.45)	29.06 (17.79)	−7.23 (7.73)			
Long-run volatility of nominal official exchange rate				−7.06 (4.92)	27.75 (17.17)	−4.37 (4.67)
Log of real GDP product	0.66 (0.20)	1.08 (0.18)	1.06 (0.12)	0.73 (0.20)	0.83 (0.21)	1.02 (0.1)
Log of real per capita GDP product	0.31 (0.26)	1.07 (0.48)	0.36 (0.16)	0.31 (0.26)	1.41 (0.69)	0.45 (0.11)
Log of distance	−1.45 (0.04)		−1.46 (0.04)	−1.45 (0.04)		−1.46 (0.04)
Common language dummy	0.35 (0.07)		0.36 (0.07)	0.36 (0.07)		0.36 (0.07)
Common border dummy	0.24 (0.14)		0.25 (0.14)	0.24 (0.14)		0.25 (0.14)
Number of landlocked countries in the country pair	−2.19 (1.44)		−0.78 (0.47)	−2.43 (1.36)		−0.81 (0.47)
Number of island countries in the country pair	−2.39 (1.02)		0.17 (0.33)	−2.00 (0.93)		0.13 (0.32)
Log of area product	0.08 (0.14)		−0.17 (0.07)	0.02 (0.12)		−0.16 (0.06)
Dummy for same colonizer after 1945	1.00 (0.10)		1.02 (0.10)	0.99 (0.10)		1.01 (0.10)
Dummy for being colonizer and colony to each other	0.95 (0.20)		0.95 (0.20)	0.95 (0.20)		0.94 (0.20)
Dummy for common Free Trade Agreement Membership	0.81 (0.17)	0.74 (0.31)	0.69 (0.18)	0.82 (0.17)	0.77 (0.33)	0.70 (0.18)
Dummy for one in World Trade Organization	0.02 (0.16)	−0.05 (0.16)	0.70 (0.39)	0.04 (0.15)	−0.09 (0.15)	0.84 (0.34)
Dummy for both in World Trade Organization	0.01 (0.22)	0.41 (0.29)	1.40 (0.73)	0.06 (0.20)	0.38 (0.28)	1.66 (0.63)
Dummy for Generalized System of Preferences	0.66 (0.04)	0.20 (0.20)	0.64 (0.04)	0.66 (0.04)	0.20 (0.20)	0.64 (0.04)
Time-fixed effects	Yes	Yes	No	Yes	Yes	No
Country-fixed effects	Yes	No	No	Yes	No	No
Country pair–fixed effects	No	Yes	No	No	Yes	No
Time-varying country effects	No	No	Yes	No	No	Yes
Number of observations	8,531	8,531	8,531	8,531	8,531	8,531
R-squared	0.75	0.52	0.77	0.76	0.49	0.77
Root mean squared errors	1.72		1.68	1.71		1.68

