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THE MUTUAL AMPLIFICATION EFFECT OF EXCHANGE RATE VOLATILITY AND UNRESPONSIVE TRADE PRICES

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ABSTRACT

The volatility of flexible exchange rates greatly exceeds what most analysts anticipated at the advent of generalized floating. The Dornbusch overshooting model accounts for the fact that exchange rates fluctuate more than the underlying fundamentals. This paper presents a model which may help account for why exchange rates have been even more volatile than the overshooting model would suggest, and why trade prices have been so unresponsive in recent years. The paper employs an extended version of the sticky–price monetary model of exchange rates and a simple industrial organization model of import pricing. The combined macro–I.O. model shows that exchange rate volatility and unresponsive trade prices can be mutually amplifying.

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International economics in the 1980s has been heavily influenced by negative empirical results. On the monetary side, we have the puzzle of "excess" exchange rate volatility. Exchange rate volatility has increased in the 1980s and it is unclear that standard theory can account for the increase (Frankel and Meese 1987, Froot and Ito 1988). Moreover, standard theory is unable to explain exchange rate movements better than a simple random walk (Meese and Rogoff 1983). On the trade side, we have the pass–through puzzle. The sharp rise and fall of the dollar in the 1980s has not been passed through to trade prices in the manner predicted by the historical pass–through relationship (Mann 1986, Baldwin 1988a, 1988b). This unresponsiveness of import prices is in part responsible for the unexpected persistence of the US trade deficit (Hooper and Mann 1987).

This paper argues that a two–way amplification effect of sluggish trade prices and exchange rate fluctuations may help account for both the excess exchange rate volatility puzzle and the pass–through puzzle. To wit, the increased instability of exchange rates may be due, in part, to firm–level changes in the pass–through elasticities rather than commonly–considered macroeconomic changes. Similarly, an important source of the dampened pass–through elasticities observed in the U.S. in the 1980s may be found in the macroeconomic instability, rather than industry level changes. Additionally, we argue that this mutual amplification effect has strong implications for macroeconomic policy and for empirical work on both the monetary and trade sides of international economics.

The work of a number of economists suggests the excess volatility and pass–through puzzles may be inter–related. Mann (1986) conjectures that foreign firms have been reluctant to pass through currency movements to import prices because the exchange rate is so volatile. Froot and Klemperer (1987) show that in a two–period model (where second–period demand depends on first–period market share) increased uncertainty about the second–period exchange rate lowers the level of the current import price. They do not consider the effect of uncertainty on the pass–through elasticity. Thus, although the economics of the connection is not formally or informally described, Mann's, and Froot and Klemperer's work suggests that the exchange rate has so little effect on trade prices precisely because it fluctuates so much.

In his classic article Dornbusch (1976) shows that when the domestic aggregate price level is sticky, the impact of nominal money changes on the exchange rate is amplified by overshooting. Although Dornbusch does not emphasize the point in his discussion, his analytics demonstrate that the less responsive is domestic aggregate demand to the relative price of traded goods, the greater is the overshooting. In other words, Dornbusch's work suggests that exchange rate may be so volatile at least in part because the trade flows are so unresponsive to trade prices. However, Dornbusch (1976, 1980) does not consider the effect of the pass–through elasticity on exchange rate volatility; in fact 100 percent instantaneous pass–through is implicitly imposed.

Krugman (1988) presents an important idea. He suggests that not only are the puzzles related, but there is in fact a "vicious circle" between currency instability and the unresponsiveness of trade. The first half of the vicious circle argument — the contention that exchange rates fluctuations are large because the trade balance is unresponsive to exchange rates — is not modelled. Krugman's informal exposition of this contention is based on the income–elasticity approach to the balance of payments. If trade were highly responsive, Krugman argues, large swings in the dollar would produce trade balance changes that would themselves limit the size of the currency swings. For instance, in the polar case of perfectly responsive trade, the instantaneous international arbitrage of goods removes the possibility of any real appreciation or depreciation (i.e., the law of one price holds).

The second half of the circle is the contention that exchange rate volatility increases the unresponsiveness of trade. This argument is based on the sunk entry cost model (Baldwin 1986, 1988a) of hysteresis in trade. The existence of sunk entry costs creates a range of exchange rates within which foreign firms neither enter nor exit the domestic market. In the version of this model that Krugman refers to (Dixit 1987), the no–exit–no–entry range widens with increased exchange rate volatility. Thus, in some sense, trade becomes less responsive to the exchange rate as the exchange rate becomes more volatile.

