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In What Sense Can Intervention Reduce Exchange Rate Volatility?

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Abstract

Can pegging reduce real as well as nominal, and multilateral as well as bilateral exchange rate volatility? We investigate this issue using monthly data for 139 countries from January 1990 to June 2006. We use the IMF regime classification system, because this closely reflects the form of governments' exchange rate commitments. We find that both nominal and real volatility against the anchor currency increase steadily with regime flexibility. Real bilateral volatility against non-anchor currencies and real *effective* exchange rate volatility are significantly higher under independent floats, but are otherwise insensitive to the exchange rate regime.

Keywords: Exchange rate regimes, inflation, volatility.

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1. Introduction

Theoretical work often contrasts fixed and flexible exchange rates, with the difference that fixed rates have zero volatility whilst flexible rates are market-determined. The real world is more complex than this for at least two reasons. One is that in practice most regimes fall between these two extremes (Masson, 2001). The other is that volatility comes in different dimensions: nominal and real; and bilateral and multilateral. Exactly what dimensions of exchange rate volatility can pegs or other less flexible regimes actually reduce? This is the question which we investigate here. It is particularly relevant in the light of the suggestion that some countries (notably China) have in recent years managed to keep their currencies persistently undervalued (and by implication less volatile on a trade-weighted basis) as part of a strategy of export-led development. The characterisation of these countries' policy as "Bretton Woods II" implies that exchange rate management can significantly reduce real effective exchange rate volatility. This is not self-evidently true, given that the major currencies float against one another. Even if this statement does turn out to be true, is it so just because of the weight of the anchor currency and others pegged to it in a country's trade, or also because bilateral volatility against non-anchor currencies is lower under a managed exchange rate regime?

An immediate question is how to identify the degree of flexibility of an exchange rate regime. We use the official regime classification of the International Monetary Fund (IMF), for two main reasons. One is that, although this classification purports only to reflect permitted flexibility relative to a central rate, without taking account of the possibility that the central rate might change, which omits a potentially important dimension of volatility, it represents quite closely the exchange rate commitments actually made by governments, which likewise tend not to mention devaluation possibilities, for obvious reasons.[1] The second reason is that the various alternatives to the IMF classification that have been developed in recent years are highly endogenous to volatility itself, and cannot therefore be meaningfully used to test whether intervention reduces volatility, as we discuss further below (see Tavlas *et al*., 2008, for a survey). Moreover the major weakness in the IMF classification that stimulated the development of alternatives – the lack of independent corroboration of countries' alleged regimes – has now been corrected.

Using data from 139 countries over the period 1990-2006, we investigate the relationship between exchange rate volatility and the IMF classification scheme. We find that the IMF classification is a good indicator of *nominal* bilateral volatility against the *anchor* currency. It is a somewhat weaker, but still highly significant, indicator of *real* bilateral volatility against the *anchor* currency. It is largely useless as an indicator of real bilateral volatility against *non-anchor* currencies, or of real *effective* exchange rate volatility, with one important exception. An independent float seems to be characterised by significantly higher multilateral volatility and bilateral volatility against non-anchor currencies, relative to all other regimes. In other words intervention does tend to reduce real effective exchange rate volatility, although the exact form of intervention is less important.

[1] It would be difficult for the IMF to deviate from this approach without being accused of inviting speculation

2. Background

There has been very little detailed work on the relationship between the exchange rate regime and exchange rate volatility (by "detailed", we mean work that uses a relatively fine breakdown of the classification system, into more than two or three broad categories). It is established that bilateral volatility of major currencies against the US dollar has been greater under floating than under pegging. This has been shown for a century of data for four countries by Hasan and Wallace (1996), and by a series of authors for a comparison of the Bretton Woods era with the post-1973 floating-rate period (Baxter and Stockman, 1989; Flood and Rose, 1995; Mussa, 1986). Rose (1996) uses data for 22 (mostly OECD) countries, and finds that bilateral exchange rate volatility against the Deutschmark increases with the width of the officially declared exchange rate band. For multilateral volatility the evidence is much scarcer and rather ambiguous. In his study of openness and real effective exchange rate volatility, Hau (2002) finds significant regime effects only amongst OECD countries, and not in a larger sample of 48 countries.

Other work has concentrated on fundamental determinants of volatility and has sometimes ignored regime effects altogether. This is defensible on the grounds that the choice of regime may be either endogenous or orthogonal to these fundamental determinants.[2] Research of this kind includes Devereux and Lane (2003) for a large

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against certain currencies.

[2] Endogeneity can arise because countries where the fundamentals make the exchange rate more volatile may be more tempted to float to facilitate adjustment to exchange rate shocks. The generally weak empirical performance of models of regime choice suggests that concern about endogeneity can be exaggerated. If the regime is orthogonal to the fundamental factors, its omission will merely affect the residuals and not the estimated coefficients of the model.

sample of nominal bilateral rates, and Bravo-Ortega and di Giovanni (2006) and Hausmann *et al*. (2006) for real effective exchange rates.

This paper aims to fill a gap in the literature by examining bilateral and multilateral volatility for a large sample of countries, using a detailed regime classification.

We turn now to the issue of classifying the exchange rate regime. The IMF has traditionally asked member countries to select the appropriate classification of their exchange rate regime from a choice of categories defined by the IMF itself. In the 1990s discontent with perceived inaccuracies in the resulting classification stimulated the development of alternative schemes, which we discuss shortly. It also led to a reform of the IMF's own procedures. From 1999, the IMF has itself decided a country's classification, relying largely on the knowledge of its own country desks. Bubula and Ötker-Robe (2002) provide a revised classification for earlier years back to 1990 that is intended to reflect the same principles, adjusting the previously reported classifications for obvious inaccuracies.

