UNIVERSITY OF NOTTINGHAM

Discussion Papers in Economics

Discussion Paper
No. 06/03

FUNDAMENTALS AND EXCHANGE RATE VOLATILITY

by Michael Bleaney

February 2006

DP 06/03

ISSN 1360-2438

UNIVERSITY OF NOTTINGHAM

Discussion Papers in Economics

Discussion Paper
No. 06/03

FUNDAMENTALS AND EXCHANGE RATE VOLATILITY

By Michael Bleaney

Michael Bleaney is Professor, School of Economics, University of Nottingham

February 2006

Fundamentals and Exchange Rate Volatility

by

Michael Bleaney

School of Economics
University of Nottingham
Nottingham NG7 2RD, U.K.
e-mail: michael.bleaney@nottingham.ac.uk
Tel. (+44) 115 951 5464
Fax. (+44) 115 951 4159

Abstract
Fundamentals may determine the range of real exchange rate fluctuation, through signals of misalignment, even if they are not a major influence on the level within that range. This can explain the puzzle that more open economies experience lower real exchange rate volatility. Adjustment of domestic prices to nominal exchange rate movements can account for only a small proportion of this effect. Sustainability analysis focuses on the ratio of the current account to GDP (rather than to total trade flows) as a misalignment signal, which implies narrower bounds for real exchange rates in more open economies.

Keywords: openness, real exchange rate volatility

JEL Nos: F31, F41

Acknowledgement
The author wishes to thank Liliana Castilleja Vargas for excellent research assistance.

1. INTRODUCTION

The well-known result of Meese and Rogoff (1983) that exchange rate models perform poorly out of sample has stood the test of time (Cheung *et al*., 2005; McCracken and Sapp, 2005). The lack of correlation of exchange rates with observed fundamentals is consistent with the asset-price interpretation of exchange rates, although there is some evidence of correlation with future fundamentals, as present-value models with rational expectations would suggest (Engel and West, 2005). Here it is argued that, although the fundamentals may do little to determine exchange rates within their observed range of fluctuation, they are probably important in setting the *width* of that range – a notion that clearly has much in common with non-linear models of mean-reversion. It will be shown that this can explain the empirically observed phenomenon that more open economies have less volatile real exchange rates, which is otherwise a puzzle, because the current account sustainability condition implies tighter boundaries on exchange rate fluctuation in economies that are less open to international trade.

The negative correlation between real exchange rate volatility and openness has been demonstrated both for bilateral rates (Devereux and Lane, 2003) and for effective rates (Hau, 2002). A further phenomenon, which we do not investigate here, is that less developed economies experience greater real exchange rate volatility (Hausmann *et al*., 2004). An obvious hypothesis is that, if prices in more open economies adjust more to exchange rate movements, then more open economies will experience less real exchange rate volatility for the same nominal exchange rate volatility. Hence, for the same volatility of nominal shocks, more open economies will experience less real exchange rate volatility (Hau, 2002). It is shown here that this effect, although statistically significant, is too small to explain the phenomenon. The cross-country pattern of nominal exchange rate volatility is virtually identical to that for real exchange rate volatility, no doubt because widespread pricing-to-market behaviour in advanced economies, combined with the weight of non-tradeables in the consumer price index, strongly attenuates any effect of exchange rate movements on the price level. The cross-country pattern of nominal exchange rate volatility does not match the cross-country pattern of nominal shocks. While nominal variables, such as monetary growth or relative inflation rates, are no less volatile in more open economies, the nominal exchange rate is much less volatile. This reflects the fact that the nominal exchange rate is the price of an asset traded in deep and liquid markets, so that its short-term movements have little to do with shocks to fundamentals.

2. A POSSIBLE EXPLANATION

An alternative explanation of the real exchange rate volatility puzzle is as follows. It is well known that real exchange rates exhibit near-random walk behaviour, but possibly only within certain bounds, outside which there is significant mean-reversion. This idea has been tested through various non-linear models, with some empirical support. Because real exchange rates spend the vast majority of their time within the random-walk range, empirically observed real exchange rate volatility will reflect the width of that range. If real exchange rates follow a bounded random walk, but the bounds are wider for less open economies, then less open economies will in practice experience greater real exchange rate volatility.