Table A10. *(concluded)*

Variable	Real Exchange Rate (1)	(2)	(3)	Nominal Exchange Rate (4)	(5)	(6)
Propensity to Share a Common Anchor Dummy as Instrumental Variable[3]						
Long-run volatility of real official exchange rate	–46.60 (12.99)	–19.76 (20.98)	–34.99 (8.86)			
Long-run volatility of nominal official exchange rate				–32.91 (8.77)	–11.48 (11.44)	–24.65 (6.14)
Log of real GDP product	1.87 (0.37)	1.53 (0.29)	1.19 (0.09)	2.03 (0.35)	1.55 (0.29)	1.19 (0.09)
Log of real per capita GDP product	–1.89 (0.67)	–0.80 (1.10)	0.47 (0.15)	–1.70 (0.59)	–0.53 (0.77)	0.60 (0.14)
Log of distance	–1.18 (0.07)		–1.22 (0.05)	–1.21 (0.06)		–1.24 (0.05)
Common language dummy	0.51 (0.10)		0.48 (0.09)	0.49 (0.09)		0.48 (0.09)
Common border dummy	–0.17 (0.21)		–0.09 (0.18)	–0.21 (0.20)		–0.13 (0.18)
Number of landlocked countries in the country pair	–6.01 (1.86)		–0.34 (0.31)	–4.73 (1.49)		–0.38 (0.30)
Number of island countries in the country pair	0.36 (1.55)		–0.20 (0.34)	1.34 (1.42)		–0.12 (0.34)
Log of area product	–0.37 (0.22)		–0.06 (0.07)	–0.49 (0.20)		–0.07 (0.07)
Dummy for same colonizer after 1945	0.55 (0.19)		0.66 (0.15)	0.53 (0.18)		0.64 (0.15)
Dummy for being colonizer and colony to each other	0.80 (0.24)		0.89 (0.21)	0.81 (0.22)		0.87 (0.20)
Dummy for common Free Trade Agreement membership	0.03 (0.22)	0.25 (0.26)	0.00 (0.21)	0.11 (0.21)	0.31 (0.22)	0.05 (0.20)
Dummy for one in World Trade Organization	–0.75 (0.31)	–0.18 (0.25)	–1.60 (0.63)	–0.53 (0.26)	–0.07 (0.18)	–0.49 (0.48)
Dummy for both in World Trade Organization	–1.62 (0.52)	–0.53 (0.58)	–3.06 (1.22)	–1.16 (0.40)	–0.27 (0.31)	–0.87 (0.91)
Dummy for Generalized System of Preferences	0.62 (0.06)	–0.22 (0.32)	0.63 (0.05)	0.60 (0.05)	–0.27 (0.28)	0.61 (0.05)
Time-fixed effects	Yes	Yes	No	Yes	Yes	No
Country-fixed effects	Yes	No	No	Yes	No	No
Country pair–fixed effects	No	Yes	No	No	Yes	No
Time-varying country effects	No	No	Yes	No	No	Yes
Number of observations	4,801	4,801	4,801	4,801	4,801	4,801
R-squared	0.73	0.44	0.81	0.76	0.49	0.81
Root mean squared errors	1.78		1.53	1.68		1.52

Note: Numbers in parentheses are standard errors.
[1]The instrumental variable is the long-run volatility of the relative money supply, constructed similarly to that of Frankel and Wei (1993).
[2]The instrumental variable is a common anchor dummy constructed by Tenreyro (2003).
[3]The instrumental variable is propensity to share a common anchor, estimated based on Tenreyro (2003).

Table A11. Alternative Measures of Volatility: Short Run and Long Run, Parallel Market, Nominal, and Conditional
(In percent)

Variable	LR, SR, Official, and Real (1)	LR, Official, Parallel, and Real (2)	LR, SR, Official, Parallel, and Real (3)	LR, Official, and Nominal (4)	Conditional, Official, and Real (5)
Long-run official real volatility	–3.86 (0.88)	–1.86 (0.98)	–3.92 (1.30)		
Short-run official real volatility Long-run official real rolatility	–1.87 (0.71)		–2.72 (1.04)		
Long-run parallel real volatility Long-run official real volatility		–1.55 (0.60)	–1.20 (0.63)		
Shot-run parallel real volatility Short-run official real volatility			–0.55 (0.73)		
Long-run official nominal volatility				–2.60 (0.60)	
Volatility conditional upon historical information					–2.20 (0.92)
Dummy for common currency union	1.37 (0.14)			1.30 (0.14)	1.41 (0.14)
Log of real GDP product	0.18 (0.13)	0.21 (0.19)	0.21 (0.19)	0.22 (0.13)	0.18 (0.13)
Log of real per capita GDP product	–0.05 (0.12)	1.04 (0.21)	1.03 (0.21)	–0.09 (0.12)	–0.04 (0.12)
Log of distance	–1.51 (0.02)	–1.40 (0.03)	–1.39 (0.03)	–1.51 (0.02)	–1.52 (0.02)
Common language dummy	0.25 (0.05)	0.30 (0.06)	0.30 (0.06)	0.25 (0.05)	0.25 (0.05)
Common border dummy	–0.12 (0.09)	–0.26 (0.12)	–0.22 (0.12)	–0.12 (0.10)	–0.12 (0.10)
Number of landlocked countries in the country pair	–3.12 (0.56)	–3.06 (0.69)	–3.33 (0.55)	–0.01 (0.50)	0.10 (0.50)
Number of island countries in the country pair	0.56 (0.54)	–3.08 (0.72)	–5.11 (1.11)	2.51 (0.36)	2.58 (0.36)
Log of area product	0.53 (0.09)	0.27 (0.10)	0.23 (0.12)	0.50 (0.08)	0.52 (0.08)
Dummy for same colonizer after 1945	0.68 (0.07)	0.70 (0.11)	0.70 (0.11)	0.70 (0.07)	0.70 (0.07)
Dummy for both currently being colonies	0.31 (0.48)	–0.81 (0.16)	–0.82 (0.16)	0.28 (0.46)	0.29 (0.47)
Dummy for common nation	0.80 (0.58)			0.91 (0.57)	0.84 (0.57)
Dummy for being colonizer and colony to each other	1.44 (0.07)	1.01 (0.09)	1.00 (0.09)	1.45 (0.07)	1.46 (0.07)
Dummy for common Free Trade Agreement membership	0.27 (0.08)	–0.49 (0.11)	–0.50 (0.11)	0.28 (0.08)	0.28 (0.08)
Dummy for one in World Trade Organization	0.27 (0.12)	–0.14 (0.18)	–0.18 (0.18)	0.26 (0.12)	0.29 (0.12)