Alternative *de facto* classification systems, such as those of Levy-Yeyati and Sturzenegger (2005), Reinhart and Rogoff (2004) and Klein and Shambaugh (2008), all attempt to take account of movements in the central rate. They do this mainly by focusing on exchange rate volatility. Levy-Yeyati and Sturzenegger (2005) use cluster analysis based on the volatility of both the level and the rate of change of the exchange rate, together with the volatility of foreign exchange reserves, to define the regime as flexible, intermediate or fixed. Reinhart and Rogoff (2004) focus on the frequency distribution of exchange rate movements, with pegs required to have 80% of the monthly movements within a ±1% band. Klein and Shambaugh (2008) define a peg as the level of the exchange rate remaining within a ±2% band at the end of each month of a calendar year. Thus, although the details differ in each case, the observed volatility of the exchange rate is a primary determinant of the resulting classification. Consequently, an investigation of volatility using these classifications is more informative about the classification algorithm than about volatility.[3]

Because there is an element of judgement in the IMF classification system, it is not entirely immune to the problem of being endogenous to volatility itself (for example in the choice between a managed and an independent float). Nevertheless, because it purports to measure flexibility relative to a central rate, there is not the same mechanical relationship between volatility and the regime classification in the IMF scheme as in the alternatives. Moreover, as mentioned in the Introduction, the IMF system closely reflects the way in which exchange rate commitments are expressed by policy makers, so that it is a natural vehicle for asking whether these commitments are effective in reducing exchange rate volatility below that which would be delivered by the market.

[3] A further point is that these alternatives are not converging to any kind of agreement, and disagree as much with each other as with the IMF classification (Bleaney and Francisco, 2007).

3. Preliminary Analysis of the Data

The categories used in the IMF *de facto* classifications are shown in Table 1.[4] A very important point to note is that a higher number in the IMF classification broadly reflects a higher degree of flexibility *relative to the central rate* against the anchor currency (or currency basket), but takes no explicit account of the frequency of *adjustments* of the central rate, except in the cases of regimes 1 (no separate legal tender) and 2 (currency board). These regimes are defined by a relatively low probability of an adjustment of the central rate (in fact zero in the case of no separate legal tender).

Table 1. Regime Classifications

1	No separate legal tender
2	Currency board arrangements
3	Conventional fixed pegs
4	Horizontal bands
5	Crawling pegs
6	Crawling bands
7	Managed floats
8	Independent floats

Notes. Categories 3 and 5 are defined by a maximum fluctuation of ±1% around the central parity; a wider range is classified in category 4 or 6, as appropriate. In categories 5 and 6 the central parity is adjusted relatively frequently by small amounts. Category 7 covers cases where the monetary authority attempts to influence the exchange rate without any specified path or target. In category 8 the exchange rate is market-determined.

Until recently, category 1 (no separate legal tender) included both currency unions (where all members have some voice in the area's monetary and exchange rate policy) and dollarisation (the adoption of a foreign currency as legal tender with no expectation of a

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[4] We are grateful to Harald Anderson of the IMF for providing the data.

policy voice). Now the IMF classifies currency union members according to the behaviour of the common currency. Whereas under the old system Belgium, Ecuador and Togo would all have been classified as 1 in December 2007, under the new system only Ecuador is 1, Belgium is 8 (because the euro floats against other major currencies) and Togo is 3 (because the CFA franc is pegged to the euro). The new system really amounts to applying the classification system to the currency union rather than to the member countries. It is therefore problematic to relate the classification to the characteristics of individual member countries rather than of the area as a whole.[5] To avoid this problem we ignore currency unions in most of the analysis.

Since the focus of the analysis is the relationship between exchange rate volatility and the exchange rate regime, we measure volatility over periods of an unchanged regime. This creates a problem of varying episode length.[6] In the empirical analysis we exclude episodes where the regime lasted for too short a time (less than four quarters), and we also split exceptionally long periods of the same regime into two or three shorter episodes. This helps to prevent countries that rarely switch regimes from being too severely under-represented. Any period of 48 quarters is split into three episodes of equal or nearly equal length, and any period of between 32 and 47 quarters is split into two episodes of equal or nearly equal length. Each episode thus defined represents an observation in the empirical analysis that follows. Thus, for the United States, which has been freely floating throughout, there are three 22-quarter episodes, lasting respectively

[5] For example under the new classification it is logical to use real effective exchange rate volatility for the euro area rather than that for individual countries, for which the index includes trade with other euro-area countries. Many variables are, however, only available on a country-by-country basis.

from January 1990 to June 1995, July 1995 to December 2000, and January 2001 to June 2006, with real exchange rate volatility measured separately over each of these three episodes, each of which represents an observation in the regressions that follow. For some other countries, there are more than three episodes of shorter average length. Imposing a higher minimum episode length reduces the disparity in countries' representation at the expense of a reduction in sample size; we do this later as part of the sensitivity analysis.

