# Understanding Exchange Rate Volatility without the Contrivance of Macroeconomics
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**Abstract**

Exchange rate regimes differ primarily by the noisiness of the exchange rate, not observable macroeconomic "fundamentals." Fixed exchange rates are typically stable and floating exchange rates are volatile, but macro phenomena are regime-independent. Fundamentals only seem to be relevant for exchange rates at low frequencies or when inflation is high. A basic task of international finance is explaining these cross-regime differences in exchange rate volatility. The evidence suggests that a switch in exchange rate policy is accompanied by a change in market structure; macroeconomic considerations are superfluous. We formalise this observation in a non-linear model with multiple equilibria.

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Floating exchange rates are volatile. This is surprising. In making his celebrated case for flexible exchange rates, Friedman (1953) argued:

> " … instability of exchange rates is a symptom of instability in the underlying economic structure … a flexible exchange rate need not be an unstable exchange rate. If it is, it is primarily because there is underlying instability in the economic conditions … "

Friedman's argument is that exchange rate instability is a *manifestation* of economic volatility. Exchange rate regimes differ in the mechanisms through which this underlying volatility is channelled. For instance, "money supply" or "liquidity" shocks affect the nominal exchange rate when rates float, but the money supply if rates are fixed. Underlying systemic volatility cannot be *reduced* by the regime, only *channelled* to one locus or another. The economy can be thought of as a balloon; squeezing volatility out of one part merely transfers the volatility elsewhere.[i]

For over a decade economists have known that floating exchange rates are more variable than fixed rates (evidence is provided below). But if the underlying "fundamental" volatility does not change across regimes, flotations of fixed exchange rates should only lead to *temporary* increases in exchange rate turbulence.

Perhaps floating rates are variable because of higher underlying economic instability? After all, the exchange rate regime is *chosen* by the policy authorities. Unfortunately, there is remarkably little evidence of a systematic relationship between the exchange rate regime and measurable macroeconomic phenomena, at least for low- and moderate-inflation countries at high- and medium-frequencies. A number of researchers have shown formally that the variability of observable macroeconomic variables such as money, output, and consumption do not differ systematically across exchange rate regimes (references are provided below). In any

case, it is simply hard to believe that the post-1973 (floating) era has been so much more volatile from a macroeconomic perspective than the pre-1973 (fixed) period.[ii]

Simply put, to a first approximation countries with fixed exchange rates have less volatile exchange rates than floating countries, but macro-economies that are equally volatile.

This stylised fact is inconsistent with theories that model both the exchange rate and the exchange rate regime as manifestations of underlying economic shocks. Unsurprisingly, such theories have performed poorly when applied to the data. Neither the exchange rate nor the exchange rate regime seems to reflect observable economic shocks. There are exceptions – countries with high inflation – and the theories do work better at long horizons. But at short- and medium-frequencies, the exchange rates of low-inflation countries are almost unrelated to macroeconomic phenomena.[iii] By choosing the exchange rate regime, policy thus has an important effect on exchange rate volatility, but not on the volatility of traditional macroeconomic fundamentals.

The observation that exchange rate volatility differs systematically in the apparent absence of corresponding differences in economic volatility is hard to understand in linear macroeconomic models. In this paper, we explore one potential explanation; non-linear models with multiple equilibria.

**1: Is the Stage Set?**

The vehicle we use to frame our discussion is a completely standard model of the foreign exchange market. This monetary model allows us to explore the trade-off between exchange rate and macroeconomic volatility in a transparent fashion.

We keep the model simple.  It consists merely of an asset market equilibrium and a purchasing power parity (PPP) condition:

$$m_t - p_t = \beta y_t - \alpha i_t + \varepsilon_t \tag{1}$$

$$p_t = e_t + p^*_t + v_t$$

(2)

where: $m_t$ is the domestic stock of money at time t; p is the price level; y is real output; i is the interest rate (level), e is the domestic price of foreign exchange; $\alpha$ and $\beta$ are parameters, an asterisk represents a foreign variable; all variables (except interest rates) are expressed as natural logarithms, $\varepsilon$ is a shock to the money market; and v is a stationary deviation from PPP.  It is important to note that the model is structural, so that the parameters and shocks are not policy-dependent.

