Using real world data, illustrate that the nominal exchange rate is more volatile than its so-called fundamentals. Show how one can model this excess volatility of the exchange rate

Niall Douglas

Firstly this paper shall analyse exchange rates between the US dollar against the British Pound, the Euro and the Brazilian Real (the latter being an example of an important developing world economy) showing that the exchange rate deviates substantially from the underlying performance of the economy. A review is then made of models explaining this behaviour and their performance in this regard.

The Empirical Record

Figure 1 shows the exchange rate volatility for the US dollar against the British Pound, the Euro and the Brazilian Real for the period 24th April 1987 to 24th April 2007[1]. The graph depicts the variation of each currency from their respective means to highlight the volatility more clearly with the Brazilian Real having the right hand scale being five times larger than the left.

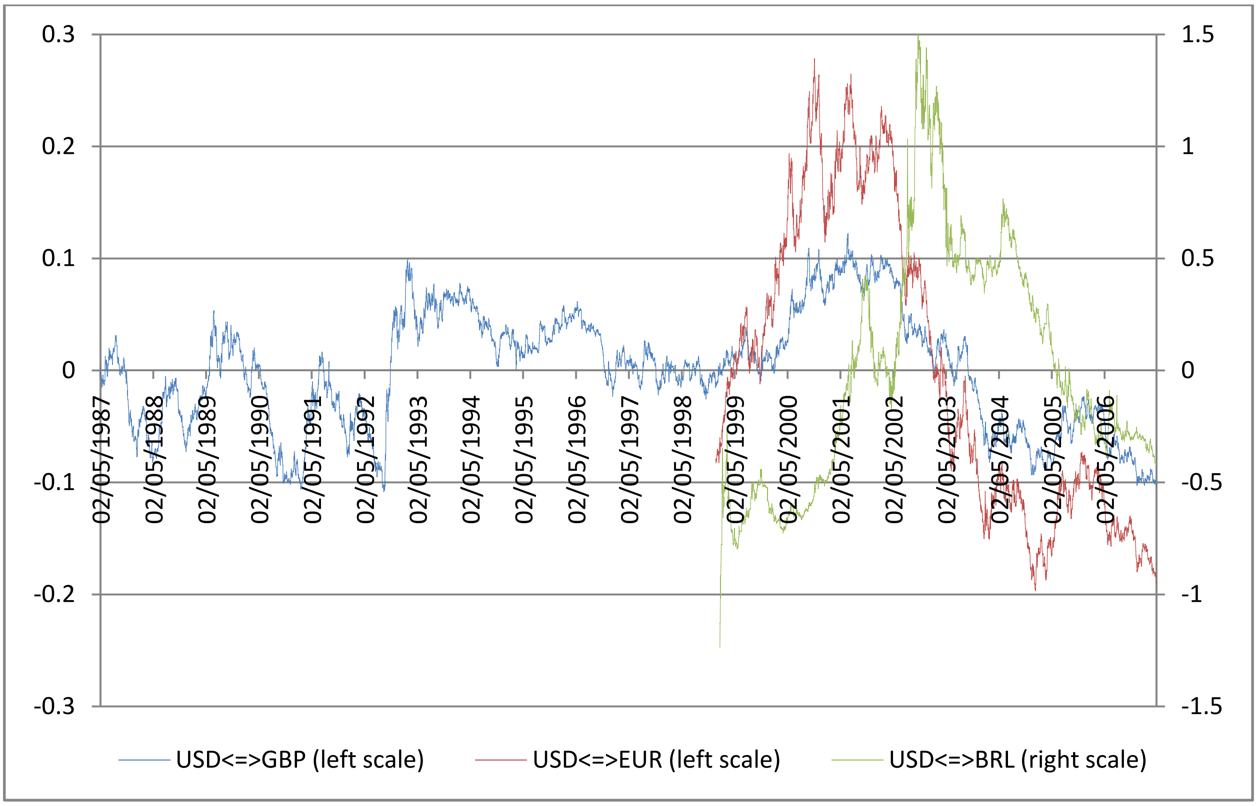

Figure 1: 1987-2007 deviations from their Means for US Dollar to Sterling, Euro and Brazilian Real

One thing obvious from this graph is that Sterling has the least volatility against the US dollar, the Euro more so and the Real considerably more so. Furthermore, the Euro and Sterling seem to track one another to a certain extent (which makes sense given the strong interdependence of these economies) whereas the Real tends to run opposite to the European currencies – when the Dollar/Europe rate is appreciating, the Dollar/Real rate is often depreciating.