Theoretical models that attempt to account for this behaviour have postulated an exchange market populated by “fundamentalists” and “chartists” (Frankel and Froot, 1986a, 1986b; Kubelec, 2004). Fundamentalists believe in reversion towards an equilibrium, but may differ amongst themselves in their beliefs about the equilibrium level of the real exchange rate (Jeanne and Rose, 2002). Chartists believe that the real exchange rate is a non-stationary variable, and thus ignore potential signals of disequilibrium such as current account deficits. In these models there is a close relationship between the range over which the real exchange rate is likely to vary and the uncertainty amongst fundamentalists about the true equilibrium. Once almost all fundamentalists are convinced that an exchange rate is overvalued, for example, then the resulting selling pressure is likely to push the rate down. Consequently the upper bound to the exchange rate will reflect what fundamentalists regard as a clear signal of overvaluation. According to this view, therefore, real exchange rate volatility will be strongly influenced by the market’s concept of a signal of fundamental disequilibrium.

The remainder of the paper is organised as follows. Section Three develops a simple theoretical model. The empirics of exchange rate volatility are investigated in Section Four. The concept of misalignment is discussed in Section Five, and its relationship to exchange rate volatility in Section Six. Section Seven concludes.

3. A SIMPLE MODEL OF THE FOREIGN EXCHANGE MARKET

The challenge in theoretical models of the foreign exchange market is to reconcile the near-random-walk behaviour of exchange rates with the idea that fundamentals matter. There is empirical support for non-linear models which imply that fundamentals become important outside a certain range (Bleaney and Mizen, 1996; Michael *et al*., 1997; Sollis *et al*., 2002). These empirical models do not, however, yield insights into the determinants of the volatility of a particular currency, since their estimated parameters have no economic meaning – they simply reflect the observed pattern of the data. In this section, we develop the idea that volatility is determined by signals of misalignment, based on the model of Frankel and Froot (1986a, b).

In Frankel and Froot's model, the foreign exchange market is populated by "fundamentalists" and "chartists", who supply exchange-rate forecasts to portfolio managers. The log of the exchange rate (foreign currency units per unit of domestic currrency) at time *t* is denoted s_t. Portfolio managers are the only agents active in the foreign exchange market, and generate their own forecasts as a weighted average of the two groups of forecasters. Chartists believe that exchange rates are non-stationary and use some ARIMA(p, 1, q) model to generate forecasts. Fundamentalists believe that exchange rates will revert to equilibrium at some predetermined rate, but it is realistic to assume that they are not certain what the equilibrium is, since even estimates by economists have quite wide confidence intervals (Bénassy-Quéré *et al*., 2004; Wren-Lewis and Driver, 1998). Suppose that fundamentalist *j* believes at time *t* that the equilibrium is S_{jt}, and let the mean of these beliefs across all fundamentalists be S_t.[1] The log of the exchange rate as forecast at time *t* by the chartists, fundamentalists and portfolio managers are respectively s_{t+1}^c, s_{t+1}^f and s_{t+1}^m. Then we have

$$s_{t+1}^m = w\, s_{t+1}^f + (1-w)\, s_{t+1}^c \qquad (1)$$

[1] It is at this point that the model diverges from that of Frankel and Froot (1986), who assume that *S* is known but that *w* varies according to the past forecasting performance of the two groups.

$$s_{t+1}^{f} = s_t + \mu \int_{j=0}^{1} (S_{jt} - s_t)dj = \mu S_t + (1-\mu) s_t \tag{2}$$

Equation (1) expresses portfolio managers' forecasts as a weighted average of those of fundamentalists and chartists, and equation (2) represents fundamentalists' average forecast as a constant rate of mean reversion to the average of their beliefs about the equilibrium rate. As in Frankel and Froot (1986a) and Engel and West (2005), the actual exchange rate is determined in a generic way consistent with a wide range of models, as the sum of the fundamentals (Z) and a term based on the expected level of the exchange rate:

$$s_t = a s_{t+1}^{m} + z_t \tag{3}$$

Substituting from equations (1) and (2) and rearranging yields:

$$s_t = \frac{a(1-w) s_{t+1}^{c} + aw\mu S_t + z_t}{1 - aw(1-\mu)} \tag{4}$$

Equation (4) says that the exchange rate is a linear combination of chartist forecasts, fundamentalists' beliefs about the equilibrium and the fundamentals. Fundamentalists' beliefs about the equilibrium are updated in the light of empirical data about the economy, and these data inevitably relate to the current exchange rate. This suggests that news that is interpreted as a signal of significant exchange rate misalignment is particularly powerful information. Fundamentalists who were previously uncertain whether the exchange rate was misaligned are forced to adjust their beliefs. For example, the announcement of a large current account deficit convinces more fundamentalists that the exchange rate is over-valued. Through (4), this adjustment of fundamentalists' beliefs exerts a pressure pulling the exchange rate back towards equilibrium (S_t falls). The exchange rate can still appreciate, if the fundamentals improve or if chartist forecasts are more bullish, but it can only do so in the face of a stiff headwind in the opposite direction from fundamentalist opinion.

