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DM/85/24

INTERNATIONAL MONETARY FUND

Research Department

Effects of Exchange Rate Volatility on Trade: Some Further Evidence

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April 16, 1985

I. Introduction and Summary

A recent survey of the empirical studies examining the effects of increased exchange rate volatility on international trade [IMF (1984)] concluded that "the large majority of empirical studies . . . are unable to establish a systematically significant link between measured exchange rate volatility and the volume of international trade, whether on an aggregate or on a bilateral basis". A more recent paper by Akhtar and Hilton (1984a) (hereafter A-H) examines afresh the issue of whether exchange rate uncertainty, proxied by observed exchange rate volatility, has had statistically significant adverse effects on international trade.

The results of the Akhtar-Hilton study differ from the findings of other researchers. A-H find that exchange rate volatility, as measured by the standard deviation of indices of nominal effective exchange rates, has had significant adverse effects on the aggregate trade in manufactured goods of the United States and West Germany. Based on regression results for export and import price and volume equations, the authors report a marginally significant adverse effect of exchange rate volatility on U.S. export volumes and U.S. import prices and significant adverse effects on German export and import volumes. Therefore, the authors conclude that nominal exchange rate uncertainty has had a significant negative impact on trade. Although their results from a similar exercise based on a measure of real exchange rate volatility are less conclusive, they find the weight of the evidence sufficient to conclude that "from the

* Acknowledgements:

The author is grateful to M. A. Akhtar and R. S. Hilton for kindly providing the data used in their study. She would also like to thank Michael Deppler for his valuable input, and to acknowledge the very beneficial conversations with Clifford Wymer, Malcolm Knight and Bonnie Loopesko.

perspective of international trade, it is desirable to reduce exchange rate uncertainty or variability". (1984a) They go on to suggest that this objective may be accomplished through changes in macroeconomic policies, official intervention, or substantial changes in the exchange rate system. The authors note, however, that notwithstanding a possible adverse effect of exchange rate uncertainty on trade, other considerations may still support the present floating exchange rate arrangements.

The purpose of the present study is to test the robustness of A-H's empirical results, taking their basic theoretical framework as given. The analysis has two parts. The first extends the A-H analysis, which was limited to the United States and Germany, to include France, Japan and the United Kingdom. The second examines the robustness of the A-H results with respect to changes in the choice of sample period, volatility measure, and estimation techniques.

The main conclusion of the analysis is that the A-H methodology fails "to establish a systematically significant link between exchange rate volatility and the volume of international trade". The results obtained are not sufficiently robust to suggest the presence of such a link. This is not to say that significant adverse effects cannot be detected in individual cases, but rather that, viewed in the large, the results tend to be insignificant or unstable. Specifically, the results suggest: (a) that straightforward application of the A-H methodology to three additional countries (France, Japan, and the United Kingdom) yields mixed results; (b) that the A-H methodology seems to be flawed in several respects and that correction for such flaws has the effect of weakening their conclusions; (c) that the estimates seem to be quite sensitive to fairly minor variations in methodology; and (d) that "revised" estimates for the five countries do not, for the most part, support the hypothesis that exchange rate volatility has had a systematically adverse effect on trade. Needless to say, and as already noted in the survey referred to above, "the failure to establish a statistically significant link ... does not prove that a causal link does not exist" [IMF (1984)].

The remainder of the paper is as follows. Section II outlines the model used by A-H and discusses its empirical implementation. Section III presents empirical results for five countries based on the A-H methodology and the conclusions they suggest. Section IV discusses a number of technical problems with the A-H estimations and illustrates their empirical significance by reference to the A-H results for the United States and Germany. Section V outlines a set of preferred methodological procedures and applies them to data for the United States, Germany, Japan, France, and the United Kingdom.

II. The Akhtar-Hilton Model

One of the main arguments against floating exchange rates has been that they lead to heightened risk and uncertainty in international transactions, and thus discourage trade and investment flows. If market participants are risk-averse, exchange rate uncertainty and the need to provide against unfavorable changes will lead to supply and demand decisions that will result in higher prices or reduced levels of transactions at any given price. Also, other things being equal, exchange rate uncertainty and the resulting uncertainty about the price to be paid or received in international trade may lead to a preference for domestic over foreign markets. This preference can lead to a gradual reduction in the volume of trade through a backward shift in supply and demand schedules. The size of the shift will depend on traders' perceptions of the risks involved, the extent of exchange rate uncertainty and the elasticities of supply and demand. 1/

International traders can, of course, avoid or minimize foreign currency uncertainty in a short-term trading transaction by hedging in the forward market. However, because forward markets for maturities beyond one year are not well developed, they cannot provide much protection for trading activity which generally requires that decisions be made only over a medium- to long-term time horizon. Moreover, even if forward cover were available for longer maturities, such markets could not eliminate exchange rate uncertainty so long as traders are unable to

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1/ Besides increasing costs through uncertainties, exchange rate fluctuations may result in costly shifts of resources between economic activities in response to changing price incentives or to greater riskiness perceived for the traded goods sector. Furthermore, exchange rate fluctuations can also distort the pattern of trade among countries by influencing the relative prices of foreign and domestic goods in specific industries, and thereby altering the distribution of supply at the industry level across countries. Given large and persistent changes in real exchange rates, the possibility of shifts in supply sources, markets, or trade patterns may, in turn, tend to increase the risk inherent in international trade. Therefore, large exchange rate fluctuations sustained over long periods can involve serious adjustment costs which affect direct investment decisions and trade patterns. Moreover, such effects might bring about fairly sizable changes in prices of traded goods and, thereby, changes in the volume of trade. However, such resource shifts and the related economic costs are not directly associated with the more short-term volatility in nominal exchange rates being examined in the present analysis, and, therefore, are not of particular relevance to it. For a review of the mechanisms by which exchange rate volatility could affect trade flows, see IMF (1984).

predict the magnitude and timing of all their foreign exchange payments needs or earnings [Lanyi (1969)].

Akhtar and Hilton, therefore, disregard the possibilities for forward cover and postulate a standard set of demand and price equations, with each equation augmented to include the exchange rate volatility variable. In the volume equations, this variable is expected to reflect the effect on demand of the price uncertainty associated with exchange rate uncertainty when invoices are denominated in a currency other than that of the demander. Similarly, in the price equations, the volatility variable is expected to reflect the increase in supply prices induced by increased exchange rate uncertainty when invoices are denominated in a currency other than that of the supplier.

Specifically, A-H postulate the following four equations:

The export demand equation:

$$(1) \quad XV = f(YF, (PX*r/PF^f), SX^f),$$

where

XV = quantity index of total manufacturing exports delivered,

YF = real foreign activity level,

PX = price of manufacturing exports in domestic currency,

r = the foreign currency price of domestic currency,

PF^f = price of foreign produced substitutes of exports in foreign currency, and

SX^f = exchange rate risk facing demanders of exported goods.

The import demand equation:

$$(2) \quad MV = g(YD, PM/PD, SM^d),$$

where

MV = quantity index of total manufacturing imports delivered,

YD = real domestic activity level,

PD = price of domestically produced substitutes for imported manufacturing goods in domestic currency,

PM = price of foreign produced manufacturing goods faced by domestic consumers in domestic currency, and

SM^d = exchange rate risk facing demanders of imported goods.

The export supply equation:

$$(3) \quad PX = F(UCD, SX^d),$$

where

UCD = costs of inputs of manufactured output in the domestic country in domestic currency, and

SX^d = exchange rate risk facing domestic producers of the exported commodity.

The import supply equation:

$$(4) \quad PM = G(UCF^f/r, SM^f),$$

where

UCF^f = cost of inputs of manufactured output in the foreign country in foreign currency,

r = the foreign currency price of domestic currency, and

SM^f = exchange rate risk facing foreign producers of the imported commodity.

It is assumed that prices are set on the date a contract is made rather than on the delivery date. The price term in equations (1) and (2) is the relative price that exporters and importers expect to receive or pay upon delivery, which is when payment is assumed to be made. If the contract price is quoted in domestic currency terms, say, for the importer, he faces no price uncertainty. However, where payment must be made in foreign currency, the (domestic) price of imports is uncertain if uncertainty exists about future exchange rates or if the importer does not hedge. This exchange rate risk is denoted by SM^d. A similar reasoning applies to the export demand equation where the exchange rate risk variable is denoted by SX^d.

It should be noted that equations (3) and (4) imply that the foreign supply of imported manufactured goods and the domestic supply of manufactured exports are both assumed to be perfectly elastic with respect to the volume of trade. Although not very realistic, this assumption permits one to use ordinary least squares regression procedures for estimating the structural equations since it implies that the supply price of traded goods is unaffected by the volume of trade. A-H note that this assumption permits one to distinguish between the different effects of volatility on demanders and suppliers in terms of the price and quantity of traded commodities. They point out that the perfectly competitive market structure imposed by this assumption implies that while the uncertainty faced by suppliers cannot directly affect the volume of trade demanded, it can indirectly affect trade volumes by raising the price of traded goods.

An important methodological issue concerns the specification of the exchange rate volatility measure. A first question is whether to base the measure on the nominal or the real exchange rate, a question which hinges on which rate better captures the risk or uncertainty faced by traders, particularly over the medium-term planning horizon adopted by them. It is frequently argued that over this time horizon, the real exchange rate is the more relevant measure because the effects of uncertainty on a firm's revenues and costs arising from nominal rate fluctuations are likely to be largely offset by movements in costs and prices. A-H, however, opt for the nominal exchange rate measure, first, because of the highly unpredictable nature of exchange rate changes and, second, because of the lack of empirical support for purchasing power parity over the medium term. Given the short time horizon over which exchange rate variations are examined in the A-H analysis, it is probably correct to suppose that most of the variability in the real exchange rate comes from the variability in the nominal rate.