We assume there is an identical foreign analogue to (1).  Subtracting it from (1) and substituting in (2), we arrive at:

$$e_t = (m-m^*)_t - \beta(y-y^*)_t + \alpha(i-i^*)_t - (\varepsilon-\varepsilon^*)_t - (v-v^*)_t \tag{3}$$

which expresses the exchange rate as a function of macroeconomic "fundamentals," namely differentials of money, output, interest rates and shocks.

Equation (3) implies a volatility trade-off.  If the exchange rate is fixed, then ($\varepsilon$ or v) shocks make money, output or interest rates volatile.  If the exchange rate floats cleanly, then the same shocks create exchange rate movements.[iv]  Expressed alternatively, volatility in the

exchange rate – the left-hand side of (3) – should mirror fundamental macroeconomic volatility of the right-hand side.

**2: Just The Fact**

Unfortunately, our simple macroeconomic model does not capture even the grossest features of the data. We focus on one key feature; the volatility of the different sides of equation (3). If the model works well, these should be similar. In reality though, exchange rate volatility (the left side) varies systematically and dramatically across exchange rate regimes, while observable macroeconomic volatility – its counterpart on the right – does not. That is, *macroeconomics is an inessential piece of the exchange rate volatility puzzle*, as we show in this section.

To the best of our knowledge, this stylised fact is uncontroversial. Indeed, we are at pains to show that our belief is consistent with conventional wisdom and is not particularly sensitive to measurement issues. The supporting literature uses univariate and multivariate data, both structural and non-structural, cross-sectional and time-series.

*New Stuff*

First, though some direct evidence. We test the model by comparing the left- and right-hand sides of equation (3).

Measuring the left-hand side of equation (3) is trivial, since exchange rates are among the most accurately measured economic data available. The right-hand side is more tricky. There are two potentially serious complications. The first issue is the unknown parameters. We could directly estimate $\alpha$ and $\beta$, but choose simply to use plausible values from the literature (unity for

both the income elasticity and the interest semi-elasticity of money demand).  In Flood and Rose

(1995), we show that our argument holds for a very wide range of reasonable parameter values.

The second issue is the unobservable nature of the money market and price disturbances

terms.  In Flood and Rose (1995), we estimate these directly, and substitute in the estimates.

Setting the disturbances to their unconditional values (of zero) leads to very similar results.  The

reason is simple; since the disturbances are structural, there is little reason why they should differ

with the exchange rate regime.  For the same reason, measurement error of money and output is

an unimportant problem.

We provide two kinds of evidence.  First, we compare the volatility of the left- and right-

hand sides of equation (3) for a number of different countries.  We ask "Do countries with

volatile exchange rates also have high macroeconomic volatility?"  This test exploits *cross-

country* evidence from a given period of time, and is thus immune to *time-specific* effects like oil

prices.  The evidence is contained in Fig. 1, which contains standard deviations of exchange rates

(e) and macroeconomic fundamentals $[(m-m^*)-(y-y^*)+(i-i^*)]$ for eighteen industrialised

countries.  The quarterly data begins with the European Monetary Systems in 1979 and extends

through 1996.  Germany is the centre country; we use M1, real GDP, and short interest rates.

Fig. 1 shows clearly that there are enormous differences in exchange rate volatility across

countries.  Some countries (the Netherlands and Austria) pegged tightly to the Deutschemark

through the period; others (Australia, Canada) floated freely and had exchange rates an order of

magnitude more volatile.  But these differences are essentially unrelated to those in

macroeconomic fundamentals.  Both stable and unstable exchange rates are consistent with

similar macroeconomic volatility.[v]

A different tactic is to examine both sides of equation (3) for a number of different countries *over time*. We can then ask "Do periods of volatile exchange rates coincide with periods of macroeconomic volatility, for a given country?" Since we examine different periods of time for a given country, we are safe from geographic, institutional and other *national* effects.

The time series evidence is in presented in Figs. 2 and 3. These use quarterly data for twenty OECD countries from 1959 through 1996. Fig. 2 is a set of time-series plots of the percentage change in the exchange rate; Fig. 3 is the analogue for the macroeconomic fundamentals on the right-hand side of equation (3). To demonstrate that our results are insensitive to the exact way we measure things, we use the United States as the centre country, the monetary base, and industrial production.