4. NOMINAL SHOCKS AND EXCHANGE RATE VOLATILITY

In many macroeconomic models nominal shocks (i.e. shocks to monetary growth or relative prices) have significant exchange rate effects. It has been repeatedly shown, however, that these models help little in explaining empirical exchange rate behaviour. In this section we examine the correlation with trade openness of the volatility of the first difference of (a) monetary growth, (b) home inflation relative to trade-weighted foreign inflation, (c) the nominal effective exchange rate (in logs), and (d) the real effective exchange rate based on consumer prices (in logs). Table 1 shows the results for OECD countries over the period from the first quarter of 1980 to the third quarter of 2005 (the picture is similar if we use data only up to the last quarter of 1998, before European Monetary Union). Openness is not significantly correlated with the two measures of the volatility of nominal shocks, but it is significantly correlated with both nominal and real effective exchange rate volatility at the 0.01 level. The correlations are even stronger with the log of openness, which reduces the importance of differences at the top end of the scale. Since countries are arranged in increasing order of openness in Table 1, these correlations are apparent by inspection. Table 1 also shows the standard deviation of the real exchange rate *level*, whose cross-country pattern is very similar to that of the standard deviation of quarterly changes. This means that the results are robust to alternative measures of volatility (short-run or long-run variation). Note that exchange rate volatility is not correlated with the volatility of nominal shocks.

Table 1. Volatility of nominal shocks and exchange rates across countries, 1980-2005

Country	Volatility of: Monetary growth	Relative inflation	Change in nominal EER	Change in real EER	Level of real EER	Trade as % GDP in 1990
	(1)	(2)	(3)	(4)	(5)	(6)
United States	2.75	9.98	3.35	2.95	11.6	19.3
Japan	3.37	10.11	4.49	4.50	18.7	21.2
Australia	3.85	5.38	4.09	3.93	12.7	34.9
Spain	2.81	7.42	2.00	2.08	8.4	37.5
Italy	2.58	6.46	2.22	2.23	7.6	40.1
France	8.74	5.06	1.58	1.44	4.1	47.6
Finland	29.37	9.03	2.25	2.29	9.8	48.1
Canada	4.38	10.4	2.01	2.30	11.0	50.8
United Kingdom	4.56	6.46	3.16	3.30	9.7	51.3
New Zealand	6.43	7.49	3.68	3.69	9.3	54.3
Germany	3.37	12.77	1.70	1.82	5.3	55.0
Sweden	2.52	9.96	2.86	2.95	9.9	61.4
Iceland	7.60	12.55	3.13	2.70	6.7	67.2
Denmark	5.02	6.84	1.50	1.47	5.7	70.0
Norway	6.02	6.58	1.81	1.82	3.8	74.5
Austria	2.95	7.48	1.05	0.99	5.3	79.1
Switzerland	5.11	6.75	2.26	2.17	6.6	85.6
Netherlands	2.69	6.99	1.54	1.42	3.8	109.0
Ireland	12.19	10.64	2.10	2.06	5.3	110.8
Belgium	4.04	5.58	1.55	1.37	4.6	141.2
Correlation with openness	0.017	–0.161	–0.564**	–0.593**	–0.684***	1
Correlation with ln (openness)	0.074	–0.155	–0.636**	–0.641***	–0.772***	
Correlation with change in ln (NEER)	–0.063	0.183	1	0.984***	0.833***	–0.636**

Notes. Columns (1) – (5) are standard deviations, using quarterly observations from 1980q1 to 2005q3, of: (1) change in annualised percentage money growth; (2) second difference in trade-weighted log relative prices (the ratio of the real to the nominal effective exchange rate index), times 1000; (3) change in log nominal effective exchange rate, times 100; (4) change in CPI-based log real effective exchange rate, times 100; (5) level of log real effective exchange rate, times 100 (source: IFS). Column (6) is exports plus imports as a percentage of GDP in 1990 (source: WDI). Iceland figures are based on 1986-2005 only, because of high inflation in 1980-5. *,**,*** denote significant at the 0.05, 0.01 and 0.001 levels respectively.

