NBER WORKING PAPER SERIES

INSIGNIFICANT AND INCONSEQUENTIAL HYSTERESIS: THE CASE OF U.S. BILATERAL TRADE

David C. Parsley
Shang-Jin Wei

Working Paper No. 4738

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
May 1994

We would like to thank David Romer for very helpful discussions. We have also received useful suggestions from Menzie Chinn, Avinash Dixit, Timothy Lane, Wooheon Rhee, Hans Stoll, an anonymous referee, and numerous seminar participants. Part of this research was supported in part by the Dean's fund for Faculty Research of the Owen Graduate School of Management at Vanderbilt University. This paper is part of NBER's research programs in International Finance and Macroeconomics and International Trade and Investment. Any opinions expressed are those of the authors and not those of the National Bureau of Economic Research.

NBER Working Paper #4738
May 1994

INSIGNIFICANT AND INCONSEQUENTIAL HYSTERESIS: THE CASE OF U.S. BILATERAL TRADE

ABSTRACT

This paper casts doubt on the validity of the hysteresis hypothesis as an explanation of the persistent U.S. trade deficits in the 1980s. We propose two tests to investigate two different implications of the hypothesis. The first implication is that cumulative changes in exchange rates, in addition to current exchange rate levels, are important determinants of trade flows. The second implication is that foreign exporting firms' perceptions of exchange rate volatility will affect their decisions to enter or exit the market. We find little support for either aspect of the hysteresis hypothesis.

David C. Parsley
Owen School of Management
Vanderbilt University
Nashville, TN 37203

Shang-Jin Wei
Kennedy School of Government
79 JFK Street
Cambridge, MA 02138
and NBER

I Motivation

The extended dollar appreciation, and subsequent steep depreciation, during the 1980s has been cited as the proximate cause of sluggish adjustment of trade volumes and prices. This idea presents a new twist to the now-traditional view that exchange rate variability is itself caused by sluggish adjustment of prices. The new view is that the structure of demand and supply in trade may be characterized by hysteresis (Dixit 89a, 89b; Krugman and Baldwin 89). Actual empirical examination of this hypothesis is, however, quite limited.

Hysteresis has been defined as the failure of an effect to be reversed once the cause of the disturbance is removed (Dixit 89b). In models proposed by Baldwin and Krugman (89), and developed in Dixit (89a, 89b) the existence of sunk costs has important implications for equilibrium real exchange rates and trade flows. In these models, the combination of exchange rate uncertainty and sunk costs produce hysteresis in trade flows because firms' entry/exit decisions are tied to some critical levels of the exchange rate. Without sunk costs revenue fluctuations would be unimportant because firms would enter in profitable periods and exit in unprofitable periods. In hysteresis models competitive strength, or the ability to export, becomes dependent on the past history of the exchange rate. Large exchange rate swings, then, entail welfare costs, since productive resources within the society must be reallocated. Given the prevalence of sunk costs, and the empirical observation that exchange rates are highly variable, we might suspect hysteresis to be highly applicable to contemporary events.

Behind the facade of novelty, the ultimate implications of hysteresis are fundamental. In addition to implying that the direction and composition of real trade flows are somewhat arbitrary, some experts have implicated the current exchange rate system as a promoter of these path dependencies. Indeed, Krugman (89) has argued this point to the extent of advocating an eventual return to a system of fixed exchange rates. The large exchange rate swings of the 1980s and the persistent trade imbalances do present a prima facie case for the potential importance of hysteresis. Often, however, more traditional explanations for these events exist. Given that alternative explanations frequently entail significantly different policy prescriptions, a careful empirical evaluation of this phenomenon is warranted.

In this paper we focus on two aspects of the hysteresis hypothesis which have testable implications. The first is that *cumulative* changes in exchange rates are important determinants of trade flows; i.e., under the hypothesis, the effect of an exchange rate change on trade flows depends on the past history of exchange rate changes. This contrasts with the traditional view that exchange rates matter only in levels. The second implication of hysteresis derives from an analogy with financial options. In particular, the hypothesis posits that because of sunk costs and uncertainty, a firm's perception of the sustainability of the current exchange rate will affect its decisions to enter or exit the market. For example, if the firm becomes less sure of the future course of the exchange rate, the option value of the "wait-and-see" strategy rises. This implies that as exchange rate volatility increases, the response of trade flows to exchange rates, will fall. These features of the hypothesis motivate the econometric tests we employ in this paper.

