Effects of Exchange Rate Uncertainty on German and U.S. Trade

Economists and policy makers now widely agree that exchange rates of major currencies have been characterized by a high degree of volatility and uncertainty since the beginning of generalized floating in 1973. But they do not agree on the economic consequences of that uncertainty. Some are concerned about the possible adverse effects of exchange rate uncertainty on trade and other important macroeconomic objectives. Others argue that, on balance, exchange rate volatility does not have any significant harmful effects. More particularly, there is a continuing debate about the influence of exchange risk on the volume of trade.

On the empirical side, thus far there has been no firm evidence that exchange rate uncertainty has any significant adverse effects on the volume of trade. A recent study by the International Monetary Fund (IMF), which surveys and updates some earlier research, reaches this conclusion and argues that "given the wide variety of empirical testing that has been performed it seems unlikely that...more intensive or sophisticated tests would show a greatly different result."[1] Most other studies have also uncovered no significant effects of exchange rate uncertainty on trade.

Our research suggests a different conclusion, however. By making use of more recent data than other studies have used, we find that exchange rate uncertainty has a significant impact on imports and exports of Germany and of the United States. In addition, we argue that the estimated effects are likely to understate the impact of exchange rate uncertainty on trade.

In this article, we first discuss the problem of defining exchange rate uncertainty and its relationship to observed variability of exchange rates. We then outline the various direct and indirect ways through which uncertainty might affect the volume of trade. Finally, we review our empirical results, and attempt to quantify the total impact that exchange rate uncertainty has had on German and U.S. trade in recent years.[2]

What is exchange rate uncertainty?

Exchange rate uncertainty refers to a state of doubt about future rates at which various currencies will be exchanged against each other. Of particular interest are the timing and size of exchange rate fluctuations that cannot be *systematically* explained by economic factors. Specifically, exchange uncertainty reflects the extent to which exchange rate changes, in terms of their timing and size, are unpredictable on the basis of past experience and existing economic models.

This notion of exchange rate uncertainty is impossible

[1] International Monetary Fund, *Exchange Rate Variability and World Trade*, forthcoming. The report was requested by the GATT and was unofficially released to the press in March 1984; according to Reuters it was discussed by the GATT's 90-Nation Council of Representatives.

[2] This article is based on a lengthier unpublished study by M. A. Akhtar and R. Spence Hilton, "Exchange Rate Uncertainty and International Trade: Some Conceptual Issues and New Estimates for Germany and the United States," Federal Reserve Bank of New York, Research Paper No. 8403, May 1984.
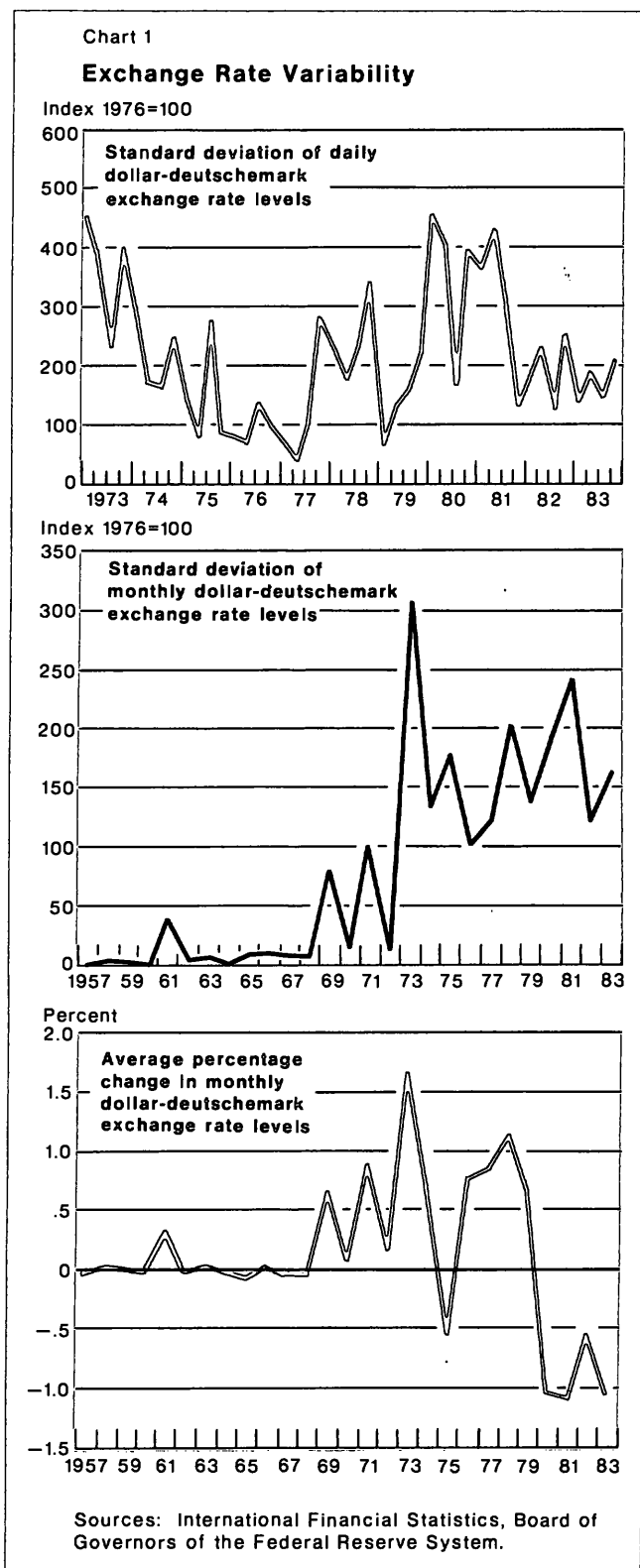
to quantify precisely. But if there were a widely used empirical model of exchange rate behavior, some measure of prediction errors from that model might provide a good approximation of exchange rate uncertainty. In other words, the timing and magnitude of those exchange rate movements not consistently predictable on the basis of the model would reflect uncertainty. In practice, however, such a model does not exist and so it is not possible to estimate even a good approximation for the theoretical notion of exchange uncertainty as defined here.