We examine end-of-month bilateral nominal and real (CPI-adjusted) real exchange rates and monthly average real effective exchange rates as given in the IMF *International Financial Statistics* database, always in logarithms. The measure of volatility that we use is the standard deviation of the level of the exchange rate. Other measures that have been used in previous literature include the mean absolute monthly change, the standard deviation of the monthly change, and the root mean square monthly change. In an earlier paper on real effective exchange rate volatility we show that these measures are all highly correlated, and that the correlates of volatility are similar whichever measure is used (Bleaney and Francisco, 2008).

A further feature of the data is that, even after high-inflation observations are removed, volatility exhibits strong positive skewness. To deal with this we employ a logarithmic transformation of volatility that removes most of the skewness.

[6] If instead we had used episodes of fixed length, it would have been difficult to deal with regime switches.

In order to avoid the influence of outliers, all episodes where the mean monthly change in the logarithm of the consumer price index is greater than 0.03 (equivalent to an annual inflation rate of 43.33%) are excluded, as are those containing fewer than four quarters. If we include currency unions, this leaves us with 503 observations from 160 countries. Table 2 provides some basic statistical data for this sample.

Table 2. Some Basic Statistics

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Regime	No.	Nom. US$	Real US$	Real SF	Inflation	GDPpc	Episode length
1 (US$)	19	0	2.62	10.84	3.14	8.22	22.2
1 (other)	54	17.43	15.29	11.05	3.76	6.94	23.4
2 (US$)	7	2.10	7.36	11.01	3.83	9.61	21.7
2 (other)	7	7.94	10.14	8.40	6.21	7.94	17.6
3 (US$)	75	2.74	5.06	10.30	5.98	7.59	17.1
3 (other)	17	12.67	11.41	6.24	6.11	8.47	17.9
3 (basket)	41	11.18	10.54	10.62	7.98	7.39	19.8
4 (US$)	9	10.13	9.17	8.94	12.37	7.02	11.9
4 (other)	33	7.92	7.95	4.71	4.27	9.73	16.2
5	32	9.93	4.84	8.35	11.72	7.61	14.9
6	21	13.22	6.84	9.83	14.23	8.10	16.1
7	115	12.52	10.01	11.23	10.09	7.03	16.7
8	73	14.56	11.22	11.61	6.80	7.93	17.9
All	503	10.62	9.18	10.13	7.51	7.67	17.9

Notes. These statistics refer to episodes of minimum length four quarters with mean inflation below 3% per month. The rows are the exchange rate regimes as given in Table 1, with an indication of whether a peg is to the US$, to another currency or to a basket of currencies. The columns are defined as follows: (1) IMF regime classification; (2) number of episodes; (3) standard deviation of the log nominal bilateral exchange rate against the US dollar, multiplied by 100; (4) as (3), but real (CPI-adjusted); (5) as (4), but against the Swiss franc; (6) average month-to-month change in the logarithm of the consumer price index multiplied by 1200, to give an annual % change equivalent; (7) average log per capita GDP in 2000 US dollars; (8) average length of episode in quarters.

Table 2 shows data by exchange rate regime and (where relevant) separated into pegs to the US dollar, to another currency (most frequently the euro) and to a currency basket. It gives information about the volatility of the bilateral real exchange rate against the Swiss franc as well as against the US dollar. Since the Swiss franc floats against all currencies, it does not function as an anchor currency for any currency; on the other hand, for geographical reason it fluctuates less against the euro than against other currencies, so currencies that peg to the euro will also tend to have less volatility relative to the Swiss franc.

Table 2 is rich in information. For example:

1) Pegs to the US dollar tend to have lower real volatility against the US dollar than against the Swiss franc, whereas the opposite is the case for pegs to other currencies;

2) Real volatility against the US dollar tends to be smaller than nominal volatility in more flexible regimes, whereas the opposite is often the case for less flexible regimes, which suggests that flexibility operates to offset inflation differentials;

3) Nominal volatility tends to be highest in more flexible regimes;

4) Inflation tends to be associated with greater flexibility, although the direction of causality remains undetermined;

5) There is no clear pattern across regimes of per capita GDP or of regime durability, apart from the (fairly obvious) point that currency unions tend to be the most durable regimes.

Table 3. Partial Correlations Between Variables

		Correlation with:					
Variable		A	B	C	D	E	F
Regime	A	1					
Nominal US$ vol'ty	B	0.262	1				
Real US$ volatility	C	0.181	0.510	1			
Real SF volatility	D	0.141	0.372	0.713	1		
Inflation	E	0.119	-0.094	0.203	0.243	1	
GDPpc	F	-0.161	-0.237	-0.174	-0.270	-0.259	1
Episode length	G	-0.053	0.118	0.171	0.172	-0.243	0.112

Notes. These statistics refer to episodes of minimum length four quarters with mean inflation below 3% per month. The sample is 427 episodes, with currency unions excluded. The first row is the exchange rate regime as given in Table 1; the other rows correspond to the columns in Table 2. All the correlations greater than 0.10 (0.14) in absolute value are statistically significant at the 0.05 (0.01) level.

Table 3 shows the partial correlations between the variables shown in Table 2, with currency unions excluded. Most of the correlations in the table are statistically significant, although not very large. The highest correlations are between the three volatility measures. Volatility tends to be positively correlated with regime flexibility (as measured by the classification in Table 1), and negatively correlated with per capita GDP. It is also positively correlated with episode length and (for real but surprisingly not for nominal volatility) with inflation.