Table 2 shows that there is a significant element of truth to the idea that relative prices adjust to offset nominal exchange rate movements in more open economies. The table shows a regression for home inflation relative to trade-weighted foreign inflation by country over the period 1980q1 to 2005q3. As expected, in almost all countries relative inflation rates fall when the nominal exchange rate appreciates, after allowing for persistence in relative inflation rates (as in Table 1, the countries are ordered by openness). Moreover the effect tends to be larger in the more open economies towards the foot of the table, although the United States stands out as a significant exception to this. Table 3 shows the effect of estimating the same regression for all twenty countries as a panel, and (in column (2)) allowing the coefficients to vary with openness. The impact of openness on the response of relative inflation rates to exchange rate movements is statistically significant. Nevertheless the effect is small, and an extra 100 per cent in the ratio of trade to GDP appears to increase the exchange-rate elasticity of relative inflation rates by only six percentage points. This is clearly insufficient to explain why relatively closed economies like Australia, Japan and the United States have more than twice as high a standard deviation of real effective exchange rate movements as the most open economies.

Table 2. Adjustment of relative inflation rates to nominal exchange rates, 1980-2005

Country	Dependent variable: change in log trade-weighted relative prices (home divided by foreign)	
	Coefficient of lagged change in relative prices (*t*-statistic)	Coefficient of change in log nominal effective exchange rate (*t*-stat.)
	(1)	(2)
United States	0.005 (0.06)	–0.137 (–7.48)
Japan	0.248 (2.45)	–0.016 (–0.90)
Australia	0.766 (12.76)	–0.038 (–3.08)
Spain	0.397 (4.29)	–0.030 (–0.93)
Italy	0.645 (8.36)	–0.021 (–0.78)
France	0.395 (4.20)	–0.082 (–2.74)
Finland	0.065 (0.64)	–0.031 (–1.03)
Canada	0.292 (2.99)	0.039 (0.91)
United Kingdom	0.391 (4.27)	0.015 (0.91)
New Zealand	0.774 (12.18)	–0.042 (–2.22)
Germany	0.203 (2.04)	–0.119 (–2.05)
Sweden	0.231 (2.28)	–0.028 (–0.21)
Iceland	0.653 (8.90)	–0.119 (–2.60)
Denmark	0.180 (1.82)	–0.084 (–2.40)
Norway	0.446 (4.87)	–0.050 (–1.59)
Austria	–0.028 (–0.28)	–0.192 (–3.76)
Switzerland	0.206 (2.21)	–0.066 (–2.93)
Netherlands	0.330 (3.63)	–0.133 (–3.56)
Ireland	0.501 (6.11)	–0.122 (–2.82)
Belgium	0.148 (1.72)	–0.143 (–5.66)

Notes. The table shows the coefficients from a regression of $\Delta\ln(RP)$ on lagged $\Delta\ln(RP)$ and $\Delta\ln(NEER)$, by country, using quarterly data 1980q1 to 2005q3 (1986q1 to 2005q3 for Iceland). NEER – nominal effective exchange rate; RP – home prices divided by trade-weighted foreign prices, derived as the ratio of the real to the nominal exchange rate index.

Table 3. Panel regression of relative inflation on nominal exchange rates

	Dependent variable: Δln(RP)	
	(1)	(2)
constant	0.000428** (2.61)	0.000665 (1.76)
Lagged Δln(RP)	0.523*** (28.6)	0.538*** (11.4)
Δln(NEER)	–0.058*** (–9.20)	–0.026 (–1.92)
Openness ratio		–0.00037 (–0.70)
Openness*Lagged Δln(RP)		–0.0261 (–0.37)
Openness*Δln(NEER)		–0.065** (–2.67)
Sample size	1958	1958
R-squared	0.336	0.339
Standard error	0.0072	0.0072

Notes. See notes to Tables 1 and 2. *,**,*** denote significant at the 0.05, 0.01 and 0.001 levels respectively.

5. SIGNALS OF DISEQUILIBRIUM IN THE EXCHANGE MARKET

The analysis in Section Three suggests that the economics profession's understanding of what constitutes exchange rate misalignment, by informing fundamentalists' assessments, will strongly influence the observed volatility of exchange rates. This is an important aspect of the argument – because fundamentalists rely on economic analysis, the assessments of the economics profession matter.