Given the choice of nominal over real exchange rates, a second question concerns the precise measure of volatility that is appropriate for use in empirical work. The various measures that have been used include the more conventional ones such as the standard deviation of the levels of exchange rates or of the changes in these rates, and others, such as absolute percentage first differences of exchange rates, non-parametric measures such as Gini's mean difference measure, and measures based on the estimated ex ante rather than the ex post exchange rate. Each of these measures has advantages and drawbacks. [For a discussion, see, for instance, Brodsky (1984), Kenen (1979), Lanyi and Suss (1982), and Rana (1981)]. The particular measure chosen by A-H is the standard deviation of the level of the daily effective exchange rate during each quarter. 1/

1/ A-H experimented with other measures of volatility, but these results are not reported in their paper. These alternative measures of volatility used were the natural log of the volatility measure, the standard deviation of the natural log measure, the standard deviation of the daily percentage changes of the multilateral exchange rate indices, the trade-weighted averages of the standard deviations of the daily observations of a country's bilateral exchange rates, and Gini's mean difference coefficient. A-H note that use of alternative measures of volatility generally yielded similar results although all alternative measures were not used in each supply and demand equation for the two countries studied.

The basic rationale underlying the use of this measure is that the average exchange rate for the quarter is the best predictor of the expected rate for each day of the quarter. (For further discussion of the choice of the volatility measure, see page 25, especially footnote 2.)

Regardless of how volatility is measured, it should be noted that the relationship between trade flows and exchange rate uncertainty may not be independent of, and cannot easily be separated out from, other uncertainties faced by traders such as those relating to other features of the economic environment. 1/ There is, therefore, need for considerable caution in interpreting empirical results. To the extent that other sources of risk faced by traders are partly offset by exchange rate fluctuations (or vice versa), the empirical results will overstate (or understate) the effects of exchange rate uncertainty on trade.

The basic structural equations, equations (1) to (4) above, were modified for empirical purposes as follows: domestic and foreign capacity utilization variables were added to each of the equations; domestic and foreign unit cost variables were proxied by series for domestic and foreign prices for manufactures; price equations were extended to include competitor price variables, seasonal dummy variables were added to all equations; and dock strike dummy variables were included in the volume equations for the United States.

Independent variables other than the price and volatility variables were assumed to enter the equations either contemporaneously or with a one-quarter lag. The relative price terms in the volume equations were permitted a lag of up to eight quarters to account for order-delivery lags. A similar lag structure was imposed on the volatility measure in order to take account not only of order-delivery lags, but also the gradual adjustment of expected volatility to actual volatility. Lags of up to eight quarters were imposed on the exchange rate volatility and relative price variables in the volume equations and on the volatility variable in the price equations. In all these cases, a second degree polynomial lag structure was imposed with a zero (far) end point constraint. A one-iteration Cochrane-Orcutt (CO) procedure was employed to correct for first-order serial correlation in all equations. Except for the volatility measure, the natural log of all variables was used, and hence the estimated coefficients represent elasticities. The resulting equations were estimated in the A-H study using United States and German

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1/ For instance, the increase in uncertainty in the economic environment in the last decade may also be attributed to the oil price shocks which overlapped with the advent of floating exchange rates.

quarterly data for various estimation periods between 1974 and 1982. The A-H paper focuses on the results for the period Q1 1974 - Q4 1981, although it also presents results for the extended period through Q4 1982.

III. Empirical Results Based on the A-H Methodology

Table 1 presents, for five countries, the regression estimates for the volatility coefficient which result from the model and estimation procedures just described. The results for the United States and Germany are, of course, those reported in the A-H paper. As noted previously, these results suggest that nominal exchange rate volatility has had a marginally significant adverse effect on U.S. export volume, and significant negative impacts on German export and import volumes. For U.S. imports, volatility was found to indirectly reduce import volumes through a marginally significant positive impact on import prices. In quantitative terms, the results indicate that a 10 percent increase in exchange rate volatility can lead to a 2 percent reduction in German exports and a 1/2 percent reduction in U.S. exports. On the import side, a 10 percent increase in volatility can cause a 1 percent decline in German imports, and a 1/2 percent decline in U.S. imports. It is these results which are the basis for the authors' conclusion that exchange rate uncertainty has had a significant adverse impact on the volume of international trade.

Table 1 also presents A-H type results for three additional countries--France, Japan, and the United Kingdom. These results were obtained by replicating the A-H methodology as closely as possible. The main difference is that the volatility measures for these countries were derived as the standard deviations of daily observations within each quarter of the MERM-weighted effective exchange rate index for each country. (The computation and sources of this and other data series for these countries are presented in Appendix A.)

The results for these three countries are rather different from those obtained by A-H for the United States and Germany. In the first place, all the coefficients for the United Kingdom are not only insignificant, but also of the "wrong" sign. Secondly, whereas the effects in the A-H results for the United States and Germany came through primarily on the volume side, the results for France and Japan suggest instead that any adverse effect of volatility on trade is indirect rather than direct. Thus, the volatility variables in the volume equations are either of the "wrong" sign or quite insignificant for France and Japan, but of the "right" sign and significant in the price equations. Given A-H's interpretation of the export and import price equations as domestic and foreign supply equations, respectively, the results have the rather paradoxical implication that whereas French and Japanese exporters bear the exchange rate

Table 1. Regression Results For The Exchange Rate Volatility Variable: Based on the A-H Methodology 1/

Dependent Variable	United States 2/	Germany 2/	France	Japan	United Kingdom
Export volume	-0.04 (1.82)	-0.22** (3.24)	-0.02 (0.81)	0.04* (2.59)	0.04 (0.81)
Import volume	0.005 (0.28)	-0.12* (2.51)	-0.002 (0.03)	0.02 (0.48)	0.05 (0.88)
Export price	-0.002 (0.31)	0.001 (0.10)	0.03** 3/ (5.24)	0.05** (3.90)	-0.03* (2.02)
Import price	0.02 (1.94)	0.01 (0.31)	0.03** (3.18)	0.06* (2.79)	-0.005 (0.32)
Memorandum: Implied total (direct and indirect) elasticity of trade flows with respect to the volatility variable: 4/					
Exports	-.05	-.20	--	-.18	--
Imports	-.06	-.12	-.04	-.16	--

* Denotes statistical significance at the 5 percent level of significance.
** Denotes statistical significance at the 1 percent level of significance.

1/ Figures in parentheses are t-statistics.
2/ These results are those reported by A-H.
3/ The relative price variable in the export volume equation is not statistically significant.
4/ In the calculations, all coefficients that were not significant at the 5 percent level were assumed equal to zero. For the U.S., the coefficients in the export volume and import price equations are significant only for a one-tail test.

risk--a not unrealistic result if most export contracts are denominated in foreign currency--French and Japanese importers do not. Rather, it is the foreign suppliers to these markets who ostensibly bear the exchange rate risk and who accordingly raise their prices to cover themselves for that risk. This result is not very plausible, especially in the light of the magnitudes of the corresponding coefficients in the import price equations for the United States and Germany which suggest that suppliers to those markets bear a substantially smaller exchange risk. (See footnote 1 on page 22).

The interpretation of the coefficients in Table 1 is somewhat obscured by the fact--stemming from the particular specification chosen by A-H--that these coefficients are not elasticities. In fact, however, because the average value of the volatility variable often tends to be around 1, the coefficients in Table 1 can be roughly interpreted as elasticities. Indeed, regression equations identical to those used to produce the results of Table 1, except for a logarithmic transformation of the volatility variable, yield regression coefficients very similar to those shown in Table 1. The only significant change in the results is that three of the eight significant and "right-signed" coefficients lose their statistical significance. 1/ Be that as it may, the statistically significant parameters in Table 1, together with the price elasticity parameters from the volume equations, may be used to calculate the overall, i.e., direct and indirect, elasticity of trade flows with respect to volatility. These are shown in the lower tier of Table 1. Taken at face value, these results suggest that German and Japanese trade is relatively sensitive to exchange rate volatility, French and U.S. trade is relatively insensitive to exchange rate volatility, and British trade is quite insensitive to such volatility.

IV. Shortcomings of the A-H Methodology

The reliability of the results reported in Table 1 is undermined by several technical problems associated with the methodology employed by Akhtar and Hilton. These problems are discussed in turn below and their quantitative significance is illustrated by reference to modified results for the United States and Germany. The section ends with a set of improved procedures which are then applied in the following section to the data for each of the five countries shown in Table 1. It should be understood that the critique to follow pertains to the empirical procedures adopted by A-H. Their basic analytical framework is taken as given.

1/ The coefficients for the United States and for the Japanese import price equations, and the coefficient for the United States export volume equation. Therefore, the results with the logarithmic transformation of the volatility variable show no effect--direct or indirect--of volatility on U.S. import and export volumes.

Although A-H state that they have tested each equation for first-order serial correlation, it appears that they have instead applied the Cochrane-Orcutt (CO) correction for serial correlation to all equations as a routine procedure without a preliminary check for the presence of serial correlation in the Ordinary Least Squares (OLS) estimation. This seems likely because, all equations reported by them incorporate a CO correction, and when their equations are estimated without correction there is no evidence of serial correlation in several of their equations. The use of the CO procedure in those equations where there was no serial correlation implies an incorrect assumption about the structure of the error term in those equations. Moreover, as shown below, the OLS and CO results were significantly different for many equations.

A second unusual feature of the A-H methodology, also related to their procedure for correcting for serial correlation, is that their equations were estimated using a one-iteration CO procedure (which belongs to the class of "two-stage" generalized least squares correction procedures for serial correlation), rather than the more customary iterative CO procedure. In the absence of serial correlation and assuming that the other conditions of the classical regression model hold, OLS estimators have all the desirable small-sample and asymptotic properties. However, this is not true when serial correlation is present. In this case, generalized least squares, iterative CO, and maximum likelihood estimators are all consistent and asymptotically equivalent to best-linear unbiased estimators. But the small-sample properties of these estimators are difficult to derive analytically and any choice between them, which is based on sampling properties, must be made on the strength of Monte Carlo evidence [see Judge et. al. (1980), p. 187, and Kmenta (1971), p. 292]. Such evidence has not led to a clear-cut choice. However, in applied work, researchers usually choose the CO iterative procedure over the two-stage procedures.