The rest of this paper is organized as follows. Section II offers several reasons why the hysteresis hypothesis has not been adequately tested in existing studies. Section III describes the data we employ. Section IV develops fully, two testable implications of the hypothesis before presenting the results of these tests. Section V concludes.

II. The Hysteresis Hypothesis

The hysteresis idea is most easily illustrated with an example. Figure 1 depicts the relationship between exchange rates and imports. Suppose the real exchange rate (home currency per foreign currency) is s_0. Along import schedule IM_0 a domestic currency appreciation (to e.g., s_1) is associated with higher imports since exports become more profitable from the foreign firm's perspective. However with hysteresis, there exists some critical level of the real exchange rate, x_0, such that a further appreciation (to e.g., s_2) will shift the import schedule to IM_1. This shift occurs because at real exchange rates below x_0 it is profitable for new foreign firms to enter the market, and/or for existing foreign firms to expand.[1]

Once foreign firms have expended these sunk costs, a depreciation from s_2 back to s_1 will not cause these firms to exit. As a result, imports will be permanently higher, i.e., only a sufficiently large depreciation will shift the import schedule back to IM_0. Note that the effect need not be limited to IM_0, i.e., beginning from IM_1, an appreciation beyond x_1 will shift the import schedule further, to IM_2. This effect is termed hysteresis.

<<< Figure 1 >>>

Surprisingly, empirical tests of the hysteresis hypothesis are few. The only attempts that we are aware of seem to suggest that hysteresis is unimportant (Baldwin 88, Krugman and Baldwin 89), but this may be the result of deficiencies of the tests employed. It is likely, however, that the dearth of explicit tests is attributable both to the assumed outcome of the test and to some general difficulties that must be overcome prior to testing.

---

[1] Expansion may take the form of investment in marketing networks or distribution channels as well as expansion of physical production processes.

One barrier to testing relates to the impreciseness of the theoretical predictions. Notably, the hypothesis states that a sufficiently large change in the exchange rate will alter the equilibrium relationship between trade flows and exchange rates, but it does not specify just how large a change in the exchange rate must be to induce such structural adjustment. Another difficulty in testing is the lack of appropriate data. During the 1980s, the large swing in the international value of the dollar took almost a decade, yet the recent floating exchange rate period has a history of less than two decades. Presumably, the number of candidate episodes is quite small.

An additional explanation for the lack of empirical tests comes from a different direction altogether. In particular, we suspect there may be strong priors regarding the outcome of the test, e.g., a break is apparent in a time series graph of the exchange rate and trade flows. Figure 2 presents such a chart; it plots quarterly real imports and the trade-weighted exchange rate based on data from Citibase (series GIMQ and EXVUS, respectively). In the chart, imports generally rise as the dollar rises; however, imports continue to rise after the dollar falls. Thus, one might conclude that the divergence signals an obvious structural break. This conclusion, however, is simply unwarranted since in the figure, we have not controlled for other determinants of imports (e.g., income, and seasonal factors) which might account for the strong upward trend.[2]

<<< Figure 2 >>>

[2] In an earlier version of this paper, (Parsley and Wei, 91), we plot one example of a de-trended imports series against the real exchange rate where no clear break in the relationship is apparent.

III. Data

To isolate hysteresis effects it is important to focus the empirical examination on disaggregated volume data to the extent possible. This serves several purposes. First, the use of disaggregated data minimizes measurement error in the dependent variable that is introduced either when import values are deflated with nonmatched price indexes or when there are quality changes in the aggregate bundle. Second, the use of bilateral data avoids the measurement error introduced when "trade-weighted" exchange rates are used. Furthermore, endogeneity is less of an issue in a disaggregated context. Finally, a focus on disaggregated cases allows hysteresis effects to surface in certain commodities only, or in trade with particular trading partners.