4. Regression Analysis of Volatility

This section contains our main results. The sample is as shown in Table 2, but with regime 1 (no separate legal tender) omitted, because currency unions are problematic for the reasons discussed above. The dependent variable is the logarithm of the standard deviation of the level of the real exchange rate during the regime episode. Taking logarithms removes the marked skewness of the data, which makes the results sensitive to outliers at the upper end. In the case of the nominal exchange rate against the US dollar, 0.1 is added to the standard deviation before taking logarithms, to avoid outliers at the lower end with exceptionally low volatility.[7]

The model is:

$$VOL_{it} = a + bREGIMEDUMMIES_{it} + cCONTROLS_{it} + u_{it} \qquad (1)$$

where VOL_{it} is the volatility of the relevant exchange rate in episode *t* in country *i*; *REGIMEDUMMIES* is a vector of exchange rate regime dummies; *CONTROLS* is a vector of control variables; and u is a stochastic term. The vector *REGIMEDUMMIES* includes dummy variables for a currency board (regime 2), a basket peg (a subset of regime 3), a horizontal band (regime 4), a crawling peg or band (regime 5 or 6), a managed float (regime 7), an independent float (regime 8), and a peg to a currency other than the US dollar. The omitted category is a peg to the US dollar (a subset of regime 3).

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[7] The problem is that the logarithm tends to minus infinity as the standard deviation tends to zero. Indeed the standard deviation is zero in a number of cases, as can be seen in Table 2. Adding 0.1 (which is close to the

In addition to that we include a dummy that is equal to one if the anchor currency is not the US dollar (regimes 2 to 6 only), since we expect such currencies to have greater volatility against the US dollar than those whose anchor currency is the US dollar, given the exchange rate regime.

The control variables are a mixture of geographical and macroeconomic variables, plus the length of the regime episode. They are as follows:

QUARTERS: the length of the episode, measured in quarters;

LYPC: the logarithm of per capita GDP (in 2000 US dollars);

LAREA: the logarithm of the size of the country, as measured by land area (in square kilometres);

LAND: a dummy=1 for a landlocked country, =0 otherwise;

TOTVOL: the standard deviation of the logarithm of the terms of trade over the five-year period that most closely matches the episode;

LDIST: the logarithm of the distance of the country's capital from Washington DC. (for bilateral rates against the US dollar), or from Bern (for the Swiss franc), or a GDP-weighted average of the logarithm of the distances from all world capitals (for the real effective exchange rate); and

INFLATION: the average monthly change in the logarithm of the consumer price index.

The expectation is that the coefficients of all these variables will be positive, except in the case of *LYPC*.

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mean of the sample) removes skewness in either direction after logs are taken. We do not add 0.1 to real exchange rate volatility before taking logs because this tends to reinstate the positive skewness.

Data are drawn from the World Bank's *World Development Indicators* database, except for *LDIST*, for which the source is *www.cepii.fr*.

Table 4 shows the results from estimating equation (1), excluding currency unions and episodes that are too short or with high average inflation rates. The control variables mostly have the expected sign and are significant more often than not. Volatility tends to decrease with per capita GDP and to increase with terms of trade volatility, inflation, the length of the episode, the size of the country, landlockedness and distance from the anchor country (these last three factors all serve to depress trade with the anchor country). A country whose anchor currency is not the US dollar has significantly greater volatility against that currency than a country with the same exchange rate regime whose anchor currency is the US dollar. On the other hand, such a country has lower volatility against the Swiss franc. This reflects the fact that the euro is the most common alternative anchor currency, and for geographical reasons the Swiss franc has lower volatility against the euro than the US dollar.

After controlling for all these factors, it is clear from Table 4 that regime effects are highly significant for the volatility of nominal and real rates against the US dollar, but not for the real rate against the Swiss franc. Moreover, if we look at the pattern of the coefficient dummies, we see that the coefficient tends to increase with the flexibility of the regime for nominal US dollar volatility, with the highest coefficient for an independent float. For real US dollar volatility, the same is also broadly true except that crawling pegs and bands break the pattern, with volatility similar to conventional US dollar pegs. This suggests that crawls operate as a form of real exchange rate targeting. For the Swiss franc, we cannot reject the null hypothesis of zero coefficients of all the regime dummies at the 0.05 level, although the independent float dummy is individually significant.[8]

To test the hypothesis that exchange rate volatility increases with regime flexibility in general, in Table 5 we report a similar regression with the regime dummies replaced by a regime flexibility index, which is the regime number reported in Table 1 (i.e. 2 for a currency board, 3 for a horizontal peg, etc.). This index has a highly significantly positive coefficient for nominal and real US dollar volatility, but the coefficient is insignificant (although positive) for Swiss franc volatility.

[8] Note that because 0.1 is added to the standard deviation for nominal (but not real) rates before logarithms are taken, coefficients for nominal and real rates are not comparable.