For reasons noted above, a preferable set of procedures for correcting for autocorrelation would be to first estimate the equations using OLS, check the Durbin-Watson statistic to test for serial correlation, and, for those equations in which serial correlation was present, estimate the equations using the iterative CO procedure. The resulting estimates for the United States and Germany are presented in Table 2. The table shows that, while the results for Germany turn out to be relatively robust, at least with respect to the present change in procedures, this is not the case for the United States. For that country, the OLS estimates of the export volume equation do not indicate the presence of serial correlation. Moreover, the OLS estimate of the volatility coefficient is not statistically significant, thus invalidating the evidence for the direct (adverse) effect of exchange rate volatility on U.S. export volumes found by A-H using the CO correction. The new results do, however, continue to indicate an indirect effect on import volumes via import prices

Table 2. Impact on A-H Results of Change in Procedures Used to Correct For Serial Correction 1/

	United States		Germany	
	A-H results	Modified results	A-H results	Modified results
Export volume	-0.04 (1.82)	-0.04 (1.36)	-0.22** (3.24)	-0.22** (3.23)
Import volume	0.005 (0.28)	0.01 (0.49)	-0.12* (2.51)	-0.12* (2.34)
Export price	-0.002 (0.31)	-0.001 (0.24)	0.001 (0.10)	0.001 (0.10)
Import price	0.02 (1.94)	0.02* (2.01)	0.01 (0.31)	-0.01 (0.24)

* Denotes statistical significance at the 5 percent level of significance.
** Denotes statistical significance at the 1 percent level of significance.

1/ Figures in parentheses are t-statistics.

as reported by A-H. Nevertheless, the adjustment in the procedure to correct for serial correlation has the overall effect of undermining a fourth of the evidence adduced by A-H in favor of their conclusion.

A second problem area in the A-H procedures concerns their choice of sample period. The issue is two-fold: why do they feature results for the 1974-81 period even though they also report results for the 1974-82 period; and second, why do they include 1974 when that implies, given the eight quarter lags used in their analysis, use of data from the pre-floating exchange rate period? These questions are not trivial. On the first point, particular importance attaches to the fact that the marginally significant negative impact of volatility on U.S. export volume for the sample period of 1974-81 (which is barely significant at the 95 percent confidence level using a one-tail test) disappears altogether when the estimation period is extended to 1982 (see Table 3). Although the contradictory results for the extended sample period are reported by A-H in their longer research paper (1984a), their main article on this research (1984b) focuses only on the results for the shorter sample period and, in fact, presents only the latter set of results. Because it is desirable to examine the effects of volatility on trade flows over the longest available estimation period of the floating exchange rate regime, it is more appropriate to look at the extended estimation period, through 1982, rather than to stop with 1981. In sum, although the results for Germany do not differ significantly over the two sample periods (1974-81 vs. 1974-82), in the case of the United States, the effect of volatility on trade is reduced, under the extended period, to an indirect effect on import volumes via import prices, without any effect on exports.

The significance of the choice of sample period becomes more crucial when the analysis turns to the choice of a starting point. A-H place considerable emphasis on the fact that their results are superior to the findings of most previous researchers in part because they have used observations only from the flexible exchange rate period. However, although their estimation period does indeed begin in 1974, i.e., the first observation for the dependent variable is Q1 1974, their analysis nevertheless necessarily includes observations from the fixed rate period since they use an eight-quarter lag structure for the exchange rate volatility variable and for the relative price variables. In effect, therefore, their estimates partly reflect developments reaching back to early 1972. This introduces the possibility of bias in specification stemming from the change in the exchange rate regime. To avoid this possibility, the sample period should start from Q1 1975 to exclude observations from the fixed rate period.

However, such a truncation of the sample period has a major impact on the estimates. As seen from Table 3, the equations failed to reproduce

Table 3. Impact on A-H Results of Changes in Sample Periods 1/

	United States			Germany		
	A-H results 1974-81	A-H results 1974-82	1975-81	A-H results 1974-81	A-H results 1974-82	1975-81
Export volume	-0.04	0.01	0.001	-0.22**	0.19*	-0.05
	(1.82)	(0.61)	(0.05)	(3.24)	(2.54)	(0.39)
Import volume	0.005	-0.003	-.02	-0.12*	-0.12**	-0.03
	(0.28)	(0.14)	(0.80)	(2.51)	(3.03)	(0.59)
Export price	-0.002	0.001	0.02	0.001	0.01	-0.02
	(0.31)	(0.20)	(1.55)	(0.10)	(0.73)	(0.79)
Import price	0.02	0.02*	0.002	0.01	-0.002	-0.07*
	(1.94)	(2.61)	(0.13)	(0.31)	(0.07)	(2.16)

* Denotes statistical significance at the 5 percent level of significance.
** Denotes statistical significance at the 1 percent level of significance.

1/ Figures in parentheses are t-statistics.

all four pieces of significant evidence reported by A-H for the 1974-81 period. In the case of the United States, the results do not support either a direct or indirect effect of exchange rate volatility on export or import volumes. In the case of Germany, the re-estimation fails to corroborate the direct effect of volatility on export and import volumes found by A-H for the 1974-81 period, and suggests a "perverse" negative effect on import prices not detected in the A-H estimation. Overall, the A-H results are evidently very sensitive to the inclusion of the observations for the transition years prior to the floating rate period. 1/

Another potential problem area with the A-H procedures relates to the arbitrary basis for their specification of the polynomial lag structure. This is questionable chiefly because of the extreme sensitivity, amply documented by other researchers, of regression results based on this technique to changes in the specification of the lag structure. 2/ 3/ It was thus deemed important to test the robustness of the A-H results with alternative specifications. Such testing sometimes yielded significantly different regression results for the United States. For instance, with a third-degree polynomial, the adverse effect of volatility on U.S. export volumes disappears once again, and there is no indication of a direct effect on import volumes. (See Table 4.) Moreover, the effect on import prices found with a second-degree polynomial (by A-H) loses its significance. The impact on export volumes also disappears when alternative lag structures and end-point constraints are used in the estimation procedure. The results for Germany are more robust with respect to alternative dynamic specifications of the basic equations. As shown in Table 4 (columns 3 and 4), the results obtained with a third-degree polynomial lag continue to show a direct effect of volatility on trade volumes, given, of course, the 1974-81 sample period featured by A-H.

1/ In addition to the problem of introducing specification bias into the estimation results, the other problem in including data from the fixed rate period is the derivation of the standard deviations of exchange rates over this period. One may have to rely on monthly rather than daily observations of the exchange rate for deriving the quarterly standard deviations and to compare end-period values with period averages, given the discrete rate changes that occurred during this period. Moreover, the appropriate exchange rate volatility measure for the fixed exchange rate period may be different from that for the floating rate period. These problems are all solved by restricting the estimation period to the floating rate period.

2/ A-H defend their choice of the polynomial lag specification on grounds of simplicity.

3/ Misspecification of the lag renders the coefficient estimates biased and inconsistent, and renders the standard hypotheses tests unreliable. [See Judge et. al. (1980)].

Table 4. Impact on A-H Results of a Change in The Polynomial Specification of the Volatility Variable 1/

	United States		Germany	
	Poly deg=2	Poly deg=3	Poly deg=2	Poly deg=3
Export volume	-0.04 (1.82)	-0.04 (1.62)	-0.22** (3.24)	-0.23** (3.23)
Import volume	0.005 (0.28)	-0.003 (0.20)	-0.12* (2.51)	-0.14* (2.86)
Export price	-0.002 (0.31)	-0.01 (1.70)	0.001 (0.10)	-0.001 (0.07)
Import price	0.02 (1.94)	0.02 (1.74)	0.01 (0.31)	0.01 (0.27)

* Denotes statistical significance at the 5 percent level of significance.
** Denotes statistical significance at the 1 percent level of significance.

1/ Figures in parentheses are t-statistics.

A further aspect of the A-H procedures which merits attention is their specification of the effective exchange rates used to compute the volatility variables. These variables were derived on the basis of trade-weighted exchange rate indices vis-a-vis major trading partners (9 countries for the United States and 13 for Germany). These measures of the effective exchange rate may be somewhat "narrow". The broadest possible measure of the effective exchange rate is likely to capture better the way in which exchange rate factors influence trading uncertainty. Furthermore, the A-H method of weighting by trading partners allows each country's effective exchange rate to vary depending on which countries were omitted in that computation. It may, instead, be more appropriate to symmetrically treat all countries being examined by standardizing cross-country comparisons by using the same set of countries (or bilateral exchange rates) for computing the effective exchange rates. 1/ Therefore, in computing the effective exchange rate, it is more appropriate to use a range of trading partners that is wider than that used by A-H.

Therefore, with an eye to the extension of the results to France, Japan, and the United Kingdom, an alternative measure of exchange rate volatility was computed. This measure--again the standard deviation of the daily observations within each quarter--was calculated using a daily version of the Fund's MERM-weighted effective exchange rate index. This index uses bilateral exchange rates for 18 industrial countries and, therefore, satisfies both the conditions noted in the previous paragraph. [See Artus and McGuirk (1981) for a description of the MERM weights]. Charts 1 and 2, for the United States and Germany, respectively, compare movements in the volatility variables used by A-H and in the alternative measure described above. Although the two measures move together, the A-H measures generally exhibit a greater variance, which might account, in part, for the differences in the estimation results described below.

For the United States, the use of the alternative volatility measure resulted in an insignificant coefficient estimate for this variable in the export volume equation. (See Table 5.) The coefficient of the volatility variable continued to have the perverse, positive sign in the U.S. import volume equation obtained with the use of the A-H volatility measure. The results also continued to show a weakly significant effect of volatility on import prices over the 1974-81 period. The substitution of the MERM-based volatility measure had a somewhat greater impact on the estimates for Germany. The volatility coefficient in the export volume equation became smaller, and the adverse effect on import volume lost its statistical significance. On the other hand, a possible positive effect of exchange rate volatility on import prices came to the fore.

1/ This point is made by Kenen and Rodrick (1984), though not with regard to the A-H paper.

Table 5. Impact on A-H Results of a Change in Measure of the Volatility Variable 1/

	United States		Germany	
	A-H results	Results with Fund measure	A-H results	Results with Fund measure
Export volume	-0.04 (1.82)	-0.04 (1.65)	-0.22** (3.24)	-0.17* (2.60)
Import volume	0.005 (0.28)	0.006 (0.29)	-0.12* (2.51)	-0.10 (1.64)
Export price	-0.002 (0.31)	-0.002 (0.31)	0.001 (0.10)	0.01 (1.03)
Import price	0.02 (1.94)	0.02 (1.88)	0.01 (0.31)	0.04 (1.81)

* Denotes statistical significance at the 5 percent level of significance.
** Denotes statistical significance at the 1 percent level of significance.