What then are the economics profession's criteria for assessing misalignment? Recent discussion of the large deficits of the United States demonstrates that it comes down to the sustainability of current account balances – an exchange rate is not misaligned if the current account balance is sustainable (Bergsten and Williamson, 2004; Cline, 2005; Mann, 1999). Advanced countries are not likely to face the same credit constraints as developing countries in financing current account deficits. The only question then is whether the indefinite continuation of a given current account balance would conflict with the principles of portfolio diversification, because of the implied accumulation of foreign assets on one side or the other. If N is the net asset position of the country, CA is the current account balance (c as a ratio to GDP), and Y is GDP, which grows at a rate g, then, because $CA = \Delta N$, an equilibrium is reached when

$$\frac{N}{Y} = \frac{c}{g} \qquad (5)$$

At this equilibrium, the growth rate of N is just equal to that of Y. If N/Y gets very large in absolute value, investors may require higher expected returns on foreign assets, implying currency movements that reduce current account imbalances. Mussa (2004) suggests that for the United States N/Y cannot go lower than –1, so that if g is 5 per cent p.a., the sustainable current account deficit cannot exceed 5 per cent (Cline (2005) provides further discussion of these issues).

For present purposes, the issue is not the limits to N/Y, but why GDP is universally treated as the appropriate scale factor. The answer is that, from the point of view of portfolio allocation, it is the best measure of a country's weight in world production. There is no reason why a country should form a lower proportion of an ideal world portfolio just because, for example, its trade/GDP ratio is low. So long as the liquidity of the currency is not in question, its foreign exchange earnings are not relevant. To summarise: sustainability analysis suggests that the ratio of the current account balance to GDP, rather than to its trade flows, should be treated as the principal signal of misalignment.

6. THE EMPIRICS OF TRADE FLOW ADJUSTMENT

The final element in the argument is that the elasticity of trade flows with respect to the real exchange rate is similar across countries. If that is the case, then more open economies will experience larger fluctuations in their current account balance, *as a ratio of GDP*, for given real exchange rate volatility. If, as argued above, it is the ratio of the current account balance to GDP that sets the limit to real exchange rate volatility, then those limits will be narrower for more open economies.

Evidence on this point is presented in Table 4. Table 4 presents the results of regressing the change in the trade surplus *as a proportion of total trade* on the change in the log terms of trade and current and lagged changes in the log real effective exchange rate, for a panel of 22 OECD countries over the period 1975-2004. In the second column, the exchange rate coefficients are allowed to vary with openness. They are similar in sign but approximately equal in absolute magnitude, which suggests that openness accelerates the effect of real exchange rate movements on trade flows, but does not increase it in the long run. In the third and fourth columns, the exercise is repeated for the current account balance as a proportion of total trade, with very similar results.

Since the real exchange rate elasticities of trade flows as a proportion of total trade are not obviously smaller for more open economies, the implication is that real exchange rate fluctuations will have larger effects on their current account balances *as a proportion of GDP*, and therefore on the assessment of sustainability.

Table 4. Trade Balances, Current Account Balances and Real Exchange Rates

	Change in trade balance/total trade		Change in current account balance/total trade	
	(1)	(2)	(3)	(4)
Constant	0.00185 (1.67)	–0.00013 (–0.05)	0.00106 (0.85)	0.00001 (0.00)
Change in ln terms of trade	0.320 (9.68)	0.319 (9.62)	0.381 (10.3)	0.378 (10.2)
Change in ln REER	–0.109 (–4.79)	–0.027 (–0.59)	–0.139 (–5.43)	–0.044 (–0.85)
Lagged change in ln REER	–0.077 (–4.17)	–0.181 (–4.40)	–0.077 (–3.73)	–0.180 (–3.90)
Openness		0.00331 (0.90)		0.00186 (0.44)
Openness*Change in ln REER		–0.164 (–2.05)		–0.189 (–2.09)
Openness*Lagged change in ln REER		0.206 (2.85)		0.202 (2.50)
Sample size	576	576	570	570
R-squared	0.162	0.178	0.176	0.189
Standard error	0.0266	0.0264	0.0297	0.0295

Notes. Estimated as a panel of annual data for 22 OECD countries, 1975-2004. REER – real effective exchange rate index; Openness – exports + imports divided by GDP.