The use of the income–elasticity approach as an exchange rate theory is problematic. The exchange rates of major industrial countries are generally thought to be determined by asset market conditions. Krugman's application of the Dixit analysis is similarly troublesome. Dixit's analysis requires that firms expect the exchange rate to evolve over time as a continuous–time random walk. This assumption is inconsistent with standard asset market equilibrium conditions such as uncovered interest parity. For instance, suppose the dollar interest rate is lower than the deutschemark rate; if risk neutral investors are to be willing to hold dollars they must expect the dollar to appreciate vis–a–vis the mark. This is not consistent with the random–walk–with–trend assumption, since the interest gap is expected to change over time.

This paper shows that there can be a mutual amplification effect between exchange rate volatility and unresponsive trade prices. The mechanisms we focus on are entirely distinct from those in Krugman (1988), Dornbusch (1976, 1980), and Dixit (1987). First, we extend the standard sticky–price monetary model of exchange rates to include a non–unitary pass–through elasticity, and show that the exchange rate volatility caused by a given money supply process is amplified by a reduction in the pass–through elasticity, in section I.

Second, we formally model the impact of exchange rate fluctuations on the pass–through elasticity (in section II). If there is persistence in consumers' purchase patterns, changes in current prices affect future profits. In this case, we show that greater exchange rate variance reduces the pass–through of exchange rates to import prices. Finally we combine the exchange rate macro model with the industrial organization pass–through model to show that exchange rate volatility and unresponsive trade prices are mutually amplifying.

The models in this paper are not intended to be complete, general descriptions of the world economy. Rather, they are highly simplified to focus on the basic economic logic of our theoretical argument.

I. Unresponsive Trade Prices Amplify Exchange Rate Volatility

This section employs a sticky–price monetary model of exchange rate determination to investigate the effect of a change in pass–through elasticity on exchange rate volatility. Two important points deserve mention at this juncture. First, in the standard model, the link between exchange rate movements and changes in the domestic price level is parameterized only by the import and export demand elasticities, and 100 percent instantaneous pass–through is assumed. However, import and export demand elasticities have been stable in the U.S. since the 1960's (Hooper and Mann 1987). Pass–through elasticities, on the other hand, have shifted in the 1980's in both the U.S. (Mann 1986, Baldwin 1988a, Feinberg 1987) and in Japan (Yamawaki 1988). Clearly then, any model of the circularity between volatility and unresponsive trade should be based on changes in the pass–through elasticity, not the demand elasticities.

The second of the two points concerns the specification of the underlying monetary uncertainty. Below we consider a simple random walk money supply process. This choice both simplifies the analytics and generates a result that is robust to far more complicated and realistic specifications. This robustness is important in light of recent work by Lyons (1988). He demonstrates that when money growth rates are unknown and agents update their beliefs using the observable stock then stock innovations are likely to have a much more powerful effect on the exchange rate than simple specifications would predict. Additionally, the Lyons (1988) results breathe new life into the potential empirical relevance of the sticky–price monetary model in that past tests, by neglecting the role of growth rate expectations, involve serious mis–specifications.

The structure of the model, described by the following equations, is quite simple so as to focus on the role of the pass–through elasticity in the adjustment process:

(1.1)	${}_te_{t+1} - e_t = i_t - i_t^*$	Uncovered Parity
(1.2)	$m_t - w_t = -\lambda i_t$	LM Curve
(1.3)	$w_{t+1} - w_t = \delta(p_t - w_t) - \gamma(e_t - w_t)$	Price Adjustment
(1.4)	$p_t = \phi e_t$	Import Pricing
(1.5)	$m_t = m_{t-1} + \epsilon_t; \quad \epsilon \sim N(0, \sigma_\epsilon^2)$	Money Process

where e is the log nominal exchange rate, i is the nominal interest rate, m is the log nominal money stock, w is the log price of domestically–produced goods, p is the log domestic price of foreign goods, and ϕ is the import price pass–through elasticity. Relevant information sets correspond to the timing of the variables except where specified.