1/ Figures in parentheses are t-statistics.

Chart 1

Exchange Rate Volatility: United States

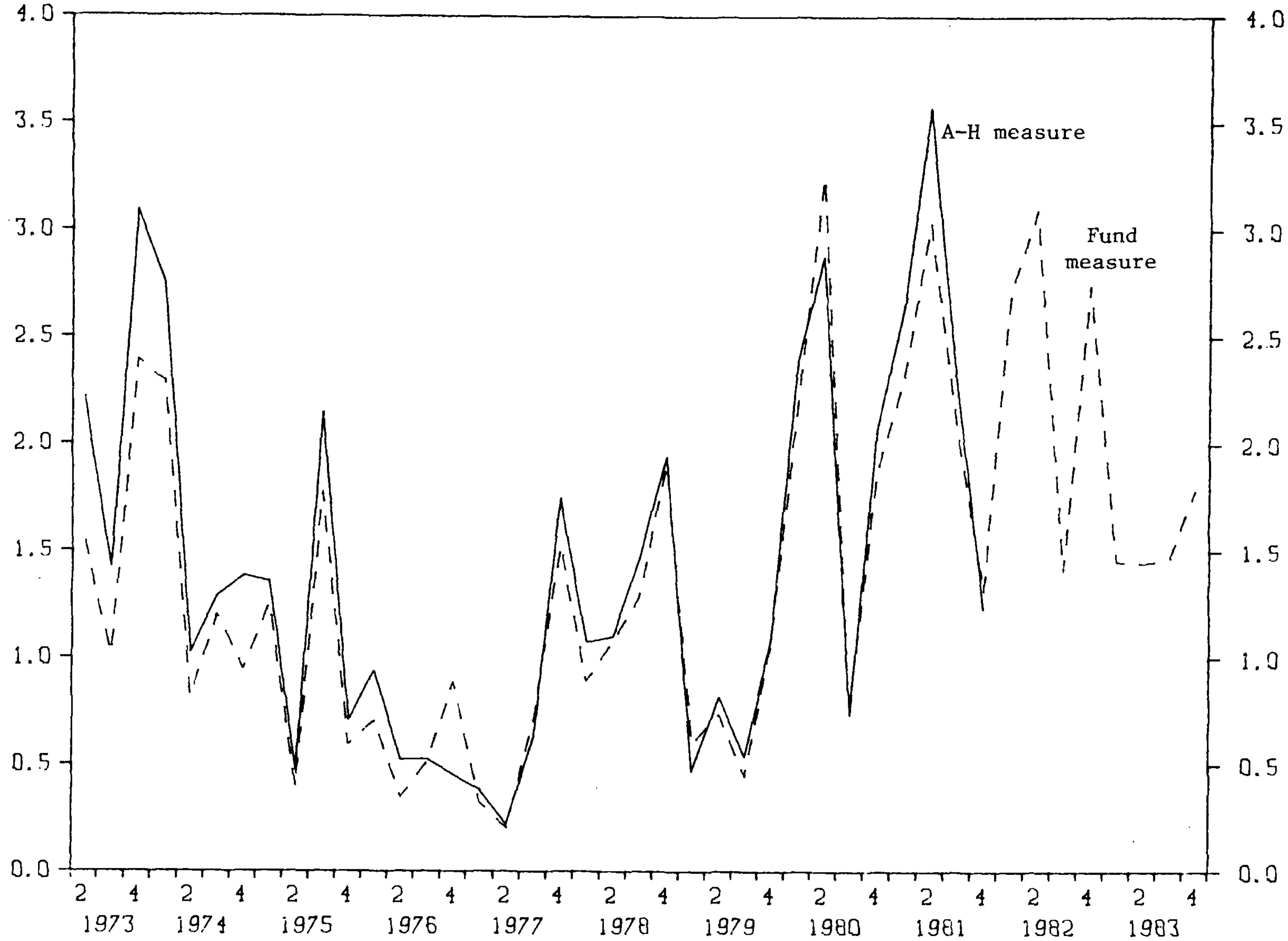
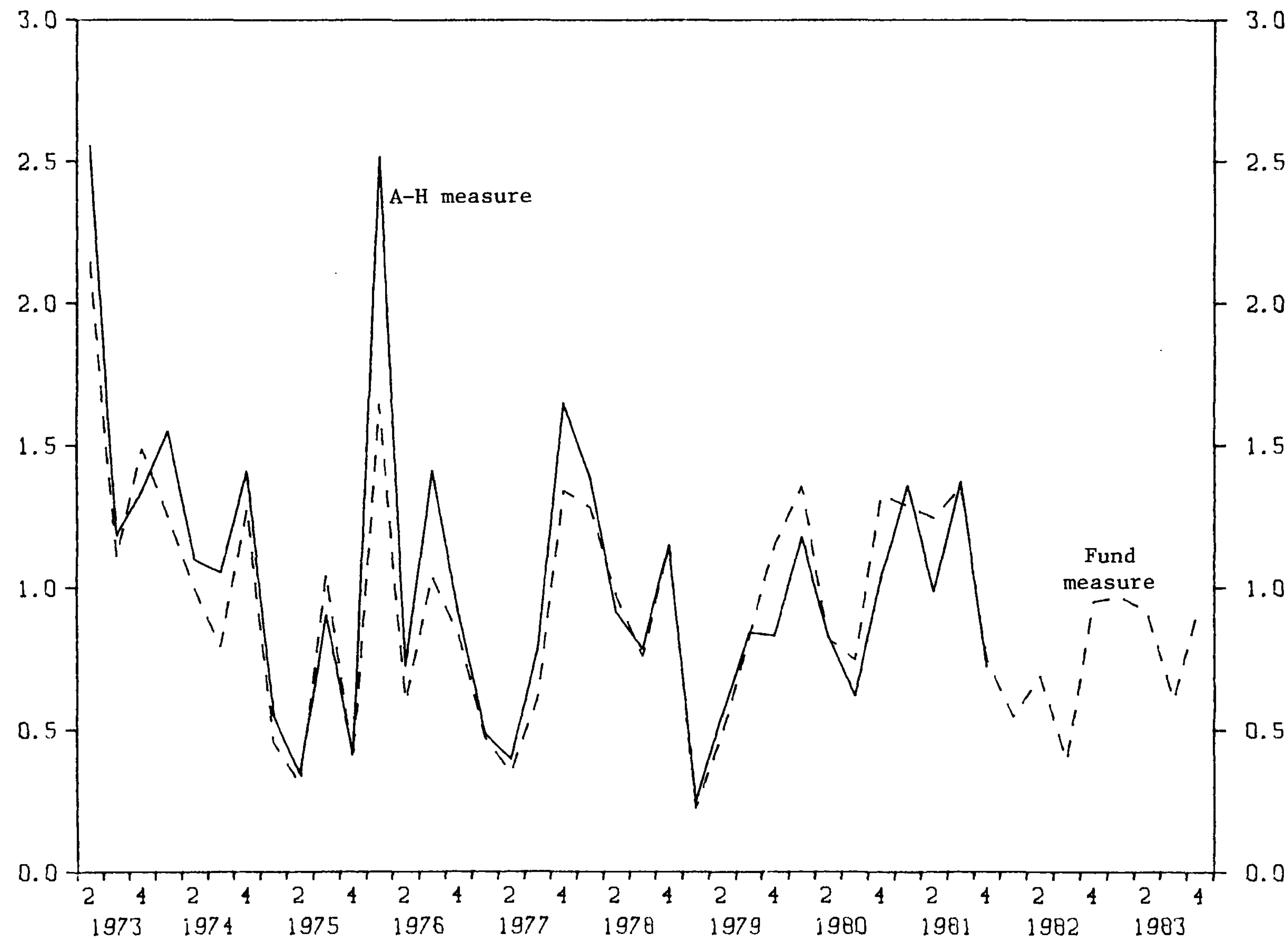


Chart 2

Exchange Rate Volatility: Germany



A final point that requires comment is the use by A-H of seasonal dummies to correct for seasonality in the regression equations. Although both seasonally adjusted and unadjusted variables appear in the regression equations, the authors do not indicate which variables were adjusted and which were not. Based on an examination of their data sources, it appears that the U.S. export volume series is the only dependent variable that was seasonally adjusted. Moreover, the dummies were statistically insignificant in this equation. The export volume equation was, therefore, re-estimated without the seasonal dummies. 1/ This re-estimation continued to show a weakly significant adverse effect of volatility on U.S. export volumes. It is noteworthy that the volatility coefficient lost its significance when the dock strike dummy variable was dropped from the estimation equation.

The foregoing findings on the implications for the A-H results of various changes in empirical methods cast doubts on the robustness of these results and thus raise questions regarding the main policy conclusion that the authors derive from them. The direct, adverse impact of volatility on U.S. export volumes appears to be highly tentative and unstable, and may therefore be disregarded. In addition, the replication results fail to provide a strong, consistent basis for any indirect impact of exchange rate volatility on trade volumes via its effect on prices of traded goods. The results for Germany are somewhat more robust than for the United States, but appear to be quite sensitive to the choice of sample period. Taken together, the apparent lack of stability and uniformity of the empirical results for both the United States and Germany significantly undermines the validity of findings reported in the A-H paper.

V. Revised Results For The United States, Germany, France, Japan, And The United Kingdom

Given the shortcomings associated with certain facets of the A-H methodology, the equations for the United States, Germany, France, Japan, and the United Kingdom reported in Table 1 were re-estimated using revised estimation procedures. The following changes were made to the A-H methodology.

1/ In correcting for seasonality, it is preferable to start with all non-seasonally adjusted series and correct for seasonality using dummy variables or other techniques; or alternatively, to use all series that are seasonally adjusted. In practice, time series are often published only in the adjusted form thus giving rise to the likelihood of both adjusted and unadjusted series appearing in the estimation equation. As a separate issue, it would be interesting to examine any possible seasonality patterns in the exchange rate volatility series.

—An iterative CO correction procedure for serial correlation was employed, but only when the OLS estimation indicated the presence of serial correlation, which was determined on the basis of the Durbin-Watson statistic and the pattern of residuals.