Table A11. ***(concluded)***

Variable	LR, SR, Official, and Real (1)	LR, Official, Parallel, and Real (2)	LR, SR, Official, Parallel, and Real (3)	LR, Official, and Nominal (4)	Conditional, Official, and Real (5)
Dummy for both in World Trade Organization	0.43 (0.14)	–0.15 (0.22)	–0.18 (0.22)	0.43 (0.14)	0.49 (0.14)
Dummy for Generalized System of Preferences	0.63 (0.03)	0.59 (0.04)	0.60 (0.04)	0.63 (0.03)	0.63 (0.03)
Time-fixed effects	Yes	Yes	Yes	Yes	Yes
Country-fixed effects	Yes	Yes	Yes	Yes	Yes
Number of observations	16,085	6,988	6,949	16,238	16,238
R-squared	0.79	0.82	0.83	0.79	0.79
Root mean squared errors	1.64	1.44	1.44	1.64	1.65

Note: LR = long run; SR = short run. Numbers in parentheses are standard errors.

Table A12. Country Pair–Fixed Effects

Variable	LR, SR, Official, and Real (1)	LR, Official, Parallel, and Real (2)	LR, SR, Official, Parallel, and Real (3)	LR, Official, and Nominal (4)	Conditional, Official, and Real (5)
Long-run official real volatlity	–4.84 (0.61)	–1.43 (0.60)	–4.72 (0.76)		
Short-run official real volatility / Long-run official real volatility	–2.97 (0.44)		–4.15 (0.55)		
Long-run parallel real volatility / Long-run official real volatility		–0.94 (0.34)	–0.42 (0.34)		
Short-run parallel real volatility / Short-run official real volatility			–1.14 (0.41)		
Long-run official nominal volatility				–2.51 (0.43)	
Volatility conditional upon historical information					–4.12 (0.70)
Dummy for common currency union	0.22 (0.38)			0.20 (0.38)	0.28 (0.38)
Log of real GDP product	0.50 (0.10)	0.61 (0.13)	0.65 (0.13)	0.51 (0.10)	0.50 (0.10)
Log of real per capita GDP product	–0.25 (0.09)	0.52 (0.14)	0.47 (0.13)	–0.27 (0.09)	–0.24 (0.09)
Dummy for both currently being colonies	0.17 (0.98)			0.15 (0.98)	0.16 (0.98)
Dummy for common Free Trade Agreement membership	0.25 (0.10)	0.29 (0.13)	0.33 (0.13)	0.26 (0.10)	0.24 (0.10)
Dummy for one in World Trade Organization	0.10 (0.10)	–0.24 (0.13)	–0.25 (0.13)	0.10 (0.10)	0.13 (0.10)
Dummy for both in World Trade Organization	0.24 (0.10)	–0.20 (0.14)	–0.20 (0.14)	0.22 (0.10)	0.29 (0.10)
Dummy for Generalized System of Preferences	0.43 (0.10)	0.03 (0.14)	0.00 (0.14)	0.45 (0.09)	0.46 (0.09)
Time-fixed effects	Yes	Yes	Yes	Yes	Yes
Country pair–fixed effects	Yes	Yes	Yes	Yes	Yes
Number of observations	16,085	6,988	6,949	16,238	16,238
R-squared errors	0.49	0.69	0.69	0.48	0.49

Note: LR = long run; SR = short run. Numbers in parentheses are standard errors.