Problems of measurement notwithstanding, it is not hard to see that the behavior of major currencies has been marked by a high degree of uncertainty since the advent of generalized floating in early 1973. This is clearly suggested by observed variability, which is commonly used as an indicator of exchange rate uncertainty. Measured variability became larger after 1973 and has shown no consistent tendency to decrease (Chart 1). Persistently large exchange rate variability is suggestive of a large random component in exchange rate movements, that is, a component which cannot be systematically explained by economic factors.

Greater rate variability by itself suggests but does not logically imply greater unpredictability of exchange rates. However, exchange rate uncertainty has also been the consequence of highly unpredictable (or at least difficult to predict) exchange rates in recent years. Many widely used structural models do not forecast exchange rates any better than a random walk. In fact, the existing *empirical* models as well as so-called structure-free empirical analysis (which combines various "fundamentals" such as prices, money stocks, current accounts, etc. from different structural models) fail to explain exchange rate movements adequately over the last ten years or so. Perhaps more importantly, virtually all exchange rate forecasts—model-based or otherwise—exhibit large prediction errors outside the observed sample period. All of these points about the performance of empirical models and forecasts are well documented in many recent studies.[3]

The difficulties of predicting exchange rates are also reflected in the fact that, like other forecasts, future spot

[3]See, for example, Richard A. Meese and Kenneth Rogoff, "Empirical Exchange Rate Models of the Seventies: Do They Fit Out-of-Sample?", *Journal of International Economics* (February 1983); Jeffrey R. Shafer and Bonnie E. Loopesko. "Floating Exchange Rates After Ten Years", *Brookings Papers on Economic Activity, 1* (1983); Ralph W. Tryon, Ralph W. Smith, and Peter Hooper, "Models of Exchange Rate Determination and Their Empirical Content in the Light of the Federal Reserve Board Model" in Bank for International Settlements, *Exchange Rate Determination Analysis and Policy Issues* (September 1983); and Richard M. Levich, "How the Rise of the Dollar Took Forecasters by Surprise", *Euromoney* (August 1982).

Chart 1

Exchange Rate Variability

Index 1976=100

Sources: International Financial Statistics, Board of Governors of the Federal Reserve System.

rate forecasts based on the forward rate for the relevant maturity yield large prediction errors. This suggests that the forward rate is an unreliable and poor predictor of the future spot rate. In fact, in recent years the forward premium or discount has often failed to indicate even the direction of exchange rate changes.

Even if the timing and magnitude of exchange rate changes are generally unpredictable, exchange rate movements might correspond to changes in relative price levels in some average sense over the medium-term, say over two or three years. If this type of medium-term purchasing power parity were to hold systematically, it would offset part of exchange rate uncertainty stemming from unpredictable rates. Economic agents would then be able to make *some* decisions by counting on the fact that deviations from purchasing power parity would systematically reverse themselves over time.

In fact, however, exchange rate movements since the mid 1970s have been persistently out of line with changes in relative price levels over long stretches of time. As a result, real effective exchange rates have experienced sharp appreciations or depreciations for periods of up to four years (Chart 2). These developments have rendered purchasing power parity less useful as an anchor for equilibrium. Large and persistent deviations from purchasing power parity have also made it more difficult to account for medium-term future exchange rate developments. Even if a differential in inflation rates *ultimately* is an important contributing factor to subsequent exchange rate changes, purchasing power parity does not appear to be a useful guide to the timing and size of such movements over a time horizon relevent for most economic decisions.