Table 4. Bilateral volatility and exchange rate regimes

	Volatility Measure		
	Nominal rate against US $	Real rate against US $	Real rate against SF
Independent variables			
Constant	-2.14** (-6.62)	-5.37** (-9.30)	-3.64** (-10.6)
Episode length (quarters/100)	1.45** (4.14)	3.11** (5.18)	3.05** (6.65)
ln (per capita GDP)/100	-4.79* (-2.23)	-1.11 (-0.37)	-4.93* (-2.28)
ln (land area)/100	1.49* (2.01)	5.01** (3.67)	2.78* (2.39)
Dummy for landlockedness	0.156** (2.97)	0.243** (2.88)	0.053 (0.74)
TOT volatility/100	0.237 (1.03)	1.12* (2.29)	0.623 (1.16)
ln (distance)	-0.025 (-0.08)	0.193** (3.20)	0.113** (3.04)
Monthly inflation rate	0.064 (0.58)	0.243* (2.23)	0.166* (1.99)
Peg to non-US$ currency dummy	0.287** (5.13)	0.659** (6.70)	-0.264* (-2.17)
Currency board dummy	0.064 (0.72)	0.471** (2.62)	0.217 (1.41)
Basket peg dummy	0.312** (4.56)	0.506** (3.90)	0.011 (0.10)
Horizontal band dummy	0.257** (3.57)	0.400** (3.26)	-0.038 (-0.34)
Crawl dummy	0.413** (5.17)	0.083 (0.62)	-0.002 (-0.02)
Managed float dummy	0.396** (6.72)	0.654** (5.91)	0.042 (0.50)
Independent float dummy	0.551** (8.02)	0.957** (8.48)	0.193* (2.28)
Observations	429	429	429
R-squared	0.348	0.397	0.365
Standard error	0.344	0.617	0.501
F-statistic (6, 414)	14.11**	18.90**	1.99

Notes. Figures in parentheses are heteroscedasticity-robust *t*-statistics. * (**) denotes significantly different from zero at the 0.05 (0.01) level. Volatility is ln (standard deviation + x), where x is 0.1 for nominal rates and zero for real rates. Sample excludes currency unions and all episodes shorter than four quarters and with monthly inflation > 0.03. The F-statistic refers to a joint test of zero coefficients on the six regime dummies from currency board dummy downwards.

Table 5. Bilateral volatility and regime flexibility

	Volatility Measure		
	Nominal rate against US $	Real rate against US $	Real rate against SF
Independent variables			
Constant	-2.50** (-7.60)	-6.29** (-10.4)	-3.75** (-10.6)
Episode length (quarters/100)	1.54** (4.38)	3.46** (5.77)	3.16** (7.00)
ln (per capita GDP)/100	-4.52* (-2.16)	-0.61 (-0.22)	-4.56* (-2.31)
ln (land area)/100	1.44 (1.87)	4.19** (2.93)	2.74* (2.45)
Dummy for landlockedness	0.142** (2.71)	0.205* (2.40)	0.045 (0.63)
TOT volatility/100	0.225 (0.95)	1.30* (2.57)	0.635 (1.20)
ln (distance)	0.019 (0.60)	0.262** (4.23)	0.119** (3.20)
Monthly inflation rate	0.079 (0.69)	0.222* (2.15)	0.157 (1.93)
Peg to non-US$ currency dummy	0.339** (7.52)	0.732** (7.92)	-0.272* (-2.47)
Regime flexibility index	0.0849** (7.51)	0.141** (7.08)	0.0221 (1.59)
Observations	429	429	429
R-squared	0.303	0.329	0.355
Standard error	0.354	0.647	0.502

Notes. Figures in parentheses are heteroscedasticity-robust *t*-statistics. * (**) denotes significantly different from zero at the 0.05 (0.01) level. Volatility is ln (standard deviation + x), where x is 0.1 for nominal rates and zero for real rates. Sample excludes currency unions and all episodes shorter than four quarters and with monthly inflation > 0.03. The regime flexibility index is the number shown in Table 1.

In Table 6 we check that the results in Table 5 are not just driven by polar regimes. We add two dummies to the Table 5 regression, one for a currency board and one for an independent float, so that the regime flexibility index coefficient is now being estimated only on regimes 3 to 7. We do this partly because the polar regimes might be particularly endogenous to volatility (volatility might influence whether the regime was characterised as an independent rather than a managed float, and currency boards have greater obstacles to devaluation than other pegs). The results show that even outside the polar cases regime flexibility matters for nominal and real US dollar volatility. The coefficient of regime flexibility is about 10% smaller in Table 6 than in Table 5, but still highly significant.

Table 6. Bilateral volatility and regime flexibility: polar and intermediate regimes

	Volatility Measure		
	Nominal rate against US $	Real rate against US $	Real rate against SF
Independent variables			
Constant	-2.46** (-7.31)	-6.09** (-9.95)	-3.68** (-10.3)
Episode length (quarters/100)	1.53** (4.30)	3.34** (5.54)	3.08** (6.83)
ln (per capita GDP)/100	-4.72* (-2.20)	-1.81 (-0.63)	-5.14* (-2.55)
ln (land area)/100	1.44 (1.86)	4.22** (2.99)	2.68* (2.38)
Dummy for landlockedness	0.142** (2.69)	0.222* (2.57)	0.055 (0.78)
TOT volatility/100	0.209 (0.86)	1.29* (2.49)	0.634 (1.19)
ln (distance)	0.018 (0.54)	0.244** (3.98)	0.112** (3.06)
Monthly inflation rate	0.081 (0.71)	0.233* (2.32)	0.165* (2.06)
Peg to non-US$ currency dummy	0.340** (7.55)	0.736** (8.21)	-0.280* (-2.55)
Regime flexibility index	0.0794** (5.46)	0.123** (4.71)	0.0113 (0.62)
Currency board dummy	0.001 (0.01)	0.437* (2.46)	0.244 (1.58)
Independent float dummy	0.047 (0.82)	0.250* (2.47)	0.145* (1.98)
Observations	429	429	429
R-squared	0.304	0.348	0.365
Standard error	0.354	0.640	0.499
F-statistic (2, 414)	0.71	7.39**	3.66*

Notes. Figures in parentheses are heteroscedasticity-robust *t*-statistics. * (**) denotes significantly different from zero at the 0.05 (0.01) level. Volatility is ln (standard deviation + x), where x is 0.1 for nominal rates and zero for real rates. Sample excludes currency unions and all episodes shorter than four quarters and with monthly inflation > 0.03. The regime flexibility index is the number shown in Table 1. The F-statistic tests for the null hypothesis that the coefficients of the last two variables are zero.