A glance at Fig. 2 shows clearly that dollar exchange rate volatility has dramatically increased following the collapse of the Bretton Woods period in the early 1970s. But there is no comparable change in the behaviour of the macroeconomic fundamentals plotted in Fig. 3. Indeed, these are broadly comparable during the Bretton Woods and post-Bretton Woods era, an ocular finding which is formally verified in Flood and Rose (1995).[vi]

This evidence might appear to depend on the exact specification of the structural model in (1) and (2). But that appearance would be deceptive. Traditional macroeconomic models of the exchange rate – and indeed most asset prices – generate equations like (3). Different assumptions (e.g., allowing for sticky prices, more complex asset market conditions, and so forth) only change the nature of the right-hand side variables, as we show in Flood and Rose (1995). Changing the specification of the right-hand side of (3) does not alter the striking contrast between Figs. 2 and 3 unless one can add a variable which behaves completely

differently during regimes of fixed and floating.[vii] Does such a beast exist? Not from our reading of the literature.

### *Received Wisdom*

Mussa (1986) established convincingly that nominal and real exchange rate variability changes substantially and systematically with the exchange rate regime. Mussa used bilateral dollar exchange rates for a variety of industrial countries from 1957-84 to show that the variance of real exchange rates is an order of magnitude greater in the floating period after the Bretton Woods period than it was during the Bretton Woods regime of pegged rates.[viii] In his published comment on Mussa, Black argued that "empirical workers in the field of exchange rates will not regard this as new information" and cites work which precedes Mussa's.[ix] Mussa's evidence is especially convincing to us for two reasons. First, it is undisputed, at least to our knowledge. Second, the objective of Mussa's paper is unrelated to ours.[x]

Baxter and Stockman (1989) extended Mussa's work on exchange rates to other macroeconomic variables. Using data for a variety of both OECD and developing countries, Baxter and Stockman examine the variability of output, trade variables, and both private and government consumption, using different de-trending techniques. They find they are

> "unable to find evidence that the cyclic behaviour of real macroeconomic aggregates depends systematically on the exchange-rate regime. The only exception is the well-known case of the real exchange rate."

Flood and Rose (1995) performed similar cross-country volatility analysis with nominal *effective* exchange rates, money, output, interest rates, inflation and stock markets and found comparable results; Rose (1994) provides related evidence.

It is easy to summarise.  Exchange rate volatility differs with the exchange rate regime.
Macroeconomic volatility doesn't.  To our knowledge, no one has identified macroeconomic
fundamentals that exhibit dramatically different volatility across exchange rate regimes *other
than the exchange rate*.

**3: Just Who *is* the Prince in Hamlet?**

Our empirical finding is undisputed; but it is not without content.  It is grossly at odds
with equation (3), and indeed all similar models that generate exchange rate volatility from
macroeconomic volatility.  To put it baldly, macroeconomics appears to be irrelevant in
explaining high- and medium-frequency exchange rate dynamics for low inflation countries.
One could contrive to make macroeconomics relevant in standard models, but that would be …
contrived.

Perhaps in hindsight this is unsurprising.  Still, researchers working in the early 1970s
surely supposed that since the monetary approach to the balance of payments (MABP) had
succeeded on the pre-1974 industrial-country data set (e.g., Frenkel and Johnson, 1976), its
fraternal twin the monetary approach to the exchange rate (MAE) would perform well during
floating.  Yet since at least Meese and Rogoff (1983) the MAE has been viewed as one of the
more dismal failures in modern economics, as discussed in Rogoff's contribution to this
symposium.

Of course the MAE does have its good points.  It performs fairly well when inflation is
high.  It also works better at low frequencies; PPP works much better over decades than over
quarters.  But for industrial countries pairs at business cycle frequencies, MAE is a major
disappointment.  The monetary approach is unable to explain the evolution of a flexible

exchange rate, even retrospectively. And as we have seen here, it cannot even come to grips with the difference between fixed rates and flexible rates.

Part of the reason economists have had so much trouble understanding foreign exchange markets is that they have largely ignored the most dramatic and possibly information-laden evidence – the regime switches. We suggest a research strategy that picks up on the few facts that we *do* know, in particular the contrasting behaviour across exchange-rate regimes. Instead of searching for the Holy Grail of macroeconomic differences, a more promising direction is to model the market structure as changing with the exchange rate regime. The policy switch between fixed and flexible exchange rates entails *an essential shift in market structure* across regimes; one need not fixate on mystical macroeconomics.