In this paper we examine the hypothesis using two different commodity level data sets available on a monthly basis.[3] The first is volume data for bilateral U.S. imports of homogeneous chemicals from Canada. The chemicals were: benzene, toluene, boric acid, phosphoric acid, carbide, uranium oxide, methylene chloride, perchloroethylene, ethylene oxide, propylene oxide, and acetic acid. The range for this data set is 1980:01 to 1988:12. The other commodity data set consists of volume data on five Japanese exports to the U.S., namely: ball bearings, bicycles, bolts, nuts, and screws. The range for this data set is 75:01 to 87:12.

These quantity series have several virtues. First, fixed costs and thus hysteresis effects, are likely to be important for these products. Secondly, the U.S. was the largest export market for each product considered; in fact, for bolts, nuts, and screws, the U.S. has been nearly the total export

---

3 A complete description is given in an appendix. In Parsley and Wei (91), we also examine two aggregate data sets: the bilateral imports of 12 OECD countries from the U.S., and the U.S.'s imports from these countries.

market.[4] This implies that third country effects will be minimized.[5] Finally, these commodities are extremely homogeneous (with the exception of bicycles). Hence, errors caused either by quality change or by improperly deflated value series will not exist.

IV. Empirical Tests of the Hysteresis Hypothesis

Test 1: The Asymmetry Hypothesis

There are three interdependent aspects of the hysteresis hypothesis relevant for constructing our first test. First, exchange rate changes must be "large" before structural shifts such as those depicted in Figure 1 can occur. That is, exchange rates may vary in the range s_0 to s_1 without triggering the shift from IM_0 to IM_1. Second, given that exchange rates evolve over time, there is a sense in which history (or the evolution of the exchange rate) matters. That is, with exchange rates beginning in the range s_0 to s_1, we could move to IM_1 only if the price of foreign exchange fell below x_0 in some previous period. Third, and this is the key aspect, there is an asymmetry in the response of trade flows to exchange rates; specifically, some exchange rate changes will produce different effects than others of equal magnitudes. This is the case at the points of shift in Figure 1. We combine these implications with insights in Dixit (89a) to form our first test of the hysteresis hypothesis.

Dixit (89a) has formalized these intuitive propositions and observed that, in effect, there is a zone of inaction around the current exchange rate

---

[4] The average (1973-87) percent of Japanese exports going to the U.S. by product are: ball bearings, 28%; bicycles, 61%; bolts, 87%; nuts, 81%; and screws, 78%.

[5] If the U.S. market were not large, then developments in other markets (e.g., changes in non-dollar/yen exchange rates) might induce changes in Japanese exports to the U.S. not related to changes in the yen/dollar exchange rate.

within which entry or exit will not occur. This situation is described as hysteresis by Dixit. More interestingly, once exchange rates breach these bands, we get a structural change; it is this path dependency that is central to our first test. In particular, combining the implications above, the model implies that the effect of a depreciation following successive depreciations will be fundamentally different from the effects of a depreciation following a series of appreciations.

We model this asymmetry as follows. First, define V_t to be equal to the cumulative change in exchange rates over some period (τ), or:

$$V_t = \sum_{i=0}^{\tau} \Delta s_{t-i} = s_t - s_{t-\tau-1} \ . \qquad (1)$$

Then define a dummy variable, D_t, that indicates whether the most recent change in the exchange rate is in the same, or opposite, direction from the change over the last τ periods, that is:

$$D_t = \begin{cases} 1 & \text{if } \Delta s_t \text{ and } V_t > 0 \\ -1 & \text{if } \Delta s_t \text{ and } V_t < 0 \\ 0 & \text{otherwise} \end{cases} \qquad (2)$$

Then, the measure of phase is:

$$\psi_t = D_t \Delta s_t V_t \qquad (3)$$

where s_t = the real exchange rate (domestic currency/foreign currency).