Table A13. Time-Varying Country Effects

Variable	LR, SR, Official, and Real (1)	LR, Official, Parallel, and Real (2)	LR, SR, Official, Parallel, and Real (3)	LR, Official, Real, Effective, and Real (4)	Conditional, Official, and Real (5)
Long-run official real volatility	5.99 (2.14)	3.34 (3.25)	7.52 (3.89)	3.64 (1.58)	
Short-run official real volatility Long-run official real volatility	4.19 (1.88)		6.70 (3.24)		
Long-run parallel real volatility Long-run official real volatility		–2.01 (2.69)	–2.20 (2.71)		
Short-run parallel real volatility Short-run official real volatility			–1.55 (2.80)		
Sum of effective long-run official real volatility of country pairs				–6.20 (1.52)	
Volatility conditional upon historical information					0.97 (1.50)
Dummy for common currency union	1.42 (0.14)			1.49 (0.15)	1.36 (0.14)
Log of real GDP product	0.81 (0.18)	0.97 (0.09)	0.99 (0.09)	0.24 (0.14)	0.72 (0.17)
Log of real per capita GDP product	0.12 (0.22)	0.69 (0.09)	0.83 (0.13)	–0.08 (0.12)	0.19 (0.21)
Log of distance	–1.54 (0.02)	–1.42 (0.03)	–1.43 (0.03)	–1.53 (0.03)	–1.53 (0.02)
Common language dummy	0.27 (0.05)	0.30 (0.06)	0.31 (0.06)	0.26 (0.05)	0.25 (0.05)
Common border dummy	–0.11 (0.09)	–0.22 (0.12)	–0.17 (0.12)	–0.13 (0.09)	–0.12 (0.10)
Number of landlocked countries in the country pair	–1.27 (0.39)	–0.19 (0.25)	–0.75 (0.29)	–2.97 (0.59)	–1.26 (0.39)
Number of island countries in the country pair	0.97 (0.75)	1.16 (0.26)	0.77 (0.26)	0.52 (0.52)	1.02 (0.76)
Log of area product	0.01 (0.18)	–0.20 (0.04)	–0.21 (0.04)	0.52 (0.08)	0.10 (0.16)
Dummy for same colonizer after 1945	0.71 (0.07)	0.72 (0.11)	0.70 (0.11)	0.73 (0.07)	0.72 (0.07)
Dummy for both currently being colonies	–1.14 (0.16)	–0.75 (0.18)	–0.70 (0.19)	0.00 (0.57)	–1.11 (0.16)
Dummy for common nation	2.42 (0.38)			1.21 (0.66)	2.33 (0.37)
Dummy for being colonizer and colony to each other	1.45 (0.07)	1.00 (0.09)	1.00 (0.09)	1.47 (0.07)	1.45 (0.07)
Dummy for common Free Trade Agreement membership	0.26 (0.08)	–0.57 (0.11)	–0.56 (0.11)	0.30 (0.08)	0.26 (0.08)
Dummy for one in World Trade Organization	1.78 (0.54)	0.64 (0.35)	0.10 (0.41)	0.26 (0.13)	1.78 (0.55)

Table A13. *(concluded)*

Variable	LR, SR, Official, and Real (1)	LR, Official, Parallel, and Real (2)	LR, SR, Official, Parallel, and Real (3)	LR, Official, Real, Effective, and Real (4)	Conditional, Official, and Real (5)
Dummy for both in World Trade Organization	3.49 (1.06)	1.40 (0.64)	0.38 (0.75)	0.41 (0.15)	3.46 (1.09)
Dummy for Generalized System of Preferences	0.58 (0.03)	0.57 (0.04)	0.56 (0.04)	0.65 (0.03)	0.59 (0.03)
Time-fixed effects	No	No	No	Yes	No
Country-fixed effects	No	No	No	Yes	No
Time-varying country effects	Yes	Yes	Yes	No	Yes
Number of observations	16,085	6,988	6,949	15,157	16,238
R-squared	0.81	0.83	0.84	0.79	0.81
Root mean squared errors	1.59	1.43	1.42	1.62	1.60

Note: LR = long run; SR = short run. Numbers in parentheses are standard errors.