—1975-83 was chosen as the sample period, a period that after allowance for lags, excludes observations from the fixed rate period but includes the experience of the entire floating rate period thus far. 1/

--Seasonal dummies were included in only those equations in which the dependent variable was not seasonally adjusted (for the United States, Germany, Japan, and the United Kingdom), and excluded when it was seasonally adjusted (for France). 2/

--The volatility measures were derived on the basis of standard deviations of daily observations within each quarter of the nominal MERM-weighted effective exchange index for each country, as described on page 17.

--With some misgivings, a polynomial lag specification was imposed on the volatility and relative price variables. However, unlike the A-H specification, it was considered important to use some empirical criterion to determine the appropriate dynamic specification for the equations, i.e., the length of the lag, the degree of the polynomial and the choice of end-point constraints. The A-H procedure of arbitrarily picking one specification for estimation was not used, because it is unlikely that the identical specification would necessarily be appropriate for all four equations for all the countries. Furthermore, given the sensitivity of the results to the dynamic specification of the equations, it was deemed important to try alternative polynomial

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1/ The data used in the estimations reported for the United States and Germany for the period 1974-81 were those that were provided to the author by A-H. Because it was difficult to extend these series through 1983, new data series were computed by the author for the entire 1973-83 period, using the same procedures adopted for computing the data for France, Japan, and the United Kingdom. Although the computation methods are broadly similar to those used by A-H, the new series for the United States and Germany do not appear to be strictly comparable to those provided by A-H.

2/ The U.S. export volume series was seasonally adjusted. This equation was estimated excluding the dummy variables.

specifications. 1/ Predictive testing was used to choose among the various specifications. In this procedure, one makes alternative assumptions about the correct lag length and the correct degree of the polynomial and chooses among them on the basis of their predictive ability. For this purpose, the equations were estimated for the 1975-81 and 1975-82 periods and extrapolated through 1983. The polynomial lag specification that yielded the smallest root-mean-squared-error (RMSE) was chosen as the preferred specification, to be used in the re-estimation over the full sample period, 1975-83.

The new results are shown in Table 6. 2/ It is difficult to interpret them as supportive of the hypothesis that exchange rate volatility has systematically undercut world trade. 3/ Focussing first on the

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1/ The problems and difficulties that arise when using the Almon lag specification are well known. [See Judge et. al. (1980) and Schmidt and Waud (1973) for a review of the issues involved.] Therefore, it is sometimes preferable to opt for alternative lag specifications. In the present analysis, this option could not be used because the objective was to determine whether the results of the A-H analysis could be extended to other industrial countries, and therefore, their broad empirical specification had to be adopted. Some researchers have handled the problem of determining the correct dynamic specification of an Almon lag estimation by using a procedure that searches over several possible values for the degree of the polynomial and the length of the lag and then by choosing the combination that minimizes the residual variances (maximizes the corrected R-squared). However, the changes in the corrected R-squared for alternative estimations are frequently too small to permit meaningful selection of one estimation over another.

2/ For a complete set of the regression results see Appendix B.

3/ Two other recent studies in this area by Justice (1983) and Kenen and Rodrick (1984) published subsequent to the IMF (1984) survey, report evidence that may be regarded as being more suggestive than conclusive. Despite testing with alternative measures of exchange rate volatility, Justice did not find a significant impact of such volatility on the volume of U.K. exports of manufactures in the floating rate period. However, he did find some tentative evidence suggesting that volatility had influenced export pricing behavior, but this result was heavily dependent on the particular measure of volatility used in the estimation. Kenen and Rodrick present new data on the short-term volatility of real exchange rates for the members of the Group of Ten plus Switzerland and analyze the impact of such volatility on trade volumes. Their results are also mixed--in only three of the seven countries examined did they find a significant negative impact of volatility on export volumes; in three others, volatility was actually found to stimulate exports, while in the remaining five the coefficient of the volatility variable was not significantly different from zero. On import volumes, they found a significant negative impact of volatility in four countries, a significant positive impact in two others, and a coefficient for the volatility variable not significantly different from zero in the remaining five countries.

results for the United States and Germany, it is noteworthy that, of the four statistically significant results that formed the basis of Akhtar and Hilton's policy conclusions, three are no longer either of the "correct" sign or statistically significant. The only robust coefficient, in this respect, is that in the equation for German export volumes. The adverse effect on German import volumes reported by A-H is now quite insignificant, as are the effects on U.S. export volumes and import prices, which are now of the opposite sign. On the other hand, the new results point to a positive impact on U.S. export prices which was not detected by A-H, an impact which would indirectly have an adverse effect on U.S. export volumes. However, the evident instability of these parameters points instead to the more general conclusion that the testing procedures used here do not appear to lend themselves to any very confident conclusions.

If one broadens the analysis of the results of Table 6 to include France, Japan and the United Kingdom, a first point to note is the paucity of any direct adverse effect of exchange rate volatility on trade volumes. Of the ten such coefficients in Table 6, only one is statistically significant and of the correct sign--the one for Germany. Moreover, half of the coefficients have the wrong sign. The same is true of the price equations where again close to half of the coefficients are negative. However, of the positive coefficients in the price equations, four meet the standard test of statistical significance, suggesting that exchange rate volatility may adversely affect trade volumes by significantly raising international trade prices.

This conclusion however, must be qualified in several important respects. First, the significance of two of these four coefficients (those for France) is undermined by the non-significance of the relative price terms in the volume equation. Secondly, the pattern of the coefficients is at odds with common sense notions about the nature of the linkages between the various countries and the world market. Taken at face value, the export price equations suggest that U.S. and French exporters bear the exchange rate risk on their exports whereas exporters from Germany, Japan and the United Kingdom do not. In the light of conventional beliefs about the relative market positions of countries in world trade and of available information on the currency composition of countries' trade, it is difficult to provide a clear rationale for that pattern. 1/ Rather, one

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1/ Although information on currency composition has not been fully compiled, findings by Magee (1974) and Page (1981) throw some light on the issue. Citing estimates for 1979-80, Page shows that over 95 percent of U.S. exports and 85 percent of U.S. imports are invoiced in dollars; 80 percent of German exports and 40 percent of German imports are invoiced in DMs; 75 percent of U.K. exports and 40 percent of U.K. imports are invoiced in sterling; 60 percent of Japanese exports and 90 percent of Japanese imports are invoiced in dollars (with about 30 percent of exports invoiced in yen); 60 percent of French exports and 35 percent of French imports are invoiced in francs; and finally 30 percent of German, U.K., and French imports, respectively, are invoiced in dollars.

Table 6. Revised Regression Results For The Exchange Rate Volatility Variable, 1975-83 1/

Dependent Variable	United States	Germany	France 2/	Japan	United Kingdom 3/
Export volume	0.14*2/ (2.70)	-0.12* (2.55)	-0.01 (0.40)	0.03 (1.50)	0.04 (0.98)
Import volume	-0.02 (1.36)	-0.05 (1.07)	0.05 (0.61)	0.09 (2.01)	0.07 (1.31)
Export price	0.10** (4.16)	0.01 (0.58)	0.04* 4/ (2.73)	0.03 (1.33)	-0.01 (0.68)
Import price	-0.005 (0.23)	-0.02 (0.70)	0.03* 4/ (2.67)	0.06* (2.43)	-0.01 (0.82)
Memorandum: Implied total (direct and indirect) elasticity of trade flows with respect to volatility variables: 5/					
Exports	0.10	0.10	--	--	--
Imports	--	--	--	0.14	--

Figures in parentheses are t-statistics.

* Denotes statistical significance at the 5 percent level of significance.

** Denotes statistical significance at the 1 percent level of significance.

1/ For the complete estimation results, see Appendix B.

2/ Estimation equation excludes seasonal dummies. Estimation results did not change substantively upon inclusion of seasonal dummies.

3/ Due to unavailability of data, equations were estimated through Q2 1983.

4/ The (relative) price variable was not statistically significant in the corresponding volume equation.

5/ In the calculations, all coefficients that were not significant at the 5 percent level were assumed equal to zero.

would expect that Japanese and French exporters, and perhaps to a lesser extent, British exporters, would bear relatively more exchange rate risk. The results on the import side are in this respect scarcely more reasonable. In the A-H perspective, the import price equations represent the world's supply price to the country in question. Hence, the positive volatility coefficients for France and Japan suggest that the world bears the exchange risk in exporting to these countries, a risk that it does not incur when exporting to the United States, Germany or the United Kingdom. Again, these results are not very plausible. Rather, one would expect that Japanese importers, and to a smaller extent, French, British, and German importers, would bear the exchange risk, while the world bears the risk in exporting to the United States.

Turning to the results by country, the main points to be noted, subject to qualifications made above, are as follows: For the United Kingdom, the results do not show either direct or indirect effects of exchange rate volatility on trade, a result which corroborates the findings of another re-estimation of the A-H results for the United Kingdom. 1/ For France, the results indicate positive effects on trade prices but these effects are undermined because of the non-significance of the relative price terms in the volume equations. For Japan, the results suggest that volatility might have reduced import volumes via its impact on prices of imported goods. However, even here, there is no indication of a direct impact on trade volumes. In quantitative terms, the results for Japan suggest that a 10 percent increase in volatility could indirectly reduce import volumes by close to 1 1/2 percent. For the United States, the results indicate that volatility might have reduced export volumes via an impact on export prices with a 1 percent reduction in export volumes likely to result from a 10 percent increase in volatility. However, once again, there is no evidence of a direct effect on export or import volumes. Only for Germany is there evidence of a direct adverse impact of volatility on export volumes. In quantitative terms, the results suggest that a 10 percent increase in volatility could reduce export volumes by about 1 percent.