Now consider a depreciation following successive depreciations. V_t and thus ψ_t will be positive. The asymmetry hypothesis predicts then, that in an equation describing the behavior of imports, the coefficient on ψ_t will be negative. This is because successive depreciations lead to exit, and thus the entire import schedule shifts inward. Similarly, an appreciation after a substantial cumulative appreciation will yield the product $\Delta s_t V_t > 0$, but now ψ_t will be negative. The hypothesis still predicts the sign of the coefficient on ψ_t will be negative since the sequence of appreciations should induce entry of foreign firms. Note that the dummy insures ψ_t will be zero when the sign of the most recent exchange rate change is opposite that of the cumulative change. In the estimations below, we choose τ to be 24 for the sake of preserving degrees of freedom; that is, we assume that information about exchange rate trends in the most recent two years is sufficient to identify hysteresis effects.[6]

As Rose and Yellen (89) note, standard two-country models of trade assume that the volume of imported goods demanded depends positively on real domestic income and negatively on the relative price of imported goods. Thus, after adding our measure of the phase, the augmented trade equation (in logs) would take the form:

$$\Delta IMP_t = \text{constant} + \text{seasonals} + A(L)\Delta p_t + B(L)\Delta\text{income}_t + \mu\psi_t + \varepsilon_t \quad (4)$$

Equation 4 is the basic trade equation estimated across all commodities. Our proxy for real income is industrial production in the importing country. Δp_t is the change in relative prices; in the chemical equations we use relative unit value indexes, and in the equations using imports from Japan we employ export price indexes specific to each commodity, denominated in dollars. Both measures are superior to bilateral exchange rates.[7]

In all estimations the order of the lag polynomials A(L), B(L) was set

---

6 Setting $\tau = 36$ yielded virtually identical results.

7 Two problems commonly plague the use of unit value indexes: changes in weights and in the quality of products composing the indexes (Kravis and Lipsey 74). The regressions here do not suffer from these problems because they are product by product and because the products themselves are highly homogeneous.

to three and each equation also included monthly dummies. Unit-root tests were performed (not reported) on all variables in the combined data set and, with the exception of chemicals, these tests could not reject the unit-root null hypothesis. Consequently, the Japanese bilateral trade equations were estimated in log-first differences and the chemicals equations were estimated in log levels.

Table 1 presents the OLS estimates of μ, the coefficient on ψ_t and the associated heteroscedasticity-consistent standard errors for each equation estimated. The Japanese bilateral trade equations were estimated using a correction for first order autocorrelated errors. At the 10 percent level of significance, the restrictions implied by this procedure could be rejected in only one equation. Finally, the range of estimation for the chemicals equations was 1982:01 to 1988:09, and for the Japanese bilateral trade equations the estimation period was 1978:03 to 1987:12. The table also presents estimates of the sum of the coefficient estimates on the contemporaneous and first three lags of ψ. The idea is to incorporate a longer time dimension for the decision process to enter or exit.[8]

The point estimates of μ reported in Table 1 are predominantly negative as predicted by the hypothesis. Unfortunately however very few of these estimates are statistically different from zero; in one case the estimate is statistically significant and positive. What evidence that exists for the importance of asymmetric effects of exchange rate changes comes from the chemicals equations. However, this evidence is clearly less than universal since statistically significant effects are limited to only three chemicals. This conclusion holds across both asymmetry measures considered. For product exports from Japan the point estimates are consistently negative, however

---

8 We thank a referee for suggesting this interpretation.

only one of ten estimates in the table is statistically different from zero. To summarize, the strongest claim that can be made is that most of the point estimates have the sign predicted by the theory.

One possible explanation for these weak results is that trade in chemicals may be driven by long term contracts, so that imports are not responsive even to a succession of appreciations or depreciations. In any case, the conclusion we draw from this test is that hysteresis effects, even if they are present, are not a pervasive phenomenon for the commodities studied.[9]

<<< Table 1 here >>>

Test 2: The Option Value Hypothesis

We develop an alternative test in this section that focuses on a different implication of the hypothesis; namely, the influence of uncertainty on the firm's decision to enter or exit the market. Test 2, like test 1, relies on the conditional nature of the response of trade flows to exchange rates; however, test 2 explicitly allows that response to vary each period.