Based on this analysis, exchange rate uncertainty may be viewed as composed of (1) a part captured by exchange rate variability, the most commonly used proxy for uncertainty, and (2) another part not captured by variability. The latter reflects the extent to which exchange uncertainty is not systematically related to variability. Instead, it may be due to unpredictable exchange rates and/or the failure of purchasing power parity to hold over the medium-term. Of particular importance is that observed variability may not fully reflect the extent to which the timing and size of exchange rate changes are unpredictable. For example, changes in exchange rates are frequently unpredictable even when exchange markets are relatively calm, (*i.e.*, even when observable exchange rate variability is low). Put differently, even if variability—which can be measured only in the *ex post* sense—is low, the *ex ante* uncertainty reflecting forecast errors may be very high.

Exchange rate variability as a proxy for uncertainty
Since there is no unique or precise way to *measure* exchange rate uncertainty, theoretical and empirical research on its effects has generally fallen back on some measure of exchange rate variability as a proxy for uncertainty. The variance or standard deviation of a set of observations on the nominal exchange rate within a specified period of time is the most commonly used gauge of exchange uncertainty. Alternatively, the variation in exchange rate changes is sometimes employed.

However, as discussed above, the traditional measures of variability are far from perfect substitutes for exchange rate uncertainty. In fact, we have argued that variability is likely to *understate* exchange uncertainty. Low levels of observed *ex post* variability may be associated with high uncertainty because there is no reliable way to predict the timing and magnitude of future changes in exchange rates. If there is no close and systematic relationship between variability and unpredictability, variability levels may not tell us much about *ex ante* uncertainty.[4] And under these circumstances any measure of variability would most likely understate the extent of "true" exchange rate uncertainty.

In contrast to this view, many economists maintain that measures of nominal exchange rate variability *overstate* the existing level of exchange rate uncertainty. But this argument ignores the fact that exchange rate changes are highly unpredictable. Instead it is frequently based on the view that exchange rate movements offset divergences in underlying inflation rates between countries. If a relationship between prices and exchange rates is known to hold with certainty, then some portion of the movement in nominal rates within a period of time could be predicted. Changes in nominal rates unaccounted for by relative price changes (*i.e.*, movements in the real exchange rate) would be smaller in magnitude than the total movement in the nominal exchange rate, so long as exchange rates move in the direction expected on the basis of relative price movements. Reasoning along these lines has led some to conclude that variability in *real* exchange rates provides a better measure of exchange risk than variability in nominal rates.

However, this proposition rests on the accuracy of purchasing power parity as a device for predicting nominal exchange rate changes, and on the confidence

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[4] It is the *ex ante* and not the *ex post* variability that is relevant for measuring exchange uncertainty. It is sometimes argued that the forward rate variability may be a better approximation of the *ex ante* variability. However, the measured variability of the forward rate (three-month) has been almost identical to that of the spot rate over the last ten years or so. Our arguments on the limitations of variability as an indicator of exchange rate uncertainty also apply to the forward rate.

Percent
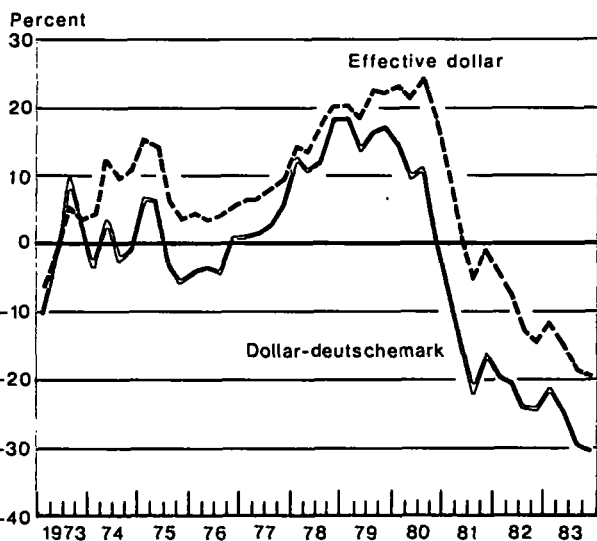
*Negative number indicates a real dollar appreciation.

Source: International Financial Statistics, Board of Governors of the Federal Reserve System.

with which these predictions are held. The persistent deviations recorded in purchasing power parity over the medium-term, along with the fact that exchange rates both influence and are influenced by domestic prices, suggest that the relationship between relative price movements and nominal exchange rate changes cannot be determined, *ex ante,* in any reliable way. Moreover, movements in real exchange rates are frequently every bit as large as those in nominal rates over extended periods of time. And the recent evidence suggests that there is no *strong* and *systematic* tendency for deviations from purchasing power parity to be self-reversing over a period of up to two or three years. Given the highly unpredictable nature of exchange rate movements and the lack of empirical support for purchasing power parity over the medium-term, the assertion that nominal exchange rate variability would overstate uncertainty is simply not true.

Even if purchasing power parity were to hold to some degree and exchange rate changes were more predictable, adjusting nominal exchange rate changes for relative inflation might not yield a superior barometer of exchange uncertainty. A measure of variability that partly

reflects fluctuations in price levels does not allow for a distinction between the risk due to exchange rate changes independent of price movements and the risk associated with all other factors which might affect inflation at home and abroad.