Table A14. Differentiation by Product Type[1]

	With Country-Fixed Effect		With Time-Varying Country Effect	
Variable	Homogeneous	Differentiated	Homogeneous	Differentiated
Long-run official real volatility	–0.59 (2.12)	–2.89 (1.66)	–2.97 (4.39)	0.98 (3.06)
Log of real GDP product	2.29 (0.28)	3.18 (0.22)	0.84 (0.09)	0.23 (0.12)
Log of real per capita GDP product	–2.16 (0.28)	–3.24 (0.22)	–0.79 (0.20)	0.49 (0.24)
Log of distance	–2.06 (0.04)	–1.01 (0.03)	–2.11 (0.04)	–1.08 (0.03)
Common language dummy	0.05 (0.09)	0.30 (0.07)	0.04 (0.08)	0.33 (0.06)
Common border dummy	–0.95 (0.14)	–0.23 (0.11)	–0.99 (0.12)	–0.28 (0.08)
Number of landlocked countries in the country pair	–1.99 (0.46)	–6.41 (1.22)	1.28 (0.41)	0.62 (0.48)
Number of island countries in the country pair	–6.82 (1.59)	–12.11 (1.25)	4.68 (0.51)	–3.97 (0.63)
Log of area product	–2.12 (0.34)	–3.36 (0.26)	–0.29 (0.08)	–0.16 (0.11)
Dummy for same colonizer after 1945	0.43 (0.27)	0.35 (0.21)	0.47 (0.24)	0.26 (0.17)
Dummy for both currently being colonies	0.49 (1.16)	0.12 (0.91)	0.13 (1.05)	0.04 (0.73)
Dummy for being colonizer and colony to each other	0.89 (0.16)	0.79 (0.12)	0.89 (0.14)	0.81 (0.10)
Dummy for common Free Trade Agreement membership	–0.34 (0.11)	0.05 (0.08)	–0.51 (0.11)	0.06 (0.08)
Dummy for one in World Trade Organization	0.67 (1.16)	1.31 (0.90)	–0.02 (0.54)	–0.12 (0.38)
Dummy for both in World Trade Organization	0.99 (1.16)	0.96 (0.91)		
Dummy for Generalized System of Preferences	–0.51 (0.09)	0.51 (0.07)	–0.41 (0.08)	0.55 (0.06)
Time-fixed effects	Yes	Yes	No	No
Country-fixed effects	Yes	Yes	No	No
Time-varying country effect	No	No	Yes	Yes
Number of observations	4,370	4,370	4,370	4,370
R-squared	0.72	0.82	0.78	0.89
Root mean squared errors	1.61	1.26	1.43	0.99

Note: Numbers in parentheses are standard errors.
[1] Using seemingly unrelated regressions (SUR) technique.

Table A15. Differentiation by Country Type[1]

Variable	Developed and Developing Countries (1)	(2)
Long-run official real volatility	43.47 (3.54)	47.90 (3.85)
Long-run official real volatility (NS dummy)	–45.70 (3.60)	–47.59 (3.90)
Long-run official real volatility (SS dummy)	–46.69 (3.64)	–47.92 (4.00)
Dummy for common currency union	–0.62 (0.23)	–0.60 (0.21)
(Currency union dummy) (SS dummy)	2.11 (0.27)	2.12 (0.25)
Dummy for north-south country pair	–0.49 (0.28)	1.11 (0.45)
Dummy for south-south country pair	–2.49 (0.52)	0.56 (0.87)
Time-fixed effects	Yes	No
Country-fixed effects	Yes	No
Time-varying country effects	No	Yes
Number of observations	16,238	16,238
R-squared	0.79	0.81
Root mean squared errors	1.64	1.59

Note: NS = trade among advanced and developing countries; SS = trade among developing countries. Numbers in parentheses are standard errors.
[1] The estimated coefficients for standard control dummies in the baseline specification are not reported.