According to the "option value" interpretation, the zone of inaction widens as the exchange rate becomes more volatile. An increase in volatility makes it more likely that any change in the level of the exchange rate is temporary, and hence it is less worthwhile to incur the costs to enter or exit. In other words, the value of the "wait and see" option rises (see e.g., Dixit 89b).

We test this aspect of the hypothesis by first estimating a stochastic parameter version of equation 4, that is, the intercept term in that equation is allowed to exhibit shifts (as suggested by Figure 1) at each sample data

---

9 These conclusions are reinforced in aggregate bilateral U.S. trade data. See Parsley and Wei (91).

point. We then relate the resulting estimated "time-series" coefficient vector to measures of real exchange rate uncertainty. The option value interpretation then, implies that changes in the (time varying) intercept will be inversely related to exchange rate volatility.

Thus, the specification for the test is:

$$|\Delta\hat{\beta}_t| = \alpha + \vartheta E_t(\sigma_{t+k}) + \varepsilon_t \qquad (5)$$

where $\hat{\beta}_t$ is a time series of estimated coefficients, $E_t\sigma_{t+k}$ is expected exchange rate volatility over the next k periods, based on information at time t. We use two measures of uncertainty: first, the standard deviation of log real exchange rate changes; and second, the standard deviation of the k-period real exchange rate changes. For each of these measures we use a naive forecast that uses only lagged real price changes, and an ex post three month ahead realized volatility. The latter forecast will differ from ex post volatility by a purely random error under rational expectations.

According to the option value interpretation ϑ, will be negative. Once we specify the stochastic nature of the shifts in the coefficients, the actual estimation of the (time-varying) response of imports to exchange rates is most efficiently handled by the Kalman filter. The Kalman filter is a set of equations which allows these coefficients to be updated as new information becomes available. Since our exercise here is not one of forecasting, we use "smoothed" Kalman filter estimates of the stochastic shifts; these smoothed estimates use information in the entire sample in constructing the time varying parameter estimates. See Newbold and Bos (85), for a description of how these smoothed estimates are constructed.

The specification of the model is the following.

$$y_t = \beta_t + z_t'\gamma + e_t \qquad (6)$$

$$\beta_t = \beta_{t-1} + u_t \quad , \tag{7}$$

where y_t is imports, z_t is a k - vector of other relevant explanatory variables, and γ is the corresponding k - vector of coefficients; we assume the elements of γ to be nonstochastic.[10] The random walk assumption (equation 7) captures the hysteresis implication that changes in the response of imports to the exchange rate are "structural" or persistent to the extent these changes involve entry and exit.

For identification we impose some additional restrictions:

$$\begin{pmatrix} e_t \\ u_t \end{pmatrix} \sim N\left(0\ ,\ \begin{pmatrix} \sigma_e^2 I_T & 0 \\ 0 & \sigma_u^2 I_T \end{pmatrix}\right) , \tag{8}$$

i.e., the disturbances in both equations are serially uncorrelated, mutually independent, normally distributed, with zero means and constant variances. The three equations (6), (7), and (8) fully define the stochastic parameter regression model. Given the observations on $(y_t, z_t')_{t=1,...T}$, we can estimate the constant coefficients in the system, $(\gamma, \sigma_e^2, \sigma_u^2)$, and a time-series of the intercept coefficients, $\{\beta_t\}$. These estimated β_t's are then used in testing the option value aspect in equation 5.

<<< Table 2 here >>>

Table 2 presents the results using the Kalman filter coefficient estimates for those chemicals with enough data to perform the test, and for the bilateral commodity trade with Japan. In the table we present four

---

[10] The variables included in the vector z_t are the same as those used in equation 4 except ψ is omitted.

measures of exchange rate volatility. Two measures are "naive" and two are "rational". The naive measures are extrapolated from past values of variability, and the rational measures use ex post realized variability. The naive measures thus assume the firm's information set contains only the past history of exchange rate variability, while the rational measures assume perfect foresight. Variability for both measures (naive and rational) is defined as the standard deviation of the kth difference of the real exchange rate; where two values of k were chosen as a further robustness check.[11] Finally, after obtaining the Kalman filter estimates of the constant coefficients in equation 4, we regress them on these measures of exchange rate uncertainty.