If one assumes rational expectations and saddle–path stability, then equations (1.1) through (1.5) imply a saddle path of the form:

(1.6) $$e_t = Aw_t + Cm_t$$

where

$$A \equiv \left[\frac{1}{\lambda(\eta-1)}\right]$$

$$C \equiv \left[\frac{1}{\phi} - \left[\frac{1}{\lambda(\eta-1)}\right]\right]$$

$$\eta \equiv \frac{(2-\delta-\gamma)-\left[(2-\delta-\gamma)^2-4\left[(1-\delta-\gamma)-(1/\lambda)(\delta\phi+\gamma)\right]\right]^{1/2}}{2}$$

and $\eta < 1$.

Since w_t is predetermined the saddle–path coefficient on m_t, C, determines the impact effect of innovations in the nominal money stock on the nominal exchange rate. Accordingly, we can write:

$$\frac{\Delta e}{\Delta m} = C(\phi)$$

where $dC/d\phi < 0$. The conditional variance of the nominal exchange rate is thus a simple function of the underlying monetary uncertainty and is decreasing in ϕ:

(1.7) $$\text{Var}[e_t - E(e_t|\Omega_{t-1})] \equiv \sigma_e^2 = C(\phi)^2\sigma_\epsilon^2$$

where Ω_t is the set of information available at time t.

The result that the pass–through elasticity and the conditional variance are inversely related is not an artifact of the very simple structure of the model. This simplicity manifests itself primarily in four ways: (1) output is constant (and normalized to zero); (2) aggregate demand depends only upon import and export demands; (3) pass–through elasticity on the export side is constant; and (4) money follows a simple random walk. The model could be richer along each of these four lines without altering the basic result. For example, while allowing output adjustment might reduce the saddle–path coefficient on m_t (C) below one, as Dornbusch (1976) points out, the derivative of this coefficient with respect to ϕ will remain negative since other things equal the lower pass through still slows the domestic price level adjustment. Similar reasoning holds for standard, more complete specifications of aggregate demand.

II. Exchange Rate Volatility Amplifies the Unresponsiveness of Trade Prices

The mechanism by which currency volatility reduces the pass–through elasticity cannot be a simple extension of the elementary theory of the firm. The crux of the problem is that foreign firms' cost functions, measured in dollars, are by definition linear in current and future exchange rates. Consequently in elementary models, the dollar–pricing decision of a risk neutral firm incorporates only the expectation of exchange rates — not the variance of the exchange rate (or higher moments). This argues that we must look beyond the basic theory of the firm to understand how currency fluctuation dampens pass–through.

A. Persistence in Peoples' Purchases Patterns

For many types of goods, consumers tend to buy this period from the same firms that they bought from last period. The theoretical literature explaining and analyzing this phenomenon is quite extensive (Phelps and Winter 1970; Nelson 1970; Okun 1975; Katz and Shapiro 1985; Gottfries 1985; Klemperer 1987; Froot and Klemperer 1988). In models marked by such persistence, a firm's current price reflects the impact that the current price has on expected future profits. Since a foreign firm's profit function is convex in the exchange rate (profit functions are convex in prices), persistence in purchase patterns opens up the possibility that the exchange rate volatility affects the import pricing behavior.

Persistence in purchase patterns could stem from a wide variety of sources. Phelps and Winter (1970) emphasize search costs faced by consumers. Nelson (1970) focuses on consumers' uncertainty about the quality of alternative products. Okun (1975) discusses the role of firm–customer relationships. Katz and Shapiro (1985) stress network externalities. Klemperer (1987) and Froot and Klemperer (1988) stress the importance of switching costs.

B. The Model

The basic point of such persistence is that current sales depend upon previous period variables over which firms have some control. There is no general agreement on which previous period variable to focus upon. Market share, sales, customer stock, contracts and price could all conceivably be important in quantifying persistence in purchase patterns. In fact it is easy to think of situations where current sales would depend upon expected future sales, market shares or price as well (e.g., products with significant network externalities).