VI. Conclusions and Avenues for Further Research

In sum, the empirical results for the five countries do not provide conclusive evidence that exchange rate volatility has had a statistically significant effect on trade flows. The results suggest that even if there is some residual impact of exchange rate uncertainty on trade, it has not operated in a stable and consistent manner. While the present

1/ Applying the A-H methodology to the equations for U.K. manufacturing trade volumes and unit values in the Bank of England's short-term model, no significant impact of short-term volatility on trade was found for the United Kingdom [Bank of England (1984)]. No significant direct effect was found on trade volumes, the relevant coefficients in the import price equation tended to be negative rather than positive, and of the expected sign but statistically insignificant in the export price equation.

analysis incorporates some improvements in the statistical methods used in the A-H analysis, it would be advisable to adopt further refinements and stability tests in future work, given that the results are sensitive to alternative equation specifications and sample periods. 1/ More fundamentally, the equations should be re-estimated using a measure of volatility that reflects only the unpredictable element of exchange rate movements, and thereby, the short-term volatility or deviations of exchange rates around a long-term trend. 2/ It is also not clear that the variation

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1/ For instance, to deal with the problem of choosing the optimal polynomial specification, a new estimator derived by Kashyap et al. (1984) may be used. This is a Bayesian distributed lag estimator that is consistent with Shiller's (1973) smoothness prior and uses sample data to improve the operating characteristics of both Almon's and Shiller's estimators. This estimator has been shown to be superior in forecasting when compared with either Almon's or Shiller's estimator.

2/ The observed variability in flexible exchange rates typically reflects both systematic rate movements, which are largely predictable, and uncertain rate movements, which are largely unpredictable. To the extent that risk from predictable rate changes can be diversified away, it may be argued that it is the unanticipated component of exchange rate movements which is the appropriate proxy for the uncertainty in exchange rate transactions. In calculating exchange rate volatility, it may be important to eliminate the movements along some predictable long-term trend, since these movements are unlikely to reflect the risk associated with exchange rate transactions. However, the standard deviation (used as a proxy for exchange rate risk) of a nonstationary process, such as the observed exchange rate series, reflects both the short-term volatility in the time series as well as the movement along a long-term trend. The main volatility measure used by A-H is derived as the standard deviations of (the levels of) the observed exchange rate series and, therefore, includes both the trend movement and the short-term volatility in the exchange rate. With a view to focussing on the unpredictable, short-term volatility in exchange rates, an alternative volatility measure derived as the standard deviation of percentage changes in the exchange rate was calculated in the present analysis. Preliminary testing with this measure led to only one significant change in the results--the direct adverse effect of volatility on German export volumes was no longer evident, thus invalidating the only direct effect of volatility on trade volumes, as reported in Table 6. A-H also undertook some re-estimation with this measure, but these results are not reported in the paper. (See footnote 1 on page 6).

in daily exchange rates is the most appropriate unit of observation. As Solomon (1984) points out, "daily fluctuations around a steady or, at least, predictable trend may not (discourage) traders since they (can) always delay or accelerate foreign exchange conversions briefly". It is also noteworthy in this regard that previous empirical findings suggest that it is the longer-term (rather than weekly or daily) movements in exchange rates which might have some impact on decisions of traders [see a review of the literature by Farrell et al. (1984)]. Finally, because the A-H theoretical specification excludes the more fundamental economic determinants of the exchange rate (and thus the basic cause of its variability) and of trade volumes and prices, the identification of a robust empirical relationship between volatility and trade flows could merely reflect the common effects of such omitted variables on these two factors rather than any causal link between them. Conclusive evidence on the effect of exchange rate volatility on trade may, therefore, hinge on the specification of a markedly more comprehensive model.

Data: Definitions and Sources

Presented below is a description of the construction of, and the data sources for, the variables used in estimations. The data used in the estimations reported for the United States and Germany for the period 1974-1981 were those that were provided to the author by Akhtar and Hilton. Because it was difficult to extend these series through 1983, new data series were computed by the author for the entire 1973-83 period, using the same procedures adopted for computing the data for France, Japan, and the United Kingdom. Although the computation methods are broadly similar to those used by A-H, the new series for the United States and Germany do not appear to be strictly comparable to those provided by A-H.

All variables were constructed generally on a basis conceptually similar to that in the A-H paper.

1. Import and export volume and average value indices for manufactured goods were used to denote the trade volume and price variables. Non-seasonally adjusted quantity and average value indices from *Trade Series A, OECD*, were used for Germany, Japan and the United Kingdom. Trade volume and price data for the U.S. were obtained from *International Economic Indicators* and other data bases of the U.S. Department of Commerce. Of the four series for the U.S., only the export volume data are published on a seasonally adjusted basis. For France, seasonally adjusted export and import value measures in constant prices were used as quantity indices could not be obtained. This variable and the export and import prices indices were obtained from *Les Comptes Nationaux Trimestriels*.

2. The exchange rate volatility variable was defined as the standard deviation of the daily observations of the MERM-weighted effective exchange rate index within each quarter over the period Q2 1973-Q4 1983. Observations for the exchange rate index for Q1 1972-Q1 1973 were obtained from the Treasurer's Department, IMF. For this period, the standard deviations were based on monthly observations for the effective exchange rate index within each quarter. The MERM weights used in computing the effective exchange rate indices are described and listed in Artus and McGuirk (1981).

3. The domestic real income variable for each country was denoted by an index of each country's seasonally-adjusted real GNP (GDP). These were obtained from the data base maintained in the Fund's Research Department, which comprises data from national sources provided by desk economists. These data series are either identical or very similar to those maintained on *International Financial Statistics* (IFS).

4. A measure of capacity utilization was obtained for each country by taking the ratio of an index of seasonally-adjusted industrial production to an index reflecting trend growth in industrial production. The data for industrial production were taken from *IFS*.

Alternative measures of trend growth were computed for various sample periods.

5. The domestic price level variable was presented by the wholesale price index for manufactured goods as reported in IFS.

6. The foreign real income variable was computed as a trade-weighted average of the real GNP (GDP) indices for all industrial country and developing country trading partners. These data were derived from the Fund's Research Department's GEE data base. (The industrial countries in this data base are the U.S., the U.K., West Germany, France, Japan, Canada, Italy, Austria, Belgium, Denmark, the Netherlands, Norway, Sweden, Switzerland, Spain, Ireland, Finland, Australia, and New Zealand. Both oil exporting and non-oil developing countries are included in this data base, with individual weights assigned to the bigger countries in these two groups.)

The foreign capacity utilization and foreign price variables were computed as trade-weighted averages of the corresponding indices for all industrial country trading partners. The data were drawn from the GEE data base (for the industrial production data underlying the capacity utilization variables) and from IFS (for the wholesale price indices).

1975 base year total export values were used in computing the trade weights for all the three "foreign" variables described above.

7. Period average, bilateral exchange rates drawn from IFS were used as conversion factors in the computation of the foreign real income and relative price variables.

Set of Complete Regression Results

Presented below is the set of complete regression results for each country corresponding to those presented in Table 6. The t-statistics are given in parentheses under the coefficient estimates. All variables, except for the dummy variables and the volatility variable, enter the equation in natural log form. For some equations, more than one polynomial lag specification yielded similar RMSEs. Only one specification is presented in these instances, because the coefficient estimates did not differ significantly for these alternative estimations.

As seen below, the coefficient of the real income variable is of the right sign and significant in most equations. The results for the capacity utilization variable and the price variables are somewhat mixed. In a few instances when a low Durbin-Watson statistic was found, reestimation using the Cochrane-Orcutt procedure yielded an insignificant estimate of the autocorrelation coefficient. This finding may indicate the possible misspecification of the structural equation rather than the presence of serial correlation.

Glossary of Variables

XV = volume of manufacturing exports

MV = volume of manufacturing imports

XP = price of manufacturing exports in domestic currency

MP = price of manufacturing imports faced by domestic consumers in domestic currency

D1, D2, D3 = quarterly seasonal dummy variables

RDY = real foreign activity level

RFY = real domestic activity level

CUF = a measure of foreign capacity utilization

CU = a measure of domestic capacity utilization

S = nominal exchange rate volatility

RP1 = price of manufacturing exports in foreign currency (domestic currency price x exchange rate)/price of foreign substitutes of exports in foreign currency

RP2 = price of imports of manufacturing goods in domestic currency/price of domestically produced substitutes for imported manufacturing goods in domestic currency

RP3 = price of foreign produced substitutes of exports for imported manufacturing goods in domestic currency (foreign currency price/exchange rate)

PD = price of domestically produced substitutes for imported goods in domestic currency.

U.S.: Export Volume Equation, 1975-83

$$XV_t = \underset{(4.72)}{7.9} + \underset{(2.56)}{1.57}\ CUF_{t-1} + \underset{(0.22)}{0.10}\ RFY_{t-1} + \underset{(2.70)}{0.14}\ S - \underset{(4.05)}{0.82}\ RPI + \underset{(1.94)}{0.25}\ e_{t-1}$$

DW = 1.90, $\overline{R}^2 = 0.879$

Variable Name	Lag Length 0	1	2	3	4	5	6
S	--	0.03 (2.54)	0.03 (3.00)	0.03 (2.54)	0.03 (2.15)	0.02 (1.90)	0.01 (1.73)
RP1	-0.43 (2.04)	-0.26 (3.16)	-0.13 (2.74)	-0.04 (0.46)	0.01 (0.13)	0.03 (0.37)	

U.S.: Export Price Equation, 1975-83

$$XP_t = \underset{(2.97)}{1.30} + \underset{(0.75)}{0.002}\ D1 - \underset{(1.00)}{0.004}\ D2 - \underset{(1.96)}{0.006}\ D3 + \underset{(0.14)}{0.01}\ CU_{t-1} + \underset{(4.22)}{0.55}\ PD_{t-1}$$

$$+ \underset{(4.16)}{0.10}\ S + \underset{(2.01)}{0.17}\ RP3_{t-1} + \underset{(36.1)}{0.85}\ e_{t-1}$$

DW = 1.91, $\overline{R}^2 = 0.993$

Variable Name	Lag Length 0	1	2	3	4	5	6	7	8
S	--	0.01 (2.14)	0.01 (4.27)	0.02 (4.72)	0.02 (4.75)	0.02 (4.17)	0.01 (3.17)	0.01 (2.22)	0.004 (1.50)

U.S.: Import Volume Equation, 1975-83

$$MV_t = \underset{(1.74)}{2.46} - \underset{(0.50)}{0.01}\,D1 + \underset{(2.14)}{0.04}\,D2 - \underset{(0.12)}{0.002}\,D3 + \underset{(15.4)}{2.33}\,RDY_{t-1}$$

$$- \underset{(2.26)}{0.68}\,[CUF/CU]_{t-1} - \underset{(1.36)}{0.02}\,S - \underset{(8.56)}{1.87}\,RP2$$