Let us begin.


### *A Formal Entrée*

The evidence presented above is a persuasive demonstration, at least to us, that the *structure* of the foreign exchange market depends on the exchange rate regime. That expectations are policy-dependent is familiar from rational expectations methodology. We refer to something different. The parameters in structural asset market equations, the shocks to these equations, and perhaps even the very identity of foreign-exchange market participants seem to be regime-dependent.[xi]

We think the money market is an inappropriate place to focus energy. There is simply not much action there (under normal circumstances), and, as we have seen, conditions do not change much across regimes. We therefore concentrate our attention on international financial markets themselves. We begin with a portfolio balance equation:

$$i_t = i^*_t + [E_t(e_{t+1}) - e_t] + z \cdot V_t(e_{t+1})(c + b - b^* - e + \delta)_t$$

(4)

where: $E_t(\cdot)$ denotes an expectation conditional on information available at t; z is a constant, proportional to the aggregate risk-aversion parameter in a mean-variance utility function (z=0 in the risk neutral case); $V_t(\cdot)$ is the one-period innovation variance operator; b is the stock of privately-held domestic-currency bonds; b* denotes privately-held foreign-currency bonds; and c is a linearization constant to ensure $(c+b–b^*-e+\delta)>0$. Finally, and most important, $\delta$ is a structural disturbance. $\delta$ shocks represent changes in the taste for domestic and foreign-currency bonds; for lack of a better name, we refer to it as a *portfolio balance shock*. An increase in $\delta$ indicates decreased demand by foreigners for domestic-currency assets.[xii]

Equation (4) is derived carefully in Flood and Marion (1998), from the point of view of large-country investors evaluating the assets of a small open economy (American investors evaluating peso-denominated investments, or Germans considering drachma bonds). It is merely uncovered interest parity, flavoured by portfolio balance considerations. The domestic interest rate is equal to the comparable foreign return (the foreign interest rate adjusted by expected exchange rate depreciation), and a time-varying risk premium. This risk premium depends on several things, including the aggregate taste for risk, return uncertainty, and relative debt levels, à la Tobin. Adding this slight twist keeps the model reasonably standard, but turns out to have dramatic consequences.[xiii]

***The Meat***

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With equation (4), the exchange rate becomes linked to expectations about both the future level and volatility of the exchange rate. This non-linearity induces multiple equilibria and results in regime- and equilibrium-dependent coefficients.[xiv]

The non-linear nature of equation (4) turns out to be important in two ways. First, when exchange rate variability disappears, the portfolio shock effectively disappears. Second, the non-linearities produce the possibility of multiple equilibria. When the exchange rate is flexible, equation (4) can produce several perfectly viable equilibria. These equilibria may correspond to exchange rate regimes with differing volatility; but movements across these equilibria could also produce exchange rate volatility without corresponding changes in fundamentals.

A credibly fixed exchange rate has neither volatility nor an expected rate of change. So the risk premium disappears, and the domestic interest rate is equal to the foreign rate. With the exchange rate fixed, the money market takes centre stage and we get a functional MABP. The only variables that enter money supply and demand are relevant to the foreign exchange market. So one of the equilibria corresponds to a stable fixed rate regime.

The situation is dramatically different when the exchange rate either floats explicitly, or is fixed unreliably so that speculative attacks are possible. In this case expected volatility is non-zero, so that if $z>0$ (the risk-averse case) *forces other than those from money and goods markets drive the foreign exchange market.* These other disturbances are summarised in our $\delta$ shock. This shock enters the risk premium non-linearly; its importance for the exchange rate is proportional to perceived exchange-rate variance. It enters the exchange-rate reduced form along with regime-specific coefficients. The portfolio-balance shock had no role in determining the balance of payments under reliably fixed rates, but it plays a major exchange rate role in a float. Thus, the shift from fixed to flexible rates is an essential shift in market structure. If the

variance of δ is large compared to the other disturbances, then the exchange rate becomes very much a *non*-monetary phenomenon.