In this paper we assume that current sales depend upon previous period price, in addition to the price charged in the current period. We fully recognize that this assumption is not the only possible choice, nor is it the most general. Nevertheless, it captures the basic effect of persistence in purchase patterns and greatly simplifies the analysis. Specifically, we assume that sales in period t+1, x_{t+1}, depend upon the price both in period t+1 and in period t:

(2.1) $$x_{t+1} = x[p_{t+1}, p_t], \text{ for all } t.$$

We use an indefinite horizon setup in order to integrate the demand persistence effect into our macro model. Given equation (2.1) the problem of a foreign monopolist choosing the home–currency price of its sales to the home market is:

$$(2.2) \qquad \max_{\{p_t\}} E\{ \sum_{t=0}^{\infty} \delta^t \pi[p_t, p_{t-1}, s_t] \},$$

where,

$$\pi[p_t, p_{t-1}, s_t] = (p_t - s_t c_t)\, x[p_t, p_{t-1}].$$

Here s_t is the level of the nominal exchange rate, c_t is the constant marginal cost in foreign–currency terms. Assuming the firm takes as given the prices of all other goods as well as p_{t-1} and observes s_t before choosing p_t, the typical Euler equation for this problem is:

$$(2.3) \qquad \frac{\partial \pi[\hat{p}_t, p_{t-1}, s_t]}{\partial p_t} + \delta E\{ \frac{\partial \pi[\hat{p}_{t+1}, \hat{p}_t, s_{t+1}]}{\partial p_t} \} = 0$$

The expectation in (2.3) is conditioned on all information available at time t. The full solution to (2.2) would define a function which gives $\hat{p}_{t+i}$ ($i=0,\ldots\infty$) as a function of s_{t+i} and p_{t+i-1}. Consequently, in (2.3) $\hat{p}_{t+1}$ is a function of s_{t+1} and $\hat{p}_t$.

C. Exchange Rate Volatility and Pass–Through Behavior

The principal goal of this section is to determine the effect of a change in exchange rate volatility on the pass–through of exchange rates to import prices. Totally differentiating (2.3) with respect to p_t and s_t allows us to define the pass–through derivative, dp_t/ds_t, as a function of p_t, s_t and the density function of the one period ahead exchange rate, s_{t+1}. At time t, we assume that s_t is already known. The period t+1 exchange rate, however, is a random variable. A convenient way to represent an increase in exchange rate volatility is to consider a family of densities of s_{t+1}, $f[s_{t+1},r]$, where increases in the index r represent mean–preserving spreads (MPS). Rothschild and Stiglitz (1970) show that an MPS of the distribution of a random variable is equivalent to adding white noise to the random variable. Operationally, we differentiate the function which defines dp_t/ds_t with respect to the index r. The object then is to sign the derivative, $\frac{d(dp_t/ds_t)}{dr}$.

Since the first order condition involves first derivatives, the total derivative involves first and second derivatives. Consequentially, the derivative of the pass–through relationship with respect to r involves first, second and third derivatives of the period t demand function and period t+1 profit function. Unfortunately, there exists little economic reasoning that allows us to sign third derivatives. One way of dealing with this problem is to proceed with the formal analysis, simply assuming that the third derivatives have the signs necessary to produce the desired overall sign.

In this paper we take what we think is a more straightforward approach. We make assumptions on the functional form of the demand equation (2.1) that insures that all third derivatives are zero. Specifically we assume that the function is separable in p_{t+1} and p_t, and that the contemporaneous price enters linearly:

(2.4) $$x_{t+1} = x[p_{t+1}]h[p_t], \text{ for all } t$$

where,

$$x[p_{t+1}] = a - bp_{t+1}, \text{ and}$$

$$h[p_t] > 0,\ h'[p_t] < 0,\ h''[p_t] < 0, \text{ and } h'''[p_t] = 0.$$

With these assumptions the pass–through derivative is:

$$(2.5) \qquad \frac{dp_t}{ds_t} = \frac{c_t bh[p_{t-1}] + \delta h'[p_t] \frac{\partial}{\partial s_t}(E\Psi[s_{t+1}])}{2bh[p_{t-1}] - \delta h''[p_t]E\Psi[s_{t+1}]}$$

where,

$$\Psi[s_{t+1}] = \pi[p_{t+1}, p_t, s_{t+1}]/h[p_t] = (p_{t+1} - c_{t+1}s_{t+1})x[p_{t+1}]$$

It is important to note that the $\Psi[s_{t+1}]$ function is convex in s_{t+1} since the profit function $\pi[s_{t+1}]$ is convex in s_{t+1} and $h[p_t]$ is positive.