For all these reasons, we reject the use of *real* exchange rate variability as the relevant proxy for uncertainty in our empirical work. Since "true" uncertainty is not measurable, that leaves us with the observed nominal exchange rate variability. Given the above discussion, the presumption in our empirical work is that even if the observed variability does not matter statistically, "true" exchange rate uncertainty may still matter; but if the observed variability matters, this strongly suggests that true uncertainty matters, and perhaps considerably more. Before we turn to empirical results, however, it seems useful to outline the main channels through which exchange rate uncertainty might influence the volume of international trade.

Effects of exchange rate uncertainty
At the simplest level, exchange rate uncertainty is a source of concern because currency values partly determine the price paid or received for output and, consequently, affect the profits and welfare of producers and consumers. If market participants are risk averse, then exchange uncertainty can cause them to curtail their activities, change prices, or shift sources of supply and demand in order to limit their exposure to the effects of unforeseen currency movements. The distribution of output across many sectors of the world economy could be altered in this way. Moreover, in the longer run the allocation of resources between industries can be modified through the influence of exchange rate uncertainty on investment decisions concerning plant and equipment. But exchange rate considerations are most clearly relevant for internationally tradeable products, such as merchandise exports and imports, which are the focus of this study.

Direct effects
Exchange rate uncertainty can directly affect the volume of goods traded internationally by making prices and profits indeterminate or uncertain. For instance, consider a firm choosing between buying a foreign-made product and a similar domestic substitute when both are equally valued in local currency terms using current exchange rate levels. A preference for the domestic product over the import will exist if it is unclear at the time a purchase order is placed what the exchange rate level will actually be when payment is due. This assumes that forward markets cannot be used to create a *perfect* hedge against exchange risk (this assumption is discussed below) and that the product price is originally

quoted in foreign currency terms, requiring the importer to engage at some future date in a foreign exchange transaction to secure the foreign currency needed for final payment. If a sizable number of buyers in a country face a similar set of conditions, then that nation's aggregate level of imports could be reduced (and partly replaced with domestic output) by an upswing in the degree of exchange rate uncertainty. Under analogous circumstances exchange risk could adversely affect export volume.

In the import example, if the product price in a contract made with a foreign supplier is specified in domestic currency terms, then the importer will be freed from the consequences of an unexpected exchange rate change. However, the foreign supplier, who now must convert receipts from the importer's currency to his own, risks a loss that might result from an unanticipated exchange rate change. As compensation for assuming this risk, suppliers might impose a premium in the form of a higher sales price. Because quantity demanded responds to price, the volume of imports would be reduced by exchange rate uncertainty even if contract prices were set in the currency of importers. In this case, exchange uncertainty results in a higher price for traded goods, thereby leading to a reduced volume of trade.

To the extent that hedging in forward markets can reduce exchange risk without significant increases in costs of doing international business, the preceding conclusions have to be modified. But studies strongly indicate that forward markets are not effective in completely eliminating exchange uncertainty at modest costs, except under very unrealistic assumptions. So long as businesses cannot predict the future cost and prices of their goods or the timing and magnitude of their foreign exchange needs, even well developed forward markets can provide only limited protection from exchange risk. The difficulties of dealing with exchange rate uncertainty are compounded by the fact that future spot rate predictions based on forward rates are very poor (*i.e.*, have large forecasting errors). Moreover, any costs of forward cover or hedging will reduce the international exchange of goods: importers who pay for this cover will face a higher effective price for foreign goods; or exporters who incur hedging costs will pass along those costs by raising prices. The result in both instances is a reduction in trade volume, so long as quantity demanded is responsive to price.

Implicit in the foregoing analysis and examples is the importance of lags in the decision-making process. Some period of time elapses between the initiation of a purchase agreement and the actual payment or receipt of revenues for a product. This "contract period" may arise from production delays, delivery lags or from the time required to arrange financing; frequently it spans several quarters. While the price of a product is generally quoted when an order is first placed, the contract currency determines whether the buyer or seller is exposed to possible exchange rate losses within the contract period.

Indirect effects

The preceding section illustrates how exchange rate uncertainty may directly reduce trade flows by making product prices and profits indeterminable, or at least more uncertain, for either importers or exporters when an order is placed. But uncertainty may also influence trade through less straightforward channels. Most of these indirect effects stem from decisions which affect trade flows over a longer period.

Beyond the contract period, the ability of a firm to anticipate its future income or expenditure stream could be impaired by doing business with foreign rather than available domestic sellers and buyers. Because the rate of foreign exchange is a major determinant of the cost of foreign products, prices of traded goods are more affected by exchange rate changes than prices for local substitutes.[5] If it is costly to change, say, a supply source, then buyers will refrain from switching between domestic and foreign producers to avoid incurring adjustment expenses. For a potential importer or buyer, risk averse behavior means preferring domestic markets to reduce the likelihood of future variations in outlays. Similar considerations apply to sales markets and exporters.