A further possibility is that the control variables do not adequately capture other sources of volatility, such as unobserved country effects. Accordingly in Table 7 we replace time-invariant control variables with fixed country effects. Despite absorbing many degrees of freedom (there are 139 countries in the sample, listed in the Appendix), the fixed country effects improve the fit, as can be seen by comparing the standard errors of the regressions in Tables 4 and 7. On the other hand, 57 of these countries had no change of regime in the sample, so that the regime coefficients are effectively being estimated on data from only 82 countries.[9] Nevertheless the general picture in Table 7 is very similar to that in Table 4. The regime effects are highly significant for nominal and real US dollar volatility, with the highest coefficients for independent floats, and much less so for real Swiss franc volatility, although the F-statistic in this case is now significant at the 0.05 level.

[9] The 57 countries had unchanged exchange rate regimes for the episodes included in the regression, but not necessarily throughout 1990-2006; in some countries episodes were excluded because of high inflation, missing data or membership of a currency union (the euro area).

Table 7. Bilateral volatility and regime flexibility: country fixed effects

	Volatility Measure		
	Nominal rate against US $	Real rate against US $	Real rate against SF
Independent variables			
Episode length (quarters/100)	1.41** (3.63)	3.31** (5.28)	2.37** (5.00)
TOT volatility/100	0.002 (0.06)	0.905 (1.50)	-0.230 (-0.50)
Monthly inflation rate	0.0110 (0.37)	0.178** (3.44)	0.127** (3.25)
Peg to non-US$ currency dummy	0.106 (0.82)	0.0533 (0.24)	-0.140 (-0.83)
Currency board dummy	-1.04* (-2.51)	-0.599 (-0.84)	-0.808 (-1.49)
Basket peg dummy	0.212* (2.07)	0.249 (1.41)	0.056 (0.41)
Horizontal band dummy	0.226* (2.13)	0.415* (2.26)	0.113 (0.82)
Crawl dummy	0.295** (3.23)	0.079 (0.50)	0.136 (1.14)
Managed float dummy	0.279** (3.87)	0.461** (3.70)	0.091 (0.96)
Independent float dummy	0.470** (5.19)	0.755** (4.82)	0.380** (3.21)
Observations	429	429	429
Countries	139	139	139
Standard error	0.334	0.576	0.436
F-statistic (6, 280)	6.37**	5.71**	2.61*

Notes. Figures in parentheses are *t*-statistics. * (**) denotes significantly different from zero at the 0.05 (0.01) level. Volatility is ln (standard deviation + x), where x is 0.1 for nominal rates and zero for real rates. Sample excludes currency unions and all episodes shorter than four quarters and with monthly inflation > 0.03. The regime flexibility index is the number shown in Table 1. The F-statistic tests for the null hypothesis that the coefficients of the last six variables are zero.

We turn now to real effective exchange rate (REER) volatility. The sample is considerably smaller, since the IMF publishes REER data for only about 90 countries. After excluding currency unions, our sample includes 229 regime episodes from 76 countries, which is only about 53% of the episodes used in the bilateral volatility regressions. To check that it is not a biased subsample of the episodes used in earlier regressions, we tested for differences in coefficients between episodes with and without REER data. The resulting Chow statistic was not significant ($F(15, 309)=1.09$ ($p=0.359$)).

The results for REER volatility (still with currency unions excluded) are shown in Table 8. The first column contains the full set of regime dummies, which are collectively significant at the 0.01 level. Individually, only two are significant: those for a crawling peg or band (negative) and for an independent float (positive). In column (2) the regime dummies are replaced by the regime flexibility index, whose coefficient is significantly positive at the 0.01 level. In column (3), we combine the regime flexibility index with the dummies for a crawl and an independent float. In this case the regime flexibility index is insignificant, whereas the two regime dummies are significant at the 0.01 level. These results suggest that only these regimes make a difference to REER volatility: a crawling peg or band reduces it significantly, acting as a close approximation to REER targeting, and an independent float increases it by about 40% relative to most other regimes. In the case of an independent float, our previous results imply that this reflects greater volatility against both anchor and non-anchor currencies, whereas the regressions in Table 2 indicate that the lower volatility of crawls derives mainly from anchor-currency effects. If we re-estimate the Table 2 regressions, but omitting all regime dummies but those for a crawl and an independent float, the crawl dummy has a coefficient of –0.348 (with a robust *t*-statistic of –3.29) for real volatility against the US dollar, but one of only –0.027 (with a robust *t*-statistic of –0.39) for real volatility against the Swiss franc. Thus crawling pegs and bands seem to be effective mechanisms for targeting real bilateral volatility against an anchor currency, to an extent that translates also into real effective exchange rate volatility.