For convenience we refer to the numerator and denominator of (2.5) as N and D. It is easy to show that both N and D are positive since we show below that $\partial E\Psi/\partial s_t$ is negative. Differentiating (2.5) with respect to r, we have:

$$(2.6) \quad \frac{d}{dr}\left(\frac{dp_t}{ds_t}\right) = D^{-2}\left(D\frac{d}{dr}\left[\delta h'[p_t]\frac{\partial}{\partial s_t}E\Psi[s_{t+1}]\right] + N\frac{d}{dr}\left[+\delta h''[p_t]E\Psi[s_{t+1}]\right]\right)$$

The sign of (2.6) depends on the signs of the two terms $\frac{d}{dr}\left[\delta h'[p_t]\frac{\partial}{\partial s_t}E\Psi[s_{t+1}]\right]$ and $\frac{d}{dr}\left[-\delta h''[p_t]E\Psi[s_{t+1}]\right]$.

We turn first to the second term, $\frac{d}{dr}\left[\delta h''[p_t]E\Psi[s_{t+1}]\right]$. To evaluate this term we must investigate the distribution of s_{t+1}. Given our macro model, the ratio of the s_{t+1} and s_t is a random variable, $s_{t+1}/s_t = u$. Uncovered interest parity requires that the conditional expectation of u equals the ratio of the (gross) nominal rates of return on home and foreign currencies. Since s_t is pre–determined we can write $s_{t+1} = s_t u$. Recalling that $h'''[p_t]$ is zero, the second term can be written as:

$$(2.7) \qquad \delta h''[p_t] \int_{u=0}^{\infty} \Psi[s_t u] \frac{\partial f}{\partial r}(u,r)du.$$

The variable u cannot be negative since the exchange rate cannot be negative. To determine the sign of this term we apply standard Rothschild and Stiglitz (1970) techniques. Integrating (2.7) by parts twice, and using the facts that $T[0] = T[\infty] = 0$, and $T[x] \geq 0$, for $0 \leq x < \infty$, where $T(x) = \int_0^x \frac{\partial f}{\partial r}(z,r)dz$, we get:

$$(2.8) \qquad \delta h'' \int_0^{\infty} \Psi[s_t u] \frac{\partial f}{\partial r}(u,r)du = \delta s_t^2 h''[p_t]\left(\int_0^{\infty} \Psi_{uu}[s_t u]\left[\int_0^u f_r[z,r]dz\right]du\right),$$

Given that $T(x) \geq 0$, this term is negative since Ψ is convex in s_{t+1} and $h''[\cdot]$ is negative.

Next we address the first term in (2.6). The optimal p_t depends upon r as well as s_t so the first term in (2.6) can be written as:

$$(2.9) \; \frac{d}{dr}\left[\delta h'[p_t]\frac{\partial}{\partial s_t} E\Psi[s_{t+1}]\right] = \delta\left[h''[p_t]\frac{dp_t}{dr}\frac{\partial}{\partial s_t}(E\Psi[s_{t+1}]) + h'[p_t]\frac{\partial^2}{\partial s_t \partial r} E\Psi[s_{t+1}]\right]$$

By totally differentiating (2.3) with respect to p_t and r, we can define dp_t/dr. Noting that profits in period t+1 are convex in s_{t+1}, standard Rothschild–Stiglitz (1970) techniques can be uses to show that dp_t/dr is negative.

Since $h''[p_t]$ is negative, the sign of the first term on the right hand side of (2.9) depends on the sign of $\frac{\partial}{\partial s_t} E\Psi[s_{t+1}]$. The expectation here is conditioned on s_t, so this partial is equal to $dE(\Psi[s_{t+1}]\,|\,s_t)/ds_t$. Intuitively this is negative since according to our macro model if s_t increases, the s_{t+1} that is expected to occur is also higher. Since a higher exchange rate is detrimental to importer's profits, the expected profits should be revised downward when a higher s_t is observed. Formally,

$$(2.10) \qquad dE(\Psi[s_{t+1}]|s_t)/ds_t = \int_u \Psi'[s_t u]u\ f(u)\ du.$$

It is clear that (2.10) is negative since $\Psi'[s_t u]$ is negative and u and f(u) are non–negative.