Under these conditions, some international trade could be discourged, perhaps permanently, as market participants reduce their exposure to the consequences of large and pervasive changes in exchange rates--during the 1970s such changes frequently entailed a large appreciation or depreciation of both nominal and real effective exchange rates. This suggests an underlying propensity to rely on domestic in place of foreign buyers and sellers, and does not necessarily depend on unpredictability of exchange rates over the contract period. Only when there are no adjustment costs (or, alternatively, only when there are no significant effects from exchange .rate changes *per se* on prices and volumes of internationally traded goods) would market participants be completely indifferent between domestic and international trade.

Large real exchange rate changes sustained over the

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[5]The substitutability between domestic and foreign goods and relative market power determine the degree to which this holds. Only if there is a strict adherence to purchasing power parity will domestic and foreign prices (translated into domestic currency) move identically in response to exchange rate changes.

Estimating the Effects of Exchange Rate Uncertainty on Trade[*]

Price and volume equations for aggregate exports and imports of manufactured goods were estimated for the United States and Germany using quarterly observations from 1974 through 1981. The independent variables in the export volume (QX) equations were the level of foreign income (YF), the relative price of exported goods to foreign substitutes in foreign currency terms (RELPX), and capacity utilization abroad (CUF). Import volume (QM) was specified as a function of domestic income (YD), the relative price of imported goods to domestic substitutes in domestic currency terms (RELPM), and the ratio of foreign to domestic capacity utilization (CUFCU).[†]

A polynomial distributed lag extending back eight quarters was imposed on the relative price terms while income and capacity utilization variables were lagged one quarter. Dock strike dummies (not reported) were included in the volume equations for the United States to capture the effects of disruptions on trade flows caused by strikes.

The export price (PX) and import price (PM) equations were estimated using price indexes for manufactured commodities produced domestically (PD) and abroad (PF) because prices for traded products largely reflect costs of similar goods in the producing and consuming countries. The domestic currency equivalent for each price variable appears in the equations. Capacity utilization in the domestic country (CU) and in the foreign country were inserted in the export and import price equations, respectively. A one quarter lag was imposed on all these independent variables in the price equations.

As in other empirical studies of trade flows, the natural logs of all the above variables were used in estimation.

Estimation Results

Export Volume
United States:
$$QX = 1.00\ YF - 1.37\ RELPX + 0.56\ CUF - 0.040\ S - 0.30\ e \qquad \bar{R}^2 = .96$$
$$\quad\ \ (8.75) \qquad (7.78) \qquad (2.78) \qquad (1.82) \qquad (1.71) \qquad DW = 1.87$$
Germany:
$$QX = 2.21\ YF - 2.38\ RELPX + 0.73\ CUF - 0.224\ S + 0.24\ e \qquad \bar{R}^2 = .93$$
$$\quad\ \ (9.63) \qquad (4.34) \qquad (3.15) \qquad (3.24) \qquad (1.33) \qquad DW = 2.02$$

Import Volume
United States:
$$QM = 2.03\ YD - 2.44\ RELPM - 0.86\ CUFCU + 0.005\ S + 0.07\ e \qquad \bar{R}^2 = .97$$
$$\quad\ \ (10.12) \qquad (6.37) \qquad (2.57) \qquad (0.28) \qquad (0.40) \qquad DW = 1.67$$
Germany:
$$QM = 1.58\ YD - 2.99\ RELPM + 0.35\ CUFCU - 0.125\ S - 0.10\ e \qquad \bar{R}^2 = .98$$
$$\quad\ \ (9.42) \qquad (5.42) \qquad (0.65) \qquad (2.51) \qquad (0.53) \qquad DW = 2.04$$

Export Price
United States:
$$PX = 1.07\ PD - 0.01\ PF + 0.02\ CU - 0.002\ S + 0.17\ e \qquad \bar{R}^2 = .99$$
$$\quad\ \ (21.12) \qquad (0.33) \qquad (0.25) \qquad (0.31) \qquad (0.93) \qquad DW = 1.81$$
Germany:
$$PX = 0.91\ PD - 0.13\ PF - 0.12\ CU + 0.001\ S + 0.28\ e \qquad \bar{R}^2 = .99$$
$$\quad\ \ (11.89) \qquad (2.12) \qquad (2.05) \qquad (0.10) \qquad (1.73) \qquad DW = 2.13$$

Import Price
United States:
$$PM = 0.39\ PD + 0.48\ PF + 0.16\ CUF + 0.018\ S + 0.44\ e \qquad \bar{R}^2 = .98$$
$$\quad\ \ (5.03) \qquad (7.78) \qquad (1.11) \qquad (1.94) \qquad (3.03) \qquad DW = 1.79$$
Germany:
$$PM = 0.63\ PD + 0.33\ PF + 0.31\ CUF + 0.008\ S + 0.34\ e \qquad \bar{R}^2 = .95$$
$$\quad\ \ (3.84) \qquad (2.64) \qquad (2.70) \qquad (0.31) \qquad (2.07) \qquad DW = 1.92$$

A constant term (not reported) was included in all equations. The estimates were adjusted for first degree serial correlation (e). Aggregate indexes of foreign activity, prices, and exchange rates were constructed by taking trade-weighted averages of individual country indexes for the major trading partners of the United States and Germany.