Table 8. Real effective exchange rate volatility

	Dependent variable: ln(standard deviation of real effective exchange rate volatility)		
	(1)	(2)	(3)
Independent variables			
Constant	-3.21** (-3.33)	-2.84** (-2.78)	-3.43** (-3.74)
Episode length (quarters/100)	3.50** (5.50)	3.60** (5.88)	3.49** (5.73)
ln (per capita GDP)/100	-8.75** (-2.94)	-7.89** (-2.88)	-8.99** (-2.97)
ln (land area)/100	4.70** (2.79)	4.68** (2.93)	4.67** (2.97)
Dummy for landlockedness	0.015 (0.18)	0.048** (0.59)	0.016 (0.19)
TOT volatility/100	1.71** (3.73)	2.18** (5.05)	1.77** (3.95)
ln (distance)	-0.034 (-0.30)	-0.125 (-1.06)	-0.023 (-0.22)
Monthly inflation rate	0.446** (6.19)	0.348** (5.00)	0.441** (6.12)
Regime flexibility index		0.0870** (4.65)	0.0307 (1.31)
Currency board dummy	-0.020 (-0.15)		
Basket peg dummy	-0.042 (-0.21)		
Horizontal band dummy	-0.052 (-0.46)		
Crawl dummy	-0.282* (-2.34)		-0.317** (-3.27)
Managed float dummy	0.087 (0.87)		
Independent float dummy	0.442** (4.14)		0.326** (2.78)
Observations	229	229	229
R-squared	0.535	0.482	0.534
Standard error	0.482	0.502	0.478
F-statistic (6, 215)	6.99**		

Notes. Figures in parentheses are heteroscedasticity-robust *t*-statistics. * (**) denotes significantly different from zero at the 0.05 (0.01) level. Volatility is ln (standard deviation + x), where x is 0.1 for nominal rates and zero for real rates. Sample excludes currency unions and all episodes shorter than four quarters and with monthly inflation > 0.03. The F-statistic refers to a joint test of zero coefficients on the six regime dummies from currency board dummy downwards.

5. Sensitivity Analysis

There is a possible concern that these results are unduly influenced by the inequality in episode lengths (and the consequent overrepresentation of countries with more regime changes). Accordingly, in Table 9 we show regressions with the same specification as Table 4, but with a minimum episode length of sixteen quarters rather than four. This reduces the maximum number of episodes for one country from seven to four, and the average episode per country from 3.1 to 2.3.

The other robustness test that we undertake is to omit all countries that are pegged to a currency other than the US dollar, or were likely to have chosen to do so had they not floated (which we assume to be the case for countries in Europe or North Africa). The reason for this test is that the results might have been significantly affected by using a dummy variable to capture a different anchor currency.[10] The results are shown in Table 10.

Neither Table 9 nor Table 10 suggests any major problem with the robustness of the results.

[10] In results not shown we also tested whether the data prefer the other-currency-anchor dummy to have different coefficients across regimes, but the improvement in fit is not statistically significant.

Table 9. With a minimum episode length of 16 quarters

	Volatility Measure		
	Nominal rate against US $	Real rate against US $	Real rate against SF
Independent variables			
Constant	-2.07** (-6.64)	-5.85** (-9.13)	-3.71** (-4.99)
Episode length (quarters/100)	1.28* (2.19)	2.70* (2.48)	4.48** (4.99)
ln (per capita GDP)/100	-5.67** (-2.70)	-2.59 (-0.82)	-6.04** (-2.62)
ln (land area)/100	1.03 (1.20)	4.33** (2.80)	2.29 (1.71)
Dummy for landlockedness	0.199** (3.45)	0.251** (2.76)	-0.043 (-0.55)
TOT volatility/100	0.281 (1.17)	0.783 (1.47)	0.551 (0.94)
ln (distance)	-0.012 (-0.37)	0.255** (3.83)	0.117** (2.99)
Monthly inflation rate	0.004 (0.04)	0.180 (1.75)	0.116 (1.34)
Peg to non-US$ currency dummy	0.319** (4.66)	0.655** (5.48)	-0.137 (-0.98)
Currency board dummy	0.092 (1.06)	0.455* (2.42)	0.166 (1.03)
Basket peg dummy	0.336** (4.89)	0.497** (3.44)	0.001 (0.01)
Horizontal band dummy	0.251** (3.18)	0.459** (3.28)	-0.104 (-0.79)
Crawl dummy	0.518** (6.24)	0.119 (0.79)	0.006 (0.06)
Managed float dummy	0.428** (6.85)	0.658** (5.06)	0.047 (0.48)
Independent float dummy	0.603** (9.37)	1.022** (8.47)	0.195* (2.10)
Observations	304	304	304
R-squared	0.381	0.401	0.340
Standard error	0.334	0.598	0.488
F-statistic (6, 289)	18.99**	16.47**	1.75

Notes. Figures in parentheses are heteroscedasticity-robust *t*-statistics. * (**) denotes significantly different from zero at the 0.05 (0.01) level. Volatility is ln (standard deviation + x), where x is 0.1 for nominal rates and zero for real rates. Sample excludes currency unions and all episodes shorter than sixteen quarters and with monthly inflation > 0.03. The F-statistic refers to a joint test of zero coefficients on the six regime dummies from currency board dummy downwards.