Table A16. Summary Statistics and Correlations

Summary Statistics of Main Variables for Aggregate Trade Data

Full-Sample

Variable	Code in Data Set	Number of Observations	Mean	Standard Deviation	Minimum	Maximum
Long-run official real volatlity	vol_lor	26,395	0.066	0.076	0.003	1.405
Long-run official nominal volatility	vol_lon	37,254	0.062	0.081	0	0.979
Long-run parallel real volatility	vol_lpr	11,844	0.090	0.074	0.007	0.684
Long-run parallel nominal volatility	vol_lpn	16,302	0.089	0.073	0	0.596
Short-run official real volatility	vol_sor	26,444	0.046	0.065	0.001	0.836
Short-run official nominal volatility	vol_son	37,416	0.041	0.069	0	0.900
Short-run parallel real volatility	vol_spr	12,575	0.073	0.075	0.000	0.664
Short-run parallel nominal volatility	vol_spn	16,753	0.073	0.069	0	0.561
Log of bilateral trade	ltrade	37,443	9.983	3.541	−16.090	20.890
Log of real GDP product	lrgdp	37,593	47.973	2.765	36.128	58.356
Log of real per capita GDP product	lrgdppc	37,593	16.047	1.662	9.160	20.850

Sample for Regressions

Variable	Code in Data Set	Number of Observations	Mean	Standard Deviation	Minimum	Maximum
Long-run official real volatility	vol_lor	16,303	0.043	0.028	0.003	0.293
Long-run official nominal volatility	vol_lon	16,303	0.039	0.031	0	0.271
Long-run parallel real volatility	vol_lpr	6,988	0.066	0.054	0.007	0.541
Long-run parallel nominal volatility	vol_lpn	6,988	0.063	0.052	0	0.517
Short-run official real volatility	vol_sor	16,149	0.034	0.025	0.002	0.254
Short-run official nominal volatility	vol_son	16,303	0.028	0.027	0	0.267
Short-run parallel real volatility	vol_spr	7,190	0.052	0.039	0.000	0.393
Short-run parallel nominal volatility	vol_spn	7,229	0.049	0.040	0	0.387
Conditional volatility	cvol	16,303	0.047	0.021	0.003	0.191
Log of bilateral trade	ltrade	16,238	10.458	3.573	–8.076	20.890
Log of real GDP product	lrgdp	16,303	48.296	2.852	37.368	58.356
Log of real per capita GDP product	lrgdppc	16,303	16.264	1.733	9.160	20.850

Correlation Matrix of Main Variables for Aggregate Trade Data

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) Long-run official real volatility	1.00											
(2) Long-run official nominal volatility	0.96	1.00										
(3) Long-run parallel real volatility	0.44	0.52	1.00									
(4) Long-run parallel nominal volatility	0.42	0.51	0.99	1.00								
(5) Short-run official real volatility	0.38	0.40	0.37	0.36	1.00							
(6) Short-run official nominal volatility	0.35	0.40	0.38	0.37	0.97	1.00						
(7) Short-run parallel real volatility	0.15	0.12	0.24	0.24	0.31	0.27	1.00					
(8) Short-run parallel nominal volatility	0.12	0.10	0.21	0.21	0.29	0.25	0.99	1.00				
(9) Log of bilateral trade	–0.32	–0.28	–0.31	–0.31	–0.19	–0.13	–0.22	–0.20	1.00			
(10) Log of real GDP product	–0.20	–0.17	–0.23	–0.23	–0.08	–0.04	–0.16	–0.14	0.76	1.00		
(11) Log of real per capita GDP product	–0.35	–0.27	–0.34	–0.33	–0.19	–0.11	–0.30	–0.26	0.61	0.44	1.00	
(12) Conditional volatility	0.56	0.57	0.33	0.32	0.32	0.31	0.09	0.07	–0.35	–0.22	–0.36	1.00

Table A16. *(concluded)*

Summary Statistics of Main Variables for Aggregate Trade Data

	Number of Observations	Mean	Standard Deviation	Minimum	Maximum
Log imports of differentiated goods (real value)	4,667	10.54	3.23	–2.62	17.84
Log imports of homogeneous goods (real value)	4,473	9.29	3.08	–4.05	17.08
Log total imports (real value)	9,140	9.93	3.22	–4.05	17.84

	1975	1980	1985	1990	1995	2000
Total imports of differentiated goods (millions of U.S. dollars)	187	290	300	538	788	946
Total imports of homogeneous goods (millions of U.S. dollars)	70	138	114	148	165	185
Share of differentiated products in total trade	0.73	0.68	0.72	0.78	0.83	0.84