The proxy for exchange rate uncertainty was based on the variability of an effective nominal exchange rate index. The standard deviation of the daily observations of this index within each three month period was calculated (S). This measure of volatility was included in each price and volume equation with a distributed lag of eight quarters to capture the effects of exchange rate uncertainty.‡

‡Other measures of variability were also tried in estimation. On the whole, our use of alternative measures did not significantly alter the general pattern of results reported here.

Coefficient estimates appear next to the corresponding variable and t-statistics are given below in parentheses—those near or above 1.7 are significant at the 95 percent confidence level using a one-tail test. The results provide support for the hypothesis that exchange risk reduces the volume of international trade. Note that an increase in exchange risk would adversely influence the volume of exports or imports as long as the risk proxy is statistically significant in either the volume or the price equations. In Germany's case, the impact of the risk proxy is negative and statistically significant in both volume equations, but is not found to have an effect on prices. For the United States, there is also evidence that exchange rate variability reduces export volume, but a smaller coefficient and lower t-statistic suggest that it is a less important factor than for German exports. And while the volume of U.S. imports is not directly reduced, their price does increase in response to exchange rate volatility.

medium-term could affect direct investment decisions and trade patterns, which could in turn lower the volume of trade. To reduce the likelihood of price fluctuations caused by currency movements, production facilities would tend to be located near final markets, leading to changes in the pattern of trade.[6] Even without any effects on direct investment decisions, exchange rate movements could distort the pattern of trade among countries by influencing the relative prices of foreign and domestic goods in specific industries. This in turn would influence the distribution of supply at the industry level across countries.

No given change in the trade pattern can be viewed as permanent, since subsequent exchange rate changes in the opposite direction could lead to a reversal or yet another shift in trade patterns. In these circumstances some exporters and importers, who may have incurred initial adjustment costs to continue at least a part of their international trade, may decide to reduce it further or perhaps eliminate it over time. With large changes in real exchange rates in one or the other direction over an extended period of time, the possibility of repeated shifts in supply sources, markets, or trade patterns may increase the risk in international trade.

It is perhaps obvious that most of the indirect effects

of uncertainty on trade mentioned here cannot be separated from the effects of exchange rate changes *per se*. This is particularly true for large pervasive exchange rate changes which can impose large adjustment costs and/or change trade patterns frequently. Such effects, though impossible to separate from the usual price effects, can be considerable given substantial price responses to exchange rate changes.

Measuring the impact of exchange rate uncertainty on trade

As mentioned earlier, we use exchange rate variability as a proxy for exchange rate uncertainty. However, we have also argued that any variability measure is likely to understate "true" uncertainty. This implies that our results would most probably also understate the effects of exchange uncertainty on trade. In addition, our discussion of uncertainty effects on trade suggests that most of the indirect effects cannot be fully separated from those of exchange rate changes *per se*. This may lead to a further downward bias in our estimates of the impact of exchange uncertainty, independent of the proxy for that uncertainty. Bearing these caveats in mind, we believe an empirical analysis which includes the component of exchange uncertainty reflected in variability would provide *some* idea about the impact of exchange rate uncertainty on trade flows.

Previous empirical investigations have failed to reach a firm conclusion about the importance of exchange rate

[6]This is only one of many important reasons, such as the desire to reduce transportation costs, frequently given for locating production facilities close to end-markets.

variability as a determinant of trade. This study sheds new light on the issue by examining the effects of exchange rate variability on multilateral exports and imports for the United States and Germany over the floating rate period.

Volume and price equations were estimated for each country's exports and imports of manufactured goods.[7] By explicitly taking into account the effects of domestic (foreign) income, relative prices, and exchange rate levels on import (export) volume, the impact of exchange rate variability on demand for traded goods can be isolated. The measure of exchange rate variability used was the standard deviation over a three month period of a daily effective exchange rate index. This measure was also included in the price equations, along with variables reflecting the cost of production. Past values of the variability measure extending back several quarters were used to capture the usual lagged effects as well as some of the longer run effects stemming from potential adjustment costs. The estimates for the 1974-81 period, together with a detailed presentation of the variable definitions and equation specifications, are reported in the box.