Table 10. Omitting actual and potential pegs to non-US$ currencies

	Volatility Measure		
	Nominal rate against US $	Real rate against US $	Real rate against SF
Independent variables			
Constant	-2.01** (-5.45)	-5.11** (-8.22)	-2.10** (-3.82)
Episode length (quarters/100)	1.37** (3.46)	3.13** (4.56)	2.83** (5.64)
ln (per capita GDP)/100	-5.77* (-2.46)	-3.80 (-1.04)	-1.83 (-0.87)
ln (land area)/100	1.60 (1.87)	6.02** (3.95)	2.56* (2.36)
Dummy for landlockedness	0.111 (1.58)	0.158 (1.47)	0.033 (0.39)
TOT volatility/100	0.174 (0.74)	1.08* (2.08)	0.382 (0.78)
ln (distance)	-0.021 (-0.57)	0.159* (2.46)	-0.054 (-0.89)
Monthly inflation rate	0.052 (0.43)	0.240 (1.90)	0.130 (1.66)
Currency board dummy	0.112 (0.97)	0.736** (2.90)	0.224 (1.64)
Basket peg dummy	0.423** (5.12)	0.640** (4.14)	-0.068 (-0.66)
Horizontal band dummy	0.484** (3.56)	0.804** (3.75)	-0.029 (-0.19)
Crawl dummy	0.488** (5.67)	0.143 (0.95)	0.011 (0.10)
Managed float dummy	0.436** (6.56)	0.667** (5.36)	0.053 (0.63)
Independent float dummy	0.601** (7.70)	0.957** (7.41)	0.214* (2.48)
Observations	318	318	321
R-squared	0.372	0.410	0.190
Standard error	0.371	0.660	0.475
F-statistic (6, n-14)	12.78**	14.02**	2.46*

Notes. Figures in parentheses are heteroscedasticity-robust *t*-statistics. * (**) denotes significantly different from zero at the 0.05 (0.01) level. Volatility is ln (standard deviation + x), where x is 0.1 for nominal rates and zero for real rates. Sample excludes currency unions, all pegs to currencies other than the US$, floats in Europe, and all episodes shorter than four quarters and with monthly inflation > 0.03. The F-statistic refers to a joint test of zero coefficients on the six regime dummies from currency board dummy downwards.

6. Conclusions

Nominal bilateral volatility against the US dollar increases systematically with exchange rate flexibility, as measured by the IMF exchange rate classification system, after controlling for pegs against other currencies. So also does real bilateral volatility, although in this case crawling pegs and bands break the pattern, with lower real volatility than most other regimes, presumably because they are designed to adjust for inflation differentials in a systematic way. Real bilateral volatility against the Swiss franc (which floats against all currencies used as anchors) is much less sensitive to the exchange rate regime, except that independent floats tend to have higher volatility than other regimes. One possible interpretation of this is that real bilateral volatility against a non-anchor currency has two components: the exchange rate of the non-anchor currency against the anchor currency, and the exchange rate of the country's own currency against the anchor currency. Unless these two components are sufficiently negatively correlated, bilateral volatility against a non-anchor currency will still tend to be reduced by intervention targeted at the rate against the anchor currency. Bilateral real volatility against any currency tends to increase with distance, inflation and the size of the country, and to decline with per capita GDP. The results are robust to alternative specifications (country fixed effects rather than pooled estimation).

Real effective exchange rate volatility is higher under independent floats and lower under crawling pegs and bands than in other regimes, but is otherwise not significantly affected by the exchange rate regime. The lower volatility of crawls seems to be purely the effect of the weight of the anchor currency in the trade-weighted basket. The higher volatility of independent floats reflects higher volatility against both anchor and non-anchor currencies, as discussed above. Thus, even in a world where the major currencies float freely against one another, real effectively exchange rate volatility can be significantly reduced by exchange market intervention.

APPENDIX

Countries in the regression sample for bilateral rates

With variation in exchange rate regime (82)
Afghanistan, Algeria, Argentina, Armenia, Azerbaijan, Bangladesh, Belarus, Botswana, Brazil, Burundi, Canada, Chile, China, Colombia, Costa Rica, Croatia, Cyprus, Czech Republic, Dominican Republic, Egypt, El Salvador, Ethiopia, Finland, Gambia, Greece, Guatemala, Guyana, Haiti, Honduras, Hungary, Iceland, India, Indonesia, Iran, Israel, Italy, Jamaica, Kazakhstan, Kenya, Korea, Kyrgyz Republic, Laos, Latvia, Madagascar, Malaysia, Maldives, Mauritania, Mauritius, Mexico, Moldova, Mongolia, Mozambique, Myanmar, Norway, Pakistan, Paraguay, Peru, Philippines, Poland, Portugal, Romania, Russia, Rwanda, Slovak Republic, Slovenia, Solomon Islands, South Africa, Sri Lanka, Sudan, Sweden, Thailand, Tonga, Trinidad and Tobago, Tunisia, Uganda, Ukraine, United Kingdom, Uruguay, Venezuela, Vietnam, Zambia and Zimbabwe.

Without variation in exchange rate regime (57)
Albania, Aruba, Australia, Austria, Bahamas, Bahrain, Barbados, Belgium, Bolivia, Brunei Darussalam, Bulgaria, Cambodia, Cape Verde, Democratic Republic of Congo, Denmark, Ecuador, Estonia, Fiji, France, Georgia, Germany, Ghana, Hong Kong, Ireland, Japan, Jordan, Kuwait, Lebanon, Lesotho, Liberia, Libya, Lithuania, Luxembourg, Macedonia, Malawi, Malta, Morocco, Nepal, Netherlands, Netherlands Antilles, New Zealand, Nicaragua, Nigeria, Oman, Qatar, Samoa, Saudi Arabia, Seychelles, Sierra Leone, Singapore, Spain, Suriname, Swaziland, Switzerland (United States), Syria, Tanzania and Turkey.

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