Table A17. List of Countries in the Regressions with Disaggregated Trade, 1975–2000

Argentina
Australia
Austria
Belgium
Brazil
Canada
Chile
China
Colombia
Denmark
Finland
France
Germany
Greece
Hong Kong SAR
India
Indonesia
Ireland
Italy
Japan
Korea, Republic of
Malaysia
Mexico
Netherlands
New Zealand
Norway
Peru
Philippines
Poland
Portugal
Singapore
South Africa
Spain
Sweden
Switzerland
Thailand
Turkey
United Kingdom
United States

Table A18. Classification of Products into Homogeneous and Differentiated Categories

Homogeneous Products

SITC 4 (rev. 1)	Item
1121	Wine of fresh grapes including grape must
1124	Distilled alcoholic beverages
1222	Cigarettes
2517	Sulphate wood pulp
3214	Coal: anthracite, bituminous
3310	Petroleum: crude and partly refined
3321	Motor spirit, gasoline, and other light oils
3411	Gas, natural
5121	Hydrocarbons and their derivatives
5122	Alcohols/phenols/phenol-alcohols/glycerine
5811	Products of condensation, polycond. and polyaddition
6411	Newsprint paper
6412	Other printing and writing paper, machine-made
6415	Machine-made paper and paperboard, simply finished
6516	Yarn and thread of synthetic fibers
6732	Bars and rods of iron or steel, ex. wire rod
6748	Other coated iron or steel plates under 3 mm
6821	Copper and alloys, unwrought
6822	Copper and alloys of copper, worked
6841	Aluminum and aluminum alloys, unwrought
6842	Aluminum and aluminum alloys, worked
7291	Batteries and accumulators

Differentiated Products

SITC 4 (rev. 1)	Item
2432	Lumber, sawn, planed, etc.—conifer
5417	Medications
5530	Perfumery and cosmetics, toothpaste, etc.
5999	Chemical products and preparations
6291	Rubber tires and tubes for vehicles and aircraft
6429	Articles of paper pulp, paper, or paperboard
6522	Cotton fabrics, woven, other than gray
6537	Knitted or crocheted fabrics, not elastic or rubber
6554	Coated or impregnated textile fabrics and products
6942	Nuts, bolts, screws, rivets, washers, etc.
6952	Other tools for manual use or in machines
6981	Locksmiths' equipment
6989	Articles of base metals
7114	Aircraft, including with jet propulsion engines
7115	Internal combustion engines, not for aircraft
7143	Statistical machines for cards or tapes
7149	Office machines
7151	Machine tools for working metals
7171	Textile machinery
7182	Printing and bookbinding machinery
7184	Construction and mining machinery
7191	Heating and cooling equipment
7192	Pumps and centrifuges
7193	Mechanical handling equipment
7195	Power tools
7196	Other nonelectrical machines
7197	Ball, roller, or needle-roller bearings
7199	Parts and accessories of machinery
7222	Apparatuses for electrical circuits
7231	Insulated wire and cable

Table A18. ***(concluded)***

Differentiated Products

SITC 4 (rev. 1)	Item
7241	Television broadcast receivers
7242	Radio broadcast receivers
7249	Telecommunications equipment
7250	Domestic electrical equipment
7293	Thermionic valves and tubes, transistors, etc.
7294	Automotive electrical equipment
7295	Electrical measuring and controlling instruments
7299	Electrical machinery and apparatuses
7321	Passenger motor cars, other than buses
7323	Trucks, including ambulances, etc.
7328	Bodies and parts for motor vehicles except motorcycles
7331	Bicycles and other cycles, not motorized, and parts
7341	Aircraft
7349	Parts of aircraft balloons and airships
7353	Ships and boats, other than warships
8210	Furniture
8310	Travel goods, handbags and similar articles
8411	Clothing of textile fabric, not knitted or crocheted
8414	Clothing and accessories, knitted or crocheted
8510	Footwear
8616	Photographic and cinematographic equipment
8617	Medical instruments
8619	Measuring, controlling, and scientific instruments
8624	Photography film and developed film other than movie
8911	Phonographs, tape, and other sound recorders, etc.
8912	Phonograph records, recorded tapes
8921	Books and pamphlets, printed
8942	Children's toys, indoor games, etc.
8944	Other sporting goods

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