Analysis of the results

The estimates reported in the box support the hypothesis that exchange risk reduces the volume of international trade. Exchange rate variability influences both exports and imports, that is, it is statistically significant either in the volume equation or in the price equation. (Note that the significance of variability in either of the two equations is sufficient to ensure a statistically significant effect on imports or exports.) In Germany, the variability effects appear directly on volumes of imports and exports; however, there are no significant effects on prices. The volume of U.S. exports also seems to be directly responsive to variability. But there appears to be no strong *direct* link between exchange rate variability and the volume of U.S. imports. Instead, the variability influence seems to work through import prices.

Like most other such estimates, our results are sensitive to any substantial changes in the observation period. In particular, if the estimation period ends in 1978 or 1979, exchange rate variability does not appear to be a significant variable in most cases. This tells us that including recent data and using a sufficiently long sample period with floating exchange rates are important for our results. However, extending the sample period

beyond 1981 has only minor impact on the exchange risk variable. If, for example, our basic equations are estimated for the period 1974-82, there is no significant change in the results for Germany, but the influence of exchange rate variability appears stronger on U.S. imports and weaker on U.S. exports.

Table 1

Effect on Multilateral Trade Volume of Manufactured Goods of a Sustained 10 percent Rise in Variability of Daily Effective Exchange Rates

Trade	United States	Germany
Exports		
In percent	− .52	− 2.09
In billions of 1980 dollars	− .74	− 3.49
Imports		
In percent	− .57	− 1.19
In billions of 1980 dollars	− .75	− 1.24

Table 2

Cumulative Effect of Exchange Rate Variability on Trade in Manufactures, 1977-81, Under Alternative Assumptions

Alternatives	Exports	U.S. Imports	Exports	German Imports
Alternative 1*				
In percent	0.5	1.1	3.3	1.9
In billions of 1980 dollars	3.6	7.2	27.5	9.9
Alternative 2†				
In percent	2.6	3.7	12.0	6.7
In billions of 1980 dollars	18.7	24.3	100.1	34.8
Alternative 3‡				
In percent	2.2	3.3	14.2	8.0
In billions of 1980 dollars	15.8	21.7	118.5	41.5

*Average value of standard deviation over 1974-81 is used as the benchmark.

†Lowest average value of standard deviation from two consecutive quarters during 1974-81 is used as the benchmark.

‡Estimated standard deviation over the fixed rate period from 1967-72 is used as the benchmark; in order to construct a benchmark comparable with daily variability under the other two alternatives, measured variability based on monthly data over the fixed rate period was adjusted by the average ratio of daily to monthly variability over the floating rate period.

[7] In order to obtain estimates for a relatively homogeneous set of products, only manufactured goods' prices and volumes were used as dependent variables. This still leaves a substantial proportion of trade as the object of investigation, since these goods account for over three-fifths of all U.S. and German trade.

Strictly speaking, these results offer evidence of a "statistically significant" relationship between trade and exchange rate variability, but do not show how large an impact this variability has had on trade. Table 1 reports the effect of a sustained rise in exchange rate variability on the volume of trade, based on estimates in the box.[8] These calculations are presented in percentage terms and in constant dollars. The elasticities are larger for Germany than for the United States.[9] A ten percent rise in the exchange rate variability index causes a two percent reduction in German export volume, but only a fall of one-half of one percent in U.S. export volume. On the import side, the estimated elasticity for German trade is about twice that for U.S. trade.

Table 2 provides estimates of what U.S. and German trade gains would have been had exchange rate variability been lower than actually experienced. The cumulative impact on trade volumes between 1977 and 1981 is presented for three alternative scenarios. Under the first alternative, the average value of the exchange rate variability index over the period 1974-81 is used as a benchmark. That is, the effects of exchange rate variability are assumed to be zero when measured variability is above average. Table 2 shows that had variability never exceeded its average value, over 1977-81 U.S. exports on average would have been 0.5 percent higher while U.S. imports would have been 1.1 percent higher. Over the same period, the trade gains for Germany would have been considerably larger.[10]

The effects of uncertainty on trade undoubtedly would appear much greater if zero variability were used as a benchmark, rather than average variability. But zero variability as a base is clearly inappropriate since it is almost certainly unattainable. The second alternative in Table 2 utilizes the lowest observed two-quarter average value as a benchmark. Had exchange variability never exceeded this two-quarter historical minimum during 1974-81, both U.S. and German trade in manufactures would have been significantly greater: on average, three to four percent higher in the United States and seven to twelve percent higher in Germany. In a third scenario, exchange rate variability estimated over the fixed rate period from 1967 to 1972 is used as a benchmark for calculating the impact of uncertainty on trade. The results are similar to those under the second alternative.