The second term in (2.9) is negative, if $\frac{\partial^2}{\partial s_t \partial r} E\Psi[s_{t+1}]$ is positive. This expression can be written as:

$$(2.11) \qquad \int_u \Psi'[s_t u]u \frac{\partial f}{\partial r}(u,r)\ du.$$

By standard Rothschild and Stiglitz (1970) techniques, this integral is positive if the function $\Psi'[s_t u]u$ is convex in u. This in turn is true if $(2s_t \Psi''[s_t u] + us_t^2 \Psi'''[s_t u])$ is positive. Applying our approach of assuming third derivatives are zero, this sum is positive since $\Psi[\cdot]$ is convex in s_{t+1}.

This finishes our demonstration that (2.6) is negative. In other words, the pass–through derivative is decreasing in the conditional variance of the exchange rate.

Most empirical studies of pass–through behavior assume that the pass–through elasticity is constant. To facilitate the integration of the above I.O. model into the macro model, we assume that the pass–through elasticity does not vary with price. With this assumption the fact that $d(dp_t/ds_t)/dr$ is negative implies that the pass–through elasticity is decreasing in r. Assuming that s_{t+1}'s distribution can be characterized by two parameters, there is a one–to–one correspondence between a mean–preserving spread and the conditional variance of the exchange rate, σ_e^2. Thus we write the pass–through elasticity, ϕ, as a function of σ_e^2:

(2.12) $$\phi \equiv \frac{dp_t}{ds_t}\frac{s_t}{p_t} = g[\sigma_e^2]$$

where $$g'[\sigma_e^2] < 0.$$

III. Mutual Amplification

Section I demonstrates that the conditional variance of the exchange rate is inversely related to the pass–through elasticity. The model which generates this result is a simplified version of the standard sticky price monetary model. Despite its wide acceptance, this model can be criticized for the fact that it is not couched wholly in maximizing behavior. This fact, apart from detracting from its intellectual elegance, implies that the model's parameters are not necessarily structural parameters.

The most satisfactory solution would be to derive a general equilibrium exchange rate model from first principles. However, such efforts (Lucas 1982, Stulz 1984, Svensson 1985) have been unable to produce models capable of accounting for short and medium run behavior of exchange rates. Essentially, exchange rate determination in these models results from the law of one price together with market determination of traded goods prices. While these models help clarify our thinking about some long–run issues, they are not very useful in thinking about problems such as the excess volatility puzzle. In a sense, these efforts to clean up exchange rate theory end up throwing the baby out with the bath water. In this paper we take an intermediate approach.

A. Putting the Models Together

As mentioned in the introduction, there is widespread empirical evidence that one of the key parameters in the sticky–price monetary model (the responsiveness of trade via the pass–through elasticity) has shifted significantly in the 1980s. This empirical fact implies that the ad–hoc nature of the sticky-price monetary model is particularly inappropriate in regard to import pricing behavior. The section II model is an attempt to clean up the ad hoc nature of the model with respect to import pricing. The industrial organization model allows us to explicitly recognize that one important parameter of the exchange rate model is in fact endogenously determined.

Equation (1.7) summarizes the connection between the conditional variance of the exchange rate and the variance of unforecastable changes in nominal money. Equation (2.12) details the dependence of pass–through behavior on the volatility of the exchange rate. Together (1.7) and (2.12) constitute a simultaneous system of equations in σ_{ϵ}^2, σ_e^2 and ϕ. Analysis of the equilibrium is facilitated by Figure 1. Here we plot (1.7) as EE and (2.12) as PT in σ_e^2, ϕ space. Stability of the equilibrium requires that the PT curve is steeper than the EE curve in the neighborhood of the equilibrium point, A^0.

B. An Increase in Volatility of Money Stock Changes

If there is an increase in the variance of unforecastable money changes, the EE schedule shifts up. The impact effect is governed by equation (1.7), which implies that the shift is C^2 times the change in the variance. The shifted schedule is depicted as the EE' in figure 1.

To fix ideas, consider the standard model where the increased volatility engenders no endogenous change in the pass–through elasticity. In this case the new equilibrium would be at point A'. The new exchange rate variance would be $\sigma_e^{2\prime}$. However if there is persistence in purchase patterns, the increased uncertainty leads firms to reduce the degree to which they pass–through contemporaneous exchange rate changes to import prices. Thus the increased exchange rate volatility lowers exchange rate pass–through. As a result the initial increase in money stock uncertainty is subject to a multiplier process.