This sort of non-monetary approach to the exchange rate is helpful when the money market disturbances are small compared to portfolio balance disturbances. Of course, there is no reason why portfolio balance (δ) shocks need *always* be large compared to other shocks. For instance during periods of high inflation, the money market reasserts itself. If inflationary changes in money, bonds, and domestic interest rates are large relative to portfolio shocks, macroeconomic variables will have a lot of explanatory power. But during ordinary periods of tranquillity, nominal variables are stable and so do not explain exchange rate changes.

The same is true at low frequencies. Suppose that the portfolio balance shock is stationary, but macroeconomic variables (e.g., relative money supplies or output levels) are not. Even if nominal variables have low conditional variance at high frequencies, they will dominate portfolio balance shocks at longer horizons. Thus a simple macroeconomic model may do a very bad job in explaining the foreign exchange market at high frequencies, but work better at low frequencies.

This model allows one to understand why exchange rate volatility can change across regimes without noticeable differences in macroeconomic phenomena. It can handle either pegged or flexible interest rates; the monetary authorities can conduct essentially any interest rate policy, independent of the exchange rate. Since there are no constraints on international capital flows, this model violates Mundell's "Incompatible Trinity" of fixed exchange rates, monetary sovereignty, and capital mobility. As the endogenous risk premia can adjust to accommodate monetary policy, the central bank has almost complete freedom to manipulate interest rates. When the interest rate is pegged and exchange rates float, the portfolio-balance

shocks that might otherwise be absorbed by the interest rate are instead shunted off into the exchange rate. This can magnify the effects of the "taste disturbances" on exchange rates as compared with completely market-responsive interest rates. But the portfolio balance structure is regime-dependent. When interest and exchange rates are fixed simultaneously, the variance created by portfolio balance shocks does not move from the interest rate locus to the exchange rate or the balance of payments. It simply disappears.

### *Leftovers*

So far, we have followed the typical practice of holding the tastes and identity of private market participants constant for enormously different government policies. This is a heroic way to think about asset markets. The change from fixed to flexible exchange rates may simply be impossible to model in a representative-agent model. Endogenous coefficients (such as $V(\cdot)$) clearly change with policy. More importantly, when markets become systematically more or less risky – due perhaps to government intervention – they attract participants who are more or less well-suited to bearing those risks. In our simple model, we would expect less risk averse (low z) agents to migrate to the foreign exchange market when it becomes more risky.

In the model we have considered, the effects of policy-induced changes in the risk-aversion parameter (z) depend very much on the precise way portfolio balance shocks enter the foreign exchange market. If the shock is *multiplicative* with z (as above), then a decrease in z acts just like a decrease in the variance of the underlying taste shock. In this case, the entry of risk bearers to the foreign exchange market might *stabilise* exchange rates. But if the shock is instead *additive*, a migration of agents which reduces z seems more likely to require increased exchange-rate changes to counter-balance the shocks; more "cowboys" in the markets mean

more volatile exchange rates. While Hau (1998) and Jeanne and Rose (1999) has made some progress along these lines, we need to know a lot more about the portfolio balance shocks and entry.

A related policy concern is the effects of taxes on foreign exchange transactions. The "Tobin Tax" is intended to discourage low-value churning and reduce exchange rate volatility. In a model like ours, a Tobin Tax would probably cause a net out-migration of low z efficient risk bearers.[xv] The effects of the tax on exchange rate volatility would depend on the source of portfolio balance shocks. For multiplicative shocks, driving away efficient risk bearers would probably increase exchange rate volatility; conversely for non-multiplicative disturbances. The welfare implications then depend on balancing reduced transactions against the tax-induced change in market structure.

**4: What is to be Done?**

Flexible exchange rates are different from fixed rates in ways that are wildly inconsistent with standard macroeconomic models. Most research in international finance has ignored this dramatic and robust piece of evidence. Our resolution of this problem starts with a simple non-linear model with a number of attractive features: multiple equilibria; endogenous changes in market structure; and portfolio balance shocks.

It is also important to know what we do *not* emphasise. When it comes to understanding exchange rate volatility, macroeconomics – "fundamentals" – is irrelevant, except in high-inflation countries or in the long run. The large differences in exchange rate volatility across countries and time are simply mysterious from an aggregate perspective. It seems farfetched to

provide a macro explanation for varying asset price volatility in the absence of observable differences in macro phenomena.