DW = 1.72, $\bar{R}^2 = 0.973$

Variable Name	Lag Length 0	1	2	3	4	5	6
S	--	-0.004 (0.54)	-0.01 (1.13)	-0.01 (1.30)	-0.004 (0.97)	-0.003 (0.77)	-0.002 (0.66)
RP2	-0.31 (2.08)	-0.37 (5.66)	-0.39 (8.03)	-0.36 (5.21)	-0.28 (3.93)	-0.17 (3.30)	

U.S.: Import Price Equation, 1975-83

$$MP_t = \underset{(0.32)}{0.10} + \underset{(0.91)}{0.01}\,D1 + \underset{(0.62)}{0.004}\,D2 - \underset{(0.42)}{0.002}\,D3 - \underset{(0.07)}{0.01}\,CUF_{t-1}$$

$$+ \underset{(4.87)}{0.41}\,PD_{t-1} - \underset{(0.23)}{0.005}\,S + \underset{(6.86)}{0.57}\,RP3_{t-1} + \underset{(3.70)}{0.49}\,e_{t-1}$$

DW = 2.04, $\bar{R}^2 = 0.994$

Variable Name	Lag Length 0	1	2	3	4	5	6
S	--	0.003 (0.80)	0.0004 (0.11)	-0.001 (0.35)	-0.003 (0.57)	-0.003 (0.68)	-0.002 (0.75)

Germany: Export Volume Equation, 1975-83

$$XV_t = \underset{(2.17)}{4.11} - \underset{(4.05)}{0.05}\,D1 - \underset{(3.17)}{0.04}\,D2 - \underset{(6.80)}{0.09}\,D3 + \underset{(1.88)}{0.52}\,CUF_{t-1} + \underset{(7.72)}{1.30}\,RFY_{t-1}$$

$$- \underset{(2.55)}{0.12}\,S - \underset{(4.58)}{1.14}\,RP1$$

DW = 1.60, a/ $\bar{R}^2 = 0.957$

Variable Name	Lag Length 0	1	2	3	4	5	6	7	8
S	--	-0.01 (0.97)	-0.02 (1.72)	-0.02 (2.40)	-0.02 (2.74)	-0.02 (2.79)	-0.02 (2.72)	-0.01 (2.63)	-0.01 (2.53)
RP1	-0.20 (2.56)	-0.19 (3.54)	-0.17 (4.51)	-0.15 (4.39)	-0.13 (3.54)	-0.11 (2.80)	-0.09 (2.29)	-0.06 (1.94)	-0.03 (1.69)

a/ Re-estimation using the CO correction procedure yielded an insignificant autocorrelation coefficient whose value was 0.10. Therefore, the OLS procedure was used for estimation.

Germany: Export Price Equation, 1975-83

$$XP_t = \underset{(9.89)}{0.89} + \underset{(1.82)}{0.01}\,D1 - \underset{(0.21)}{0.001}\,D2 - \underset{(0.05)}{0.0001}\,D3 + \underset{(0.47)}{0.02}\,CU_{t-1} + \underset{(10.32)}{0.88}\,PD_{t-1}$$

$$+ \underset{(0.58)}{0.01}\,S - \underset{(0.92)}{0.07}\,RP3_{t-1} + \underset{(2.39)}{0.38}\,e_{t-1}$$

DW = 1.85, $\bar{R}^2 = 0.994$

Variable Name	Lag Length 0	1	2	3	4	5	6	7	8
S	--	0.002 (0.55)	0.002 (0.62)	0.002 (0.60)	0.002 (0.55)	0.002 (0.49)	0.001 (0.45)	0.001 (0.41)	0.001 (0.38)

Germany: Import Volume Equation, 1975-83

$$MV_t = \underset{(2.10)}{12.1} - \underset{(1.95)}{0.03}\,D1 - \underset{(0.71)}{0.01}\,D2 - \underset{(6.08)}{0.09}\,D3 + \underset{(4.41)}{1.70}\,RDY_{t-1} + \underset{(0.29)}{0.22}\,[CUF/CU]_{t-1}$$

$$- \underset{(1.07)}{0.05}\,S - \underset{(3.76)}{3.29}\,RP2$$

DW = 1.60, a/ $\overline{R}^2 = 0.975$

Variable Name	Lag Length 0	1	2	3	4	5	6	7	8
S	--	-0.006 (0.46)	-0.008 (0.75)	-0.008 (1.01)	-0.008 (1.12)	-0.008 (1.11)	-0.007 (1.05)	-0.005 (0.99)	-0.003 (0.94)
RP2	-0.24 (0.88)	-0.35 (2.17)	-0.43 (3.72)	-0.47 (3.56)	-0.48 (2.94)	-0.45 (2.53)	-0.39 (2.27)	-0.30 (2.10)	-0.17 (1.98)

a/ Re-estimation using the CO correction procedure yielded an insignificant autocorrelation coefficient whose value was 0.10. Therefore, the OLS procedure was used for estimation.

Germany: Import Price Equation, 1975-83

$$MP_t = \underset{(7.50)}{0.89} + \underset{(4.41)}{0.02}\,D1 + \underset{(2.53)}{0.01}\,D2 + \underset{(3.62)}{0.01}\,D3 + \underset{(2.72)}{0.23}\,CUF_{t-1} + \underset{(3.77)}{0.43}\,PD_{t-1}$$

$$- \underset{(0.70)}{0.02}\,S + \underset{(3.73)}{0.37}\,RP3_{t-1} + \underset{(2.84)}{0.35}\,e_{t-1}$$

DW = 2.21, $\overline{R}^2 = 0.991$

Variable Name	Lag Length 0	1	2	3	4	5	6	7	8
S	--	-0.0002 (0.04)	-0.0003 (0.08)	-0.001 (0.28)	-0.002 (0.57)	-0.004 (0.88)	-0.004 (1.06)	-0.004 (1.09)	-0.003 (1.06)

France: Export Volume Equation, 1975-83

$$XV_t = \underset{(0.11)}{-0.34} + \underset{(1.23)}{0.34}\, CUF_{t-1} + \underset{(5.45)}{1.52}\, RFY_{t-1} - \underset{(0.40)}{0.01}\, S - \underset{(1.03)}{0.44}\, RP1 + \underset{(2.51)}{0.39}\, e_{t-1}$$

DW = 1.79, $\overline{R}^2 = 0.977$

Variable Name	Lag Length 0	1	2	3	4	5	6	7	8
S	--	0.005 (0.83)	0.001 (0.33)	-0.001 (0.26)	-0.003 (0.59)	-0.004 (0.75)	-0.004 (0.84)	-0.004 (0.88)	-0.002 (0.92)
RP1	-0.28 (2.97)	-0.18 (2.61)	-0.11 (1.73)	-0.04 (0.71)	0.003 (0.05)	0.03 (0.54)	0.05 (0.86)	0.05 (1.08)	0.03 (1.24)

France: Export Price Equation, 1975-83

$$XP_t = \underset{(11.33)}{0.50} + \underset{(2.52)}{0.22}\, CU_{t-1} + \underset{(8.57)}{0.57}\, PD_{t-1} + \underset{(2.73)}{0.04}\, S + \underset{(5.05)}{0.32}\, RP3_{t-1} + \underset{(1.02)}{0.19}\, e_{t-1}$$

DW = 1.85, $\overline{R}^2 = 0.997$

Variable Name	Lag Length 0	1	2	3	4	5	6	7	8
S	--	-0.006 (1.57)	0.0001 (0.02)	0.004 (2.15)	0.007 (3.50)	0.009 (3.98)	0.009 (4.13)	0.007 (4.17)	0.004 (4.17)

France: Import Volume Equation, 1975-83

$$MV_t = -2.90 + 2.21\ RDY_{t-1} + 0.67\ [CUF/CU]_{t-1} + 0.05\ S - 0.59\ RP2 + 0.64e_{t-1}$$

(0.48) (2.95) (1.34) (0.61) (1.07) (5.38)

DW = 1.82, $\overline{R}^2$ = 0.975

Variable Name	Lag Length 0	1	2	3	4	5	6	7	8
S	--	-0.01 (1.29)	-0.003 (0.26)	0.01 (0.47)	0.01 (0.80)	0.01 (0.96)	0.01 (1.06)	0.01 (1.12)	0.01 (1.16)
RP2	-0.20 (1.56)	-0.15 (1.73)	-0.11 (1.46)	-0.07 (0.89)	-0.04 (0.47)	-0.02 (0.22)	-0.01 (0.06)	0.003 (0.04)	0.005 (0.12)

France: Import Price Equation, 1975-83

$$MP_t = 1.31 + 0.41\ CUF_{t-1} + 0.19\ PD_{t-1} + 0.03\ S + 0.52\ RP3_{t-1}$$

(28.7) (4.36) (2.49) (2.67) (7.26)

DW = 1.84, $\overline{R}^2$ = 0.995

Variable Name	Lag Length 0	1	2	3	4	5	6	7	8
S	--	-0.001 (0.18)	0.002 (0.86)	0.005 (2.32)	0.006 (3.01)	0.007 (2.98)	0.006 (2.83)	0.005 (2.70)	0.003 (2.60)

Japan: Export Volume Equation, 1975-83

$$XV_t = \underset{(3.71)}{8.12} - \underset{(8.45)}{0.09}\,D1 - \underset{(3.72)}{0.04}\,D2 - \underset{(3.37)}{0.03}\,D3 + \underset{(0.11)}{0.01}\,CUF_{t-1} + \underset{(5.85)}{1.22}\,RFY_{t-1}$$

$$+ \underset{(1.50)}{0.03}\,S - \underset{(7.08)}{1.96}\,RP1$$

DW = 1.84, $\overline{R}^2 = 0.991$

Variable Name	Lag Length 0	1	2	3	4	5	6	7	8
S	--	-0.005 (1.01)	-0.003 (0.86)	0.0001 (0.01)	0.004 (1.24)	0.01 (2.70)	0.01 (3.77)	0.01 (4.05)	0.01 (3.91)
RP1	-0.22 (2.35)	-0.28 (7.27)	-0.31 (12.5)	-0.31 (11.5)	-0.28 (10.7)	-0.23 (7.95)	-0.17 (4.67)	-0.11 (2.69)	-0.05 (1.60)