The evidence presented in Table 2 is unsupportive of the hypothesis that hysteresis effects are important for trade flows. In particular, none of the coefficient estimates is statistically significant and relatively few have the sign predicted by the hypothesis. Furthermore, this conclusion is robust to all four measures of exchange rate uncertainty. Thus we conclude that even the qualified interpretation given to the statistically insignificant evidence in Table 1 is not confirmed by the results from test 2.

It is now possible to offer an interpretation of the combined results of the two tests. Broadly, test 1 asks the question: in terms of import response to exchange rate changes, does history matter? Test 2 asks: Does the zone of inaction depend on exchange rate volatility? Our results

---

[11] Another proxy for exchange rate uncertainty we tried was to fit an ARCH model to the residuals in a random walk (with drift) specification for each bilateral exchange rate series. This procedure would generate an ex ante conditional forecast of exchange rate volatility appropriate if the exchange rate actually followed a random walk process and expectations were formed rationally. However attempts to fit an ARCH model to these data proved unsuccessful; ARCH effects seem not to be present at the monthly frequency. Another way of measuring ex ante volatility is to use volatility implied by currency options, as in Wei (1991).

indicate that a negative answer is appropriate for both questions.

V. Summary

Exchange rate swings, such as the one experienced by the U.S. dollar during the 1980s have generated considerable controversy about their causes and their effects. One line of research into their effects emphasizes the importance of sunk costs in the investment decisions of firms. According to this view, a large exchange rate cycle can have lasting effects on trade flows. Such path dependency of trade on exchange rates is labelled as hysteresis.

The possibility of hysteresis has been demonstrated in several theoretical papers and has, in turn, added intellectual force to proposals to limit exchange rate movements. Empirical examination of this issue, however, has not kept pace with the theoretical developments. This paper contributes to bridging this gap.

This paper focuses on two testable implications of the hypothesis of hysteresis in trade. We test data at a commodity level where hysteresis effects are more likely noticeable, and where econometric and measurement difficulties are minimized. The first test looks for asymmetries in the response of imports to exchange rates. In particular we ask whether cumulative changes in exchange rates are an important additional determinant of trade flows. We find little statistical support for the asymmetry hypothesis in the data. Our second test focuses on the option value of the investment decision. According to this interpretation, increases in uncertainty raise the value of a wait-and-see option. As volatility increases, trade flows become less responsive to exchange rate changes. The results from this test again do not support the existence of hysteresis effects.

BIBLIOGRAPHY

Baldwin, Richard, 1988, "Hysteresis in Import Prices: The Beachhead Effect", **American Economic Review**, pp. 773-85.

Baldwin, Richard, and Paul Krugman, 1989, "Persistent Trade Effects of Large Exchange Rate Shocks", **Quarterly Journal of Economics**, pp. 635-54.

Bank of Japan, **Price Indexes Annual**, various issues.

Citibank, N.A., **Citibase economic database** (machine-readable magnetic data file), New York, N.Y.

Dixit, Avinash, 1989a, "Hysteresis, Import Penetration, and Exchange Rate Pass-Through", **Quarterly Journal of Economics**, pp. 205-28.

Dixit, Avinash, 1989b, "Entry and Exit Decisions Under Uncertainty", **Journal of Political Economy**, pp. 620-38.

International Monetary Fund, **International Financial Statistics**, various issues.

Japan Tariff Association, **Japan Exports and Imports: Commodity by Country**, various issues.

Kravis, Irving, and Robert Lipsey, 1974, "International Trade Prices and Price Proxies", in **The Role of the Computer in Economic and Social Research in Latin America**, Nancy Ruggles, ed., pp. 253-66.

Krugman, Paul, and Richard Baldwin, 1987, "The Persistence of the U.S. Trade Deficit", **Brookings Papers on Economic Activity**, pp. 1-43.