Understanding exchange rate volatility is a high-priority task for scholars of international finance.  It is a critical feature of the landscape; it has no analogue in domestic finance; and it is poorly understood.  Traditional linear macro models do not shed light on the problem.  In this paper, we have outlined a non-linear approach which exploits multiple equilibria and focuses attention on regime-dependent market structure.  Other leads include those pursued by Carlson and Osler (1997), De Grauwe (1994), De Long et. al. (1990), Hau (1998), Ito et. al. (1998), Jeanne and Rose (1999), and Krugman and Miller (1993).  Let the race begin!

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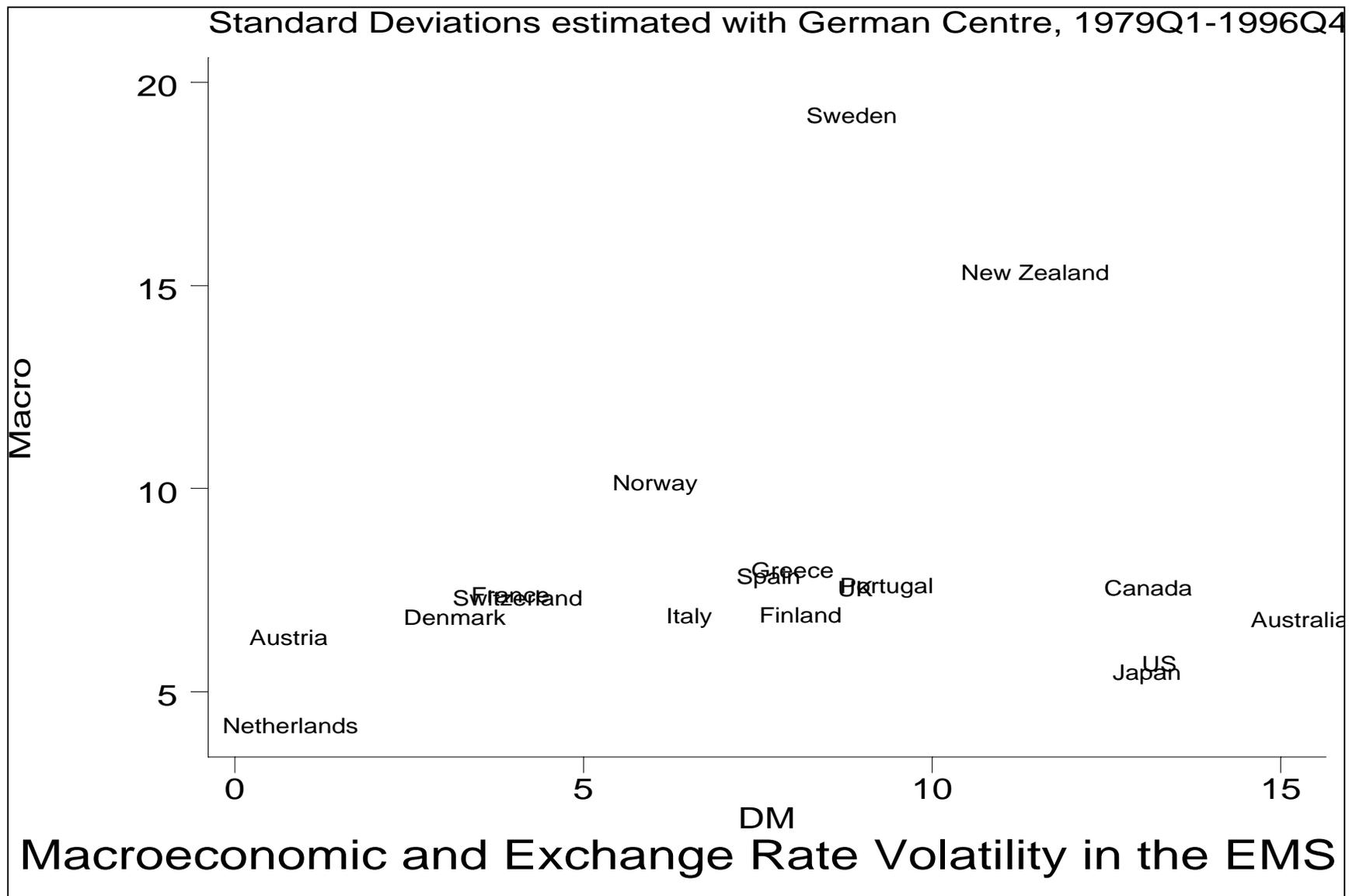
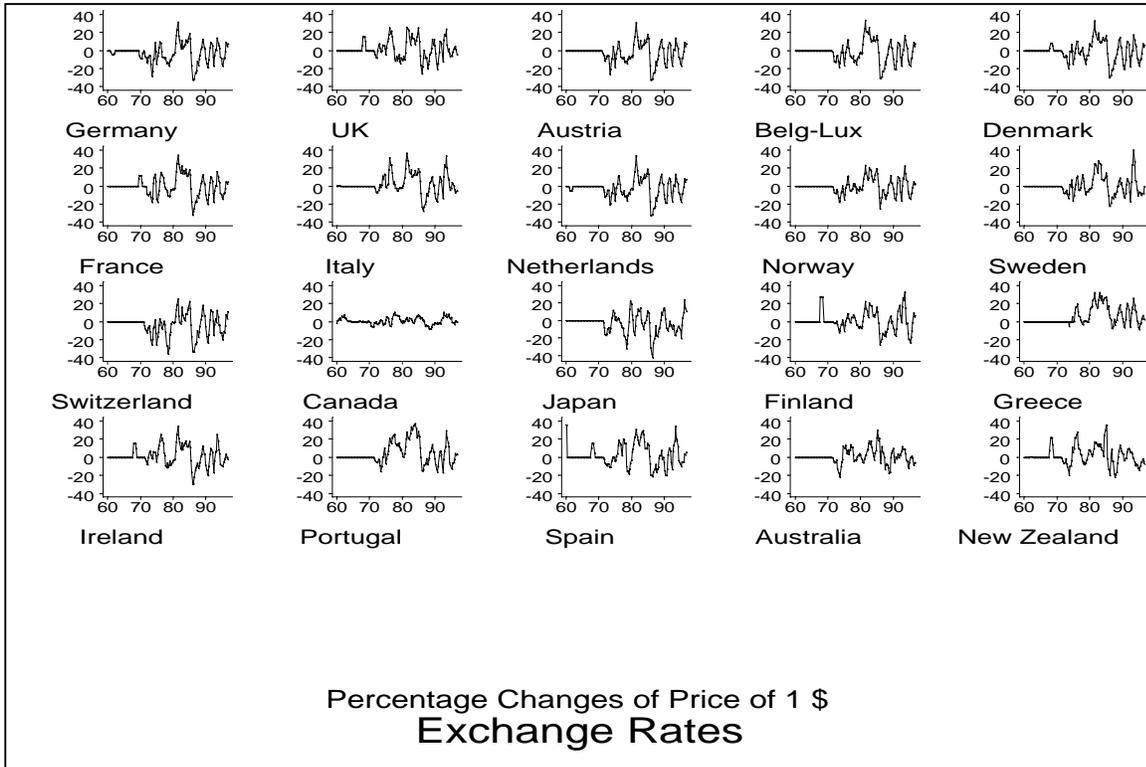Fig. 1: **A Cross Section of Exchange Rate and Macroeconomic Volatility During the EMS**