7. CONCLUSION

It has been argued here that the correlation of real exchange rate volatility with trade openness is evidence that fundamentals matter in determining the range over which exchange rates fluctuate. The adjustment of domestic prices to exchange rate movements can only explain a small proportion of the phenomenon, and consequently the cross-country pattern of nominal exchange rate volatility is strikingly similar to that for real exchange rate volatility, and not related to shocks to nominal variables such as monetary growth or relative inflation rates. Theoretical models suggest that exchange rates are likely to struggle to reach values where 100 per cent of fundamentalist opinion believes them to be over- or under-valued, because of the resulting pressure to revert towards equilibrium. For the economics profession (and implicitly therefore for fundamentalist opinion in the market), misalignments tend to be judged by the sustainability of current account positions. Since sustainability is defined in terms of the implied long-run net asset position as a ratio of GDP, it is the current account balance as a ratio of GDP rather than as a ratio of total trade flows that is taken as a signal of misalignment. More open economies have higher ratios of trade flows to GDP, so their current account/GDP ratios react more strongly to real exchange rate movements. Consequently, their real effective exchange rates fluctuate within a narrower range.

More broadly, this paper may be regarded as resurrecting the importance of fundamentals in the determination of exchange rates. Fundamentals may not explain why the real exchange rate is at a certain level at a certain date, but they can explain why it is rarely observed outside a certain range. Economists have long suspected this to be the case, but have had difficulty in identifying evidence to support this hypothesis.

REFERENCES

Bénassy-Quéré, A., P. Duran-Vigneron, A. Lahrèche-Révil and V. Mignon (2004) Burden sharing and misalignments within the group of twenty, Ch. 4 of Bergsten and Williamson (2004).

Bergsten, C.F. and J. Williamson (eds) (2004) *Dollar Adjustment: How Far? Against What?* Washington, DC: Institute for International Economics.

Bleaney, M.F. and Mizen, P.D. (1996) Non-linearities in exchange-rate dynamics, *Economic Record* 72 (216), 36-45.

Cheung, Y.-W., M.D. Chinn and A. Garcia Pascual (2005) Empirical exchange rate models of the nineties: are any fit to survive? *Journal of International Money and Finance* 24, 1150-75.

Cline, W.R. (2005) *The United States as a Debtor Nation*, Washington, DC: Institute for International Economics.

Devereux, M.B. and Lane, P.R. (2003) Understanding bilateral exchange rate volatility, *Journal of International Economics* 60, 109-32.

Engel, C. and K.D. West (2005) Exchange rates and fundamentals, *Journal of Political Economy* 113, 485-517.

Frankel, J.A. and K. Froot (1986a) The dollar as a speculative bubble: a tale of fundamentalists and chartists, Working Paper no. 1854, *National Bureau of Economic Research*.

Frankel, J.A. and K. Froot (1986b) Understanding the US dollar in the eighties: the expectations of fundamentalists and chartists, *Economic Record* Supplement, 24-38.

Hau, H. (2002) Real exchange rate volatility and economic openness: theory and evidence, *Journal of Money, Credit and Banking* 34 (3), 611-30.

Hausmann, R., U. Panizza and R. Rigobon (2004) The long-run volatility puzzle of the real exchange rate, Working Paper no. 10751, *National Bureau of Economic Research.*

Jeanne, O. and A. Rose (2002) Noise trading and exchange rate regimes, *Quarterly Journal of Economics* 117, 537-70.

Kubelec C. (2004) Intervention when exchange rate misalignments are large, Ch. 10 of Bergsten and Williamson (2004).

McCracken, M.W. and S.G. Sapp (2005) Evaluating the predictability of exchange rates using long-horizon regressions: mind your *p*'s and *q*s! *Journal of Money, Credit and Banking* 37, 473-94.

Mann, C. (1999) *Is the U.S. Trade Deficit Sustainable?* Washington, DC: Institute for International Economics.

Meese, R. and K. Rogoff (1983) Empirical exchange rate models of the seventies: do they fit out of sample? *Journal of International Economics* 14, 3-24.

Michael , P., A.R. Nobay and D.A. Peel (1997) Transactions costs and nonlinear adjustment in real exchange rates: an empirical investigation, *Journal of Political Economy* 105, 862-79.

Mussa, M. (2004) Exchange rate adjustments needed to reduce global payments imbalances, Ch. 5 of Bergsten and Williamson (2004).

Sollis, R., S.J. Leybourne and P. Newbold (2002) Tests for symmetric and asymmetric nonlinear mean reversion in real exchange rates, *Journal of Money, Credit and Banking* 34 (3), 687-700.

Wren-Lewis, S. and R.L. Driver (1998) *Real Exchange Rates for the Year 2000*, Washington, DC: Institute for International Economics.