Krugman, Paul, 1989, **Exchange Rate Instability**, The MIT Press.

Newbold, Paul, and T. Bos, 1985, "Stochastic Parameter Regression Models", Sage University Papers: Quantitative Applications in the Social Sciences, Sage Publications.

Parsley, David, and Shang-Jin Wei, 1991, "Insignificant and Inconsequential Hysteresis: The Case of U.S. Bilateral Trade", **Owen Financial Markets Research Center**, working paper #91-36, Vanderbilt University.

Rose, Andrew, and J. Yellen, 1989, "Is There a J-Curve?", **Journal of Monetary Economics**, pp. 53-68.

U.S. Department of Commerce, **U.S. imports: Schedule A, Commodity by Country**, various issues.

Wei, Shang-Jin, 1991, "Anticipations of Foreign Exchange Rate Volatility and Bid-Ask Spreads", **International Finance Discussion Papers**, # 409, Board of Governors of the Federal Reserve System.

Data Appendix

The data sources are the following. U.S. Industrial production and consumer prices are from **Citibase**. The bilateral exchange rates used are period-average values from **International Financial Statistics**. The source for the U.S. imports of chemicals is **U.S. Imports: Schedule A, Commodity by Country**, U.S. Department of Commerce. Both quantity and value series are used. Due to missing values only eleven of the twenty-three homogeneous candidate chemicals initially chosen were actually used. For the same reason, we examine only U.S. imports from Canada of these chemicals. The source for U.S. imports of the five commodities from Japan is **Japan Exports and Imports: Commodity by Country** published by the Japan Tariff Association. Finally, the source for the relative price variables for these commodities is **Price Indexes Annual**, published by the Bank of Japan.