An interesting aspect of these findings is that German manufacturing trade seems to be more responsive to exchange rate volatility than U.S. trade in comparable goods. Of course, strong conclusions cannot be reached on the basis of just one set of empirical results, but it is possible that German goods are more sensitive to exchange rate variability than U.S. goods. One reason for this may be that a high degree of openness of the German economy leads to a greater sensitivity of traded goods to prices and exchange rates and, consequently, to exchange rate uncertainty. Germany is widely believed to be more open than the United States since traded goods represent a larger share of total output; in 1980, for example, the sum of total exports and imports as a ratio of GNP was 46 percent for Germany and 18 percent for the United States. The larger price elasticities estimated for the German trade volume equations compared to the U.S. (box) are consistent with the view that exports and imports may be more responsive to prices and exchange rates in a more open economy than in a less open economy.[11]

Putting aside the quantitative differences, the results indicate that exchange rate variability is a significant factor in trade for both countries, and an important one for Germany. In addition, our estimates suggest that the link between variability and trade has become stronger in recent years.

Conclusions
The results of this study suggest that exchange rate variability reduces the volume of international trade in manufactured goods. This conclusion differs from the findings of previous empirical research,[12] which has often

[8] For U.S. import volume, all calculations for Tables 1 and 2 were made by first substituting the price into the volume equation and then making computations on the basis of the estimated relationship between variability and price. German trade values were converted into dollar terms using the average mark-dollar exchange rate for the year 1980.

[9] Elasticity is defined as the percentage change in trade volume that follows a rise in the exchange rate variability measure by a certain percentage amount. This variable was not converted into natural log form before estimation, so only the mean elasticity of exchange rate variability is reported in Table 1. The mean elasticity is the product of the estimated coefficient on the variability index appearing in the volume equation and the mean value of this index.

[10] The calculations for this scenario were made as follows. For each quarter where actual exceeded average variability, the difference between the actual value of the variability index and its mean value was multiplied by the coefficient on this variable appearing in the estimated volume equations. This product was subtracted from the index of trade volume used in estimation. The difference between the hypothetical volume and actual volume was converted into a 1980 dollar equivalent and the results for each quarter were summed over the five year interval. Under the second and third alternatives, this same procedure was used replacing the average value of the variability measure with other benchmark levels, described in Table 2. For U.S. import volume, all calculations were made on the basis of the estimated relationship between variability and price.

[11] In fact, under certain conditions it can be rigorously demonstrated that the size of the coefficient on the exchange rate variability index is directly related to the size of the price elasticity coefficient.

[12] This statement applies to previous studies about the effects of nominal exchange rate variability on trade flows for individual countries. However, there are a few studies in which exchange risk turns out to be significant; they are based either on cross-section data for bilateral trade flows or on *real* exchange variability.

failed to uncover any significant impact of exchange risk on trade. Admittedly, our conclusion is based on the floating rate experience of only two countries, Germany and the United States. Further empirical research on the experience of a broader group of countries would be necessary to reach more general conclusions on the significance of exchange rate uncertainty.

Why do the findings in this study differ from those in earlier studies? One obvious explanation would seem to be our choice of an investigation period which covers the more recent experience with floating exchange rates. Including recent data is important for our results because exchange rate volatility has shown no consistent downward tendency over time and because it provides a sufficiently long sample period with floating exchange rates. This impression is confirmed by the results obtained with data through 1978. Earlier research has not investigated the period since 1977-78 and generally has mixed observations from the first few years of floating with those from the fixed rate period before 1973. Even the recent IMF study, mentioned above, does not update previous econometric tests dealing with effects of *nominal* exchange rate variability on trade flows of individual countries; it does update, however, one earlier investigation based on *real* exchange rate variability. But we have argued that real exchange rate variability is not an appropriate proxy for exchange rate uncertainty.

Another reason for the differences in findings may be that our measure of average quarterly variability, based on a daily effective exchange rate index, provides a better proxy for uncertainty than those in earlier studies that were based on a very small number of observations, *e.g.*, average quarterly variability calculated by using three monthly observations. Finally, by explicitly considering the impact of risk on volume through prices, our study probably provides a better reading of the full effect of exchange rate variability on trade.

We have argued that our estimates are likely to underestimate the effects of exchange rate uncertainty on trade for two reasons. First, measured exchange rate variability may itself understate the extent of true uncertainty and second, some indirect exchange risk effects on trade cannot be separated from those of exchange rate changes themselves. The indirect effects are particularly important when long-range investment decisions and choices of input sources or output markets must be made under the shadow of potentially large future exchange rate changes. Our use of long lags on the variability index may capture a part of these long-term effects. But this procedure is not adequate for fully isolating and measuring those effects. In any case, the main point of our theoretical arguments on uncertainty is that the results in this study are best interpreted as providing a lower bound on the effects of exchange uncertainty on international trade.

One important policy implication of our study is that, from the perspective of international trade, it is desirable to reduce exchange rate uncertainty or variability. Broadly speaking, variability may be reduced either by changes in macroeconomic policies, by exchange market intervention strategies, or by moving to a substantially different exchange rate system. A discussion of such a complex and broad issue is obviously beyond the scope of this study. But it should be noted that the possible adverse effect of exchange rate uncertainty on international trade is only one of several considerations in the choice of an exchange rate system, and on other grounds one may still favor the present exchange rate arrangements.

M. A. Akhtar and R. Spence Hilton