Percentage Changes of Price of 1 $

**Exchange Rates**

**Fig. 2: Evidence from the Left**



Percentage Changes in [(m-m*)-(y-y*)+(i-i*)], US Center
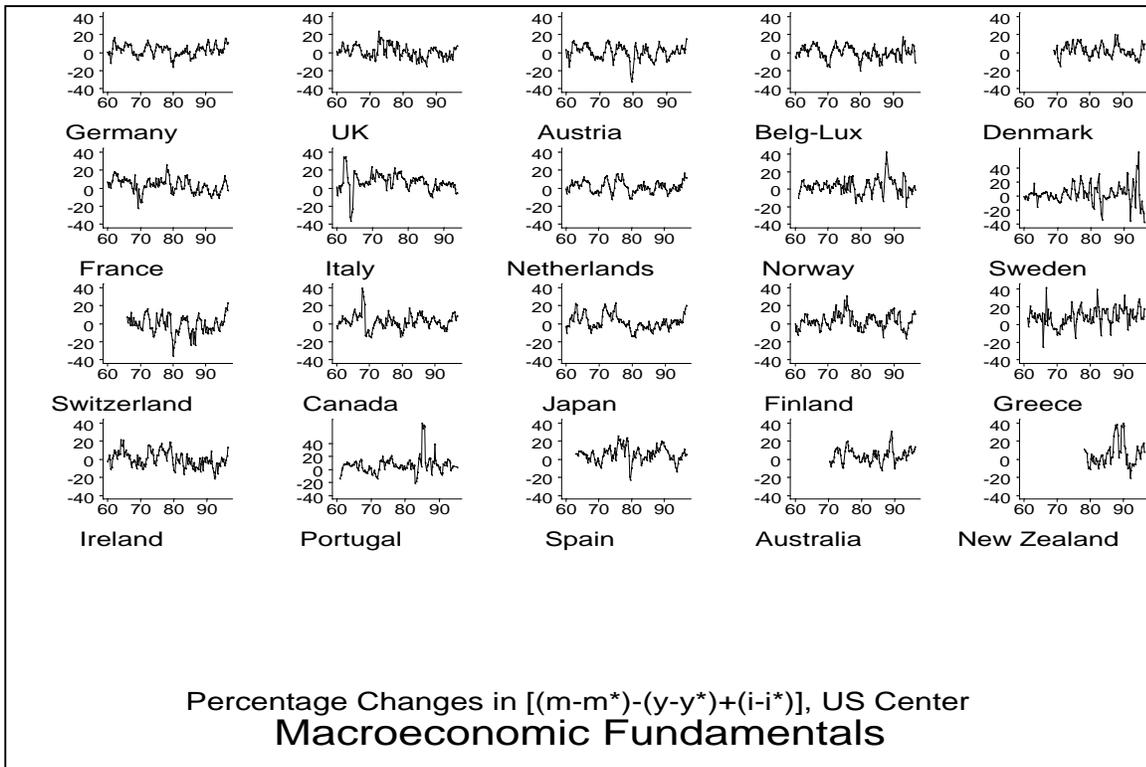
**Macroeconomic Fundamentals**

**Fig. 3: … and the Right**

**Endnotes**

i  This persuasive argument lead many to be surprised by the magnitude of the increase in exchange rate volatility following the breakup of Bretton Woods in 1973, e.g., Mussa (1979) or Obstfeld (1995). Indeed, much of the most influential work in international finance during the 1970s and 1980s was geared towards rationalizing the apparently high level of floating exchange rate volatility; Dornbusch (1976) is the classic example.

ii  Especially when this isn't reflected in other asset prices and would have to be true only for countries that float.

iii  See e.g., Rogoff's contribution to this symposium.

iv  This straightforward intuition is the heart of Mundell's "Incompatible Trinity" of fixed exchange rates, domestic monetary sovereignty and perfect capital mobility.

v  Sweden is an outlier because of the volatility in its short interest rates during the Autumn crisis of 1992.

vi  Flood and Rose use a closely related technique, but combine exchange rates and interest differentials into a "virtual fundamental" which is then compared with a "traditional fundamental" consisting of money, output, prices, shocks and so forth.

vii  Equation (3) has no *coefficient* instability since it relies only on *structural parameters*.

viii  Mussa's "first important regularity" is "The short term variability of real exchange rates is substantially larger when the nominal exchange rate between these countries is floating rather than fixed."

ix  Certainly Stockman (1983) provides consistent evidence earlier. See also Aliber (1976) and other references given by Black.

x  Mussa was interested in rejecting models which do not incorporate price sluggishness, since the latter embody the property of nominal exchange regime neutrality.

xi  Frankel and Froot (1990) and Krugman and Miller (1993) provide some of the inspiration.

xii  In Flood and Rose (1996), we show that uncovered interest parity works better under fixed exchange rate regimes than floats, consistent with (4). To our knowledge, no one has tested a model like (4) empirically.

xiii  In Flood and Marion, the prices of both domestic and foreign goods are sticky, and (home and foreign-currency short-term) bonds are the only assets, so that foreign-currency investment risk is exclusively exchange-rate risk.

xiv  Flood and Marion provide more analysis, covering speculative attacks and the solution of the model.

xv  Our intuition is based on an un-modelled correlation of efficient risk bearing with market churning. This is motivated by discussions of market cowboys who like to trade but are relatively comfortable with market risk.