In other words, increased monetary volatility increases exchange rate volatility according the overshooting–model dynamics. The amplified exchange rate swings, however, dampens the pass–through elasticity. This reduced pass–through, in turn, boosts the volatility–amplifying effects of the overshooting–model. A new equilibrium is reestablished at point A''.

This is the main result of the paper. Any increase in the volatility of underlying shocks is amplified in the usual manner by the dynamics of the sticky–price monetary model. We have shown that the magnitude of this overshooting–amplification depends inversely on magnitude of the pass–through elasticity. The magnitude of pass–through elasticity, however, depends inversely on the exchange rate volatility. Clearly then exchange rate volatility and unresponsive trade prices are mutually amplifying.

The consequences of this mutual amplification are clear. The standard sticky–price model (which takes the responsiveness of trade as constant) would predict that a one percent increase in monetary shocks would lead to a C^2 percent increase in the conditional variance of the exchange rate. Our model suggests that an increase in underlying uncertainty can lead to a greater, possibly much greater, increase in exchange rate volatility, together with a dampened pass–through elasticity.

IV. Discussion and Conclusions

The mutual amplification result was derived in the context of a highly simplified exchange rate model and a highly simplified I.O. model of import pricing. We conjecture, though, that the result could be obtained in a broad class of models. We first discuss the exchange rate side. Exchange rates are relevant to trade in both goods and assets. Exchange rate models place varying degrees of importance on the two types of trade. Nonetheless the balance of trade in goods is implicitly or explicitly the ultimate anchor in any model of exchange rates. If the responsiveness of merchandise trade flows to exchange rates is dampened, it seems likely that increased exchange rate volatility will be the result.

On the pass–through side, our result that increased exchange rate volatility leads to lower pass–through is likely to go through in a broad class of models. Models allowing for persistence in purchase patterns is only one class of models in which volatility might reduce the responsiveness of trade prices. For instance, any model in which firms solved a signal extraction problem would probably give such a result. Suppose firms face a one period delivery lag so that current imports are determined before the current exchange rate is known. If the firms knew the exchange rate model but were faced with an unobservable parameter in the money supply process, an optimal forecast of the exchange rate would involve a signal extraction problem. In such problems the information content of the exchange rate varies inversely with the volatility of the underlying uncertainty. Clearly then the more volatility the exchange rate is, the less responsive import prices would be to the current exchange rate.

Conclusions

Flexible exchange rates have been much more volatile than anticipated at the advent of generalized floating. The Dornbusch (1976) overshooting model provides an explanation for why flexible exchange rates fluctuate more than the underlying fundamentals (such as monetary and fiscal policy). The mutual amplification effect provides one possible explanation for the fact that exchange rates have been even more volatile than the overshooting model suggests. This paper explains how even small increases in the unpredictability of monetary and fiscal policy can have potentially very large costs in terms of increased exchange rate instability.

The mutual amplification result has several strong implications for empirical work in international economics. First, it argues that the separate estimation of exchange rate models and pass–through equations is inappropriate. On the monetary side, empirical tests of exchange rate models typically assume that the regression parameters are stable. The section II model demonstrates that one of the "structural" parameters (the pass–through elasticity) can vary systematically with changes in monetary uncertainty. Moreover, the nature of structural shift cannot be captured by a simple dummy variable, since the pass–through elasticity varies smoothly with the conditional variance of the exchange rate. On the trade side, the estimation of pass–through equations based on partial equilibrium models can lead to serious mis–specification. Section IV points out that the pass–through elasticity and the exchange rate process are jointly determined.

One policy implication of the mutual amplification result is that attempts to manage exchange rates via monetary policy coordination would be facilitated by a reduction of monetary surprises. In other words, monetary coordination should pay attention to the conditional variances as well as the conditional means of monetary aggregates.

On the trade policy side, the mutual amplification effect implies that dumping can be a perfectly rational, non–predatory, response to increased exchange rate instability. Indeed the model predicts that we should observe a correlation between violations of anti–dumping laws and exchange rate instability.

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Figure 1: The Mutual Amplification Effect