Japan: Export Price Equation, 1975-83

$$XP_t = \underset{(2.44)}{2.08} - \underset{(0.52)}{0.005}\,D1 + \underset{(0.85)}{0.01}\,D2 - \underset{(0.25)}{0.002}\,D3 + \underset{(1.02)}{0.22}\,CU_{t-1} + \underset{(0.79)}{0.21}\,PD_{t-1} + \underset{(1.33)}{0.03}\,S$$

$$+ \underset{(2.71)}{0.32}\,RP3_{t-1} + \underset{(5.13)}{0.65}e_{t-1}$$

DW = 1.70, $\overline{R}^2 = 0.942$

Variable Name	Lag Length 0	1	2	3	4	5	6	7	8
S	--	-0.005 (1.14)	0.00003 (0.01)	0.004 (1.08)	0.006 (1.69)	0.007 (2.00)	0.007 (2.17)	0.006 (2.26)	0.004 (2.32)

Japan: Import Volume Equation, 1975-83

$$MV_t = \underset{(1.97)}{5.57} - \underset{(2.03)}{0.04}\ D1 + \underset{(1.60)}{0.03}\ D2 - \underset{(1.41)}{0.02}\ D3 + \underset{(3.47)}{1.11}\ RDY_{t-1} - \underset{(1.14)}{0.80}\ [CUF/CU]_{t-1}$$

$$\underset{(2.01)}{0.09}\ S - \underset{(2.73)}{1.33}\ RP2 + \underset{(3.96)}{0.51}e_{t-1}$$

$DW = 1.91$, $\overline{R}^2 = 0.967$

Variable Name	Lag Length 0	1	2	3	4	5	6	7	8
S	--	-0.01 (0.98)	-0.01 (0.81)	0.002 (0.23)	0.02 (1.46)	0.02 (2.61)	0.03 (3.37)	0.03 (3.63)	0.02 (3.59)
RP2	-0.50 (4.11)	-0.37 (4.04)	-0.25 (3.44)	-0.16 (2.34)	-0.08 (1.25)	-0.03 (0.43)	0.01 (0.13)	0.02 (0.52)	0.02 (0.80)

Japan: Import Price Equation, 1975-83

$$MP_t = \underset{(3.43)}{2.70} + \underset{(0.48)}{0.01}\ D1 + \underset{(0.16)}{0.003}\ D2 + \underset{(0.06)}{0.001}\ D3 + \underset{(1.09)}{0.27}\ CUF_{t-1} - \underset{(1.59)}{0.48}\ PD_{t-1}$$

$$+ \underset{(2.43)}{0.06}\ S + \underset{(5.06)}{0.89}\ RP3_{t-1} + \underset{(1.74)}{0.30}\ e_{t-1}$$

$DW = 1.66$, $\overline{R}^2 = 0.906$

Variable Name	Lag Length 0	1	2	3	4	5	6	7	8
S	--	-0.004 (0.61)	0.003 (0.64)	0.008 (2.10)	0.01 (2.79)	0.01 (2.95)	0.01 (2.94)	0.01 (2.91)	0.01 (2.87)

U.K.: Export Volume Equation, 1975-83

$$XV_t = \underset{(1.86)}{1.74} - \underset{(2.36)}{0.05}\,D1 + \underset{(1.06)}{0.02}\,D2 - \underset{(2.86)}{0.06}\,D3 + \underset{(0.54)}{0.22}\,CUF_{t-1} + \underset{(3.52)}{1.44}\,RFY_{t-1}$$

$$+ \underset{(0.98)}{0.04}\,S - \underset{(3.26)}{0.82}\,RP1$$

DW = 2.32, $\overline{R}^2$ = 0.654

Variable Name	Lag Length 0	1	2	3	4	5	6	7	8
S	--	0.002 (0.23)	0.01 (0.77)	0.01 (1.04)	0.01 (1.14)	0.01 (1.18)	0.01 (1.19)		
RP1	-0.12 (1.16)	-0.12 (2.10)	-0.12 (3.53)	-0.11 (2.86)	-0.10 (1.96)	-0.09 (1.49)	-0.07 (1.23)	-0.05 (1.07)	-0.03 (0.96)

U.K.: Export Price Equation, 1975-83

$$XP_t = \underset{(2.34)}{0.36} + \underset{(0.84)}{0.003}\,D1 - \underset{(0.94)}{0.003}\,D2 - \underset{(1.51)}{0.005}\,D3 + \underset{(2.04)}{0.18}\,CU_{t-1} + \underset{(24.7)}{0.76}\,PD_{t-1}$$

$$- \underset{(0.68)}{0.01}\,S + \underset{(3.60)}{0.17}\,RP3_{t-1} + \underset{(5.17)}{0.68}\,e_{t-1}$$

DW = 1.39, $\overline{R}^2$ = 0.997

Variable Name	Lag Length 0	1	2	3	4	5	6	7	8
S	--	0.005 (1.91)	0.001 (0.48)	-0.001 (0.47)	-0.003 (0.99)	-0.004 (1.29)	-0.004 (1.48)	-0.004 (1.61)	-0.002 (1.71)

U.K.: Import Volume Equation, 1975-83

$$MV_t = -4.86 - 0.01 D1 + 0.06 D2 - 0.03 D3 + 2.91 RDY_{t-1} - 0.54 [CUF/CU]_{t-1}$$
(2.04) (0.03) (2.57) (1.26) (8.25) (1.25)

$$+ 0.07 S - 0.87 RP2$$
(1.31) (4.46)

$DW = 1.89$, $\overline{R}^2 = 0.938$

Variable Name	Lag Length 0	1	2	3	4	5	6	7
S	--	0.02 (1.54)	0.02 (1.53)	0.01 (1.31)	0.01 (1.05)	0.01 (0.84)	0.005 (0.68)	0.002 (0.57)
RP2	-0.02 (0.15)	-0.10 (1.50)	-0.15 (4.46)	-0.18 (3.19)	-0.18 (2.45)	-0.14 (2.11)	-0.09 (1.92)	

U.K.: Import Price Equation, 1975-83

$$MP_t = 0.49 - 0.01 D1 - 0.01 D2 - 0.01 D3 + 0.36 CUF_{t-1} + 0.34 PD_{t-1} - 0.01 S$$
(4.24) (0.73) (0.81) (1.29) (3.03) (10.37) (0.82)

$$+ 0.57 RP3_{t-1}$$
(11.85)

$DW = 1.85$, $\overline{R}^2 = 0.993$

Variable Name	Lag Length 0	1	2	3	4	5	6	7	8
S	--	0.01 (2.17)	0.003 (0.97)	-0.001 (0.47)	-0.004 (1.32)	-0.01 (1.75)	-0.01 (1.97)	-0.005 (2.11)	-0.003 (2.20)

References

1. Akhtar, M.A. and R.S. Hilton, "Exchange Rate Uncertainty and International Trade: Some Conceptual Issues and New Estimates for Germany and the U.S.", Federal Reserve Bank of New York Research Paper No. 8403 (May 1984), 1984a.

2. Akhtar, M.A. and R.S. Hilton, "Effects of Exchange Rate Uncertainty on German and U.S. Trade", Federal Reserve Bank of New York Quarterly Review (Spring 1984), 1984b.

3. Artus, J.R. and A.K. McGuirk, "A Revised Version of the Multilateral Exchange Rate Model", International Monetary Fund Staff Papers (June 1981).

4. Bank of England, "The Variability of Exchange Rates: Measurement and Effects", Bank of England Quarterly Bulletin (September 1984).

5. Brodsky, D.A., "Fixed versus Flexible Exchange Rates and the Measurement of Exchange Rate Instability", Journal of International Economics (August 1984).

6. Farrell, S., with A. De Rosa and T. McCown, "Effects of Exchange Rate Variability on International Trade and Other Economic Variables: A Review of the Literature, "Staff Studies", No. 130, Board of Governors of the Federal Reserve System, (December 1983).

7. International Monetary Fund, "Exchange Rate Volatility and World Trade", Occasional Paper No. 28 (July 1984).

8. Judge, G., W.E. Griffiths, R.C. Hill, and T. Lee, The Theory and Practice of Econometrics, John Wiley and Sons (1980).

9. Justice, G., "The Impact of Exchange Rate Variability on International Trade Flows", Discussion Papers, No. 4, Bank of England, London (December 1983).

10. Kashyap, A.K., P.A.V.B. Swamy, J.S. Mehta, and R.D. Porter, "Estimating Distributed Lag Relationships Using Near-Minimax Procedures", Federal Reserve Board of Governors Working Paper (1984).

11. Kenen, P., "Exchange Rate Instability: Measurement and Implications", International Finance Section Research Memorandum, Princeton University (June 1979).

12. Kenen, P. and D. Rodrik, "Measuring and Analyzing the Effects of Short-term Volatility in Real Exchange Rates", International Finance Section Working Papers G-84-01, Princeton University (March 1984).

13. Kmenta, J., Elements of Econometrics (1971).

14. Lanyi, A., "The Case for Floating Exchange Rates Reconsidered", Essays in International Finance 72. Princeton, N.J.: Princeton University, Department of Economics, International Finance Section, (February 1969).

15. Lanyi, A. and E. Suss, "Exchange Rate Variability: Alternative Measures and Interpretation", International Monetary Fund Staff Papers (December 1982).

16. Magee, S.P., "U.S. Import Prices in the Currency Contract Period", Brookings Papers on Economic Activity, Brookings Institution (1: 1974).

17. Page, S.A.B., "The Choice of Invoicing Currency in Merchandise Trade", National Institute Economic Review, National Institute of Economic and Social Research (November 1981).

18. Rana, P.B., "Exchange Rate Risk under Generalized Floating: Eight Asian Countries", Journal of International Economics (November 1981).

19. Schmidt, P. and R. Waud, "The Almon Lag Technique and the Monetary Versus Fiscal Policy Debate", Journal of the American Statistical Association, Vol. 68, No. 341 (March 1973).

20. Shiller, R.J., "A Distributed Lag Estimator Derived from Smoothness Priors", Econometrica, Vol. 41 (1973).

21. Solomon, R., "The Consequences of Exchange Rate Variability," Brookings Discussion Papers in International Economics No. 24, (December 1984).