Figure 1: Hysteresis in the Relationship
Between Imports and the Exchange Rate

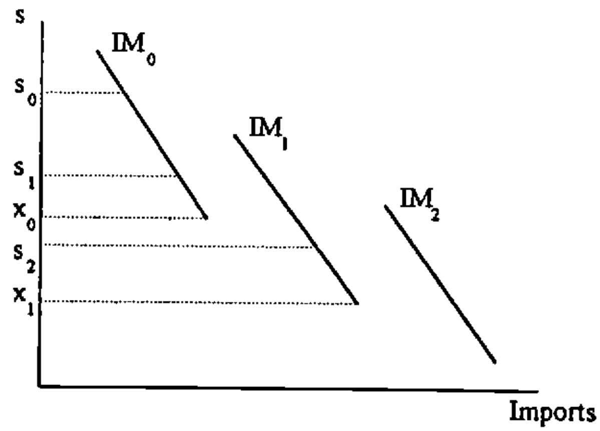

Figure 2: Imports and Weighted Average Exchange Rate

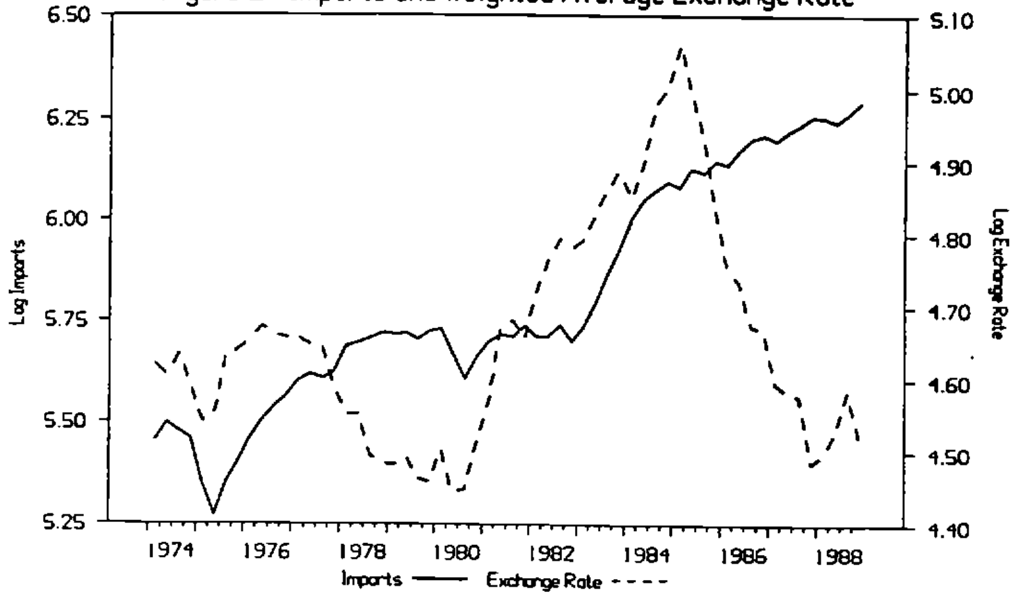

TABLE 1: ESTIMATES OF ASYMMETRY IN THE RESPONSE OF IMPORTS TO EXCHANGE RATE CHANGES

CHEMICALS FROM CANADA	$\hat{\mu}$	$\Sigma\hat{\mu}$	PRODUCTS FROM JAPAN	$\hat{\mu}$	$\Sigma\hat{\mu}$
BENZENE	.080 (.141)	.225 (.134)	BEARINGS	-.004 (.008)	-.002 (.010)
TOLUENE	.020 (.044)	-.070 (.087)	BICYCLES	-.001 (.009)	-.003 (.011)
BORIC ACID	.031 (.070)	.000 (.112)	BOLTS	-.007 (.009)	-.008 (.012)
PHOSPHORIC	-.215* (.081)	-.537* (.189)	NUTS	-.011 (.009)	-.006 (.011)
CARBIDE	-.219* (.050)	-.365* (.051)	SCREWS	-.052 (.030)	-.107* (.035)
URANIUM OX.	-.012 (.012)	-.018 (.017)			
METHYLENE	-.110* (.036)	.053 (.035)			
P-CHLORETH	-.057 (.038)	-.141* (.027)			
ETHYL OX.	.071 (.100)	-.111 (.088)			
PROPYL OX.	.015 (.022)	-.005 (.031)			
ACETIC ACID	.031* (.007)	.066* (.008)			

Standard errors are in parentheses.

* indicates significant at the .01 level.

Entries in the table are estimates of μ in equation 4. The lag lengths for the polynomials A(l), B(l) were set to 3. The chemicals equations were run in log levels as opposed to log first differences. The entries reported in the second and fourth columns refer to the sum of the estimated coefficients on the contemporaneous and first three lags of the ψ variable.

TABLE 2: EFFECTS OF UNCERTAINTY ON THE COEFFICIENTS FROM A TIME VARYING PARAMETER MODEL

CHEMICALS FROM CANADA	k = 1 naive	k = 1 rational	k = 3 naive	k = 3 rational
URANIUM OX.	4.37	-2.12	.833	.396
	(2.89)	(3.02)	(1.49)	(1.58)
METHYLENE	-17.1	9.29	4.96	.841
	(24.1)	(24.4)	(12.3)	(12.6)
PRODUCTS FROM JAPAN				
BEARINGS	-.013	.076	-.036	.021
	(.100)	(.099)	(.051)	(.051)
BICYCLES	-.162	.195	-.124	.025
	(.088)	(.132)	(.068)	(.073)
BOLTS	.024	.004	-.072	-.049
	(.123)	(.124)	(.063)	(.063)
NUTS	.020	.132	-.072	-.038
	(.107)	(.107)	(.055)	(.057)
SCREWS	.444	-.394	.089	.202
	(.342)	(.333)	(.175)	(.171)

Standard errors are in parentheses.

Entries in the table are estimates of ϑ in the following regression:

$$|\Delta\hat{\beta}_t| = \alpha + \vartheta\sigma_{t+k} + \sum_{j=1}^{m}|\Delta\hat{\beta}_{t-j}| + \varepsilon_t .$$

Where σ_{t+k} = the standard deviation of the kth difference of the log real exchange rate series. In the table, two values of k are chosen: k=1, and k=3; m was chosen to mitigate the effects of autocorrelation in the residuals, m=4 for all equations.