[1] Source: http://www.oanda.com/convert/fxhistory. The Brazilian Real is only shown from where its peg to the US dollar was removed.

Figure 2 shows the fundamentals of real interest rate and inflation rate for the developed economies[2]:

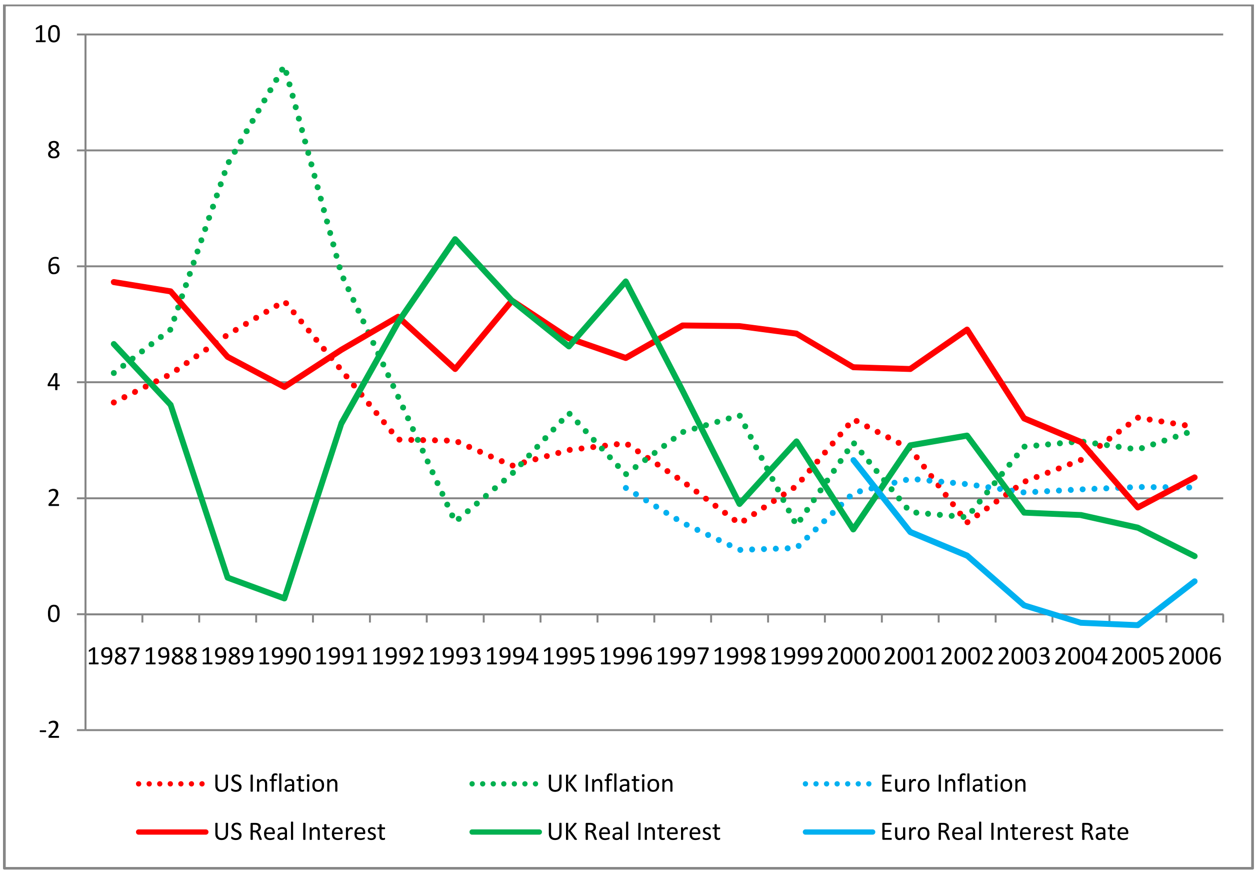

Figure 2: 1987-2006 Inflation & Real Interest Rates for US, UK & Eurozone

We now plot each exchange rate differential against the differential of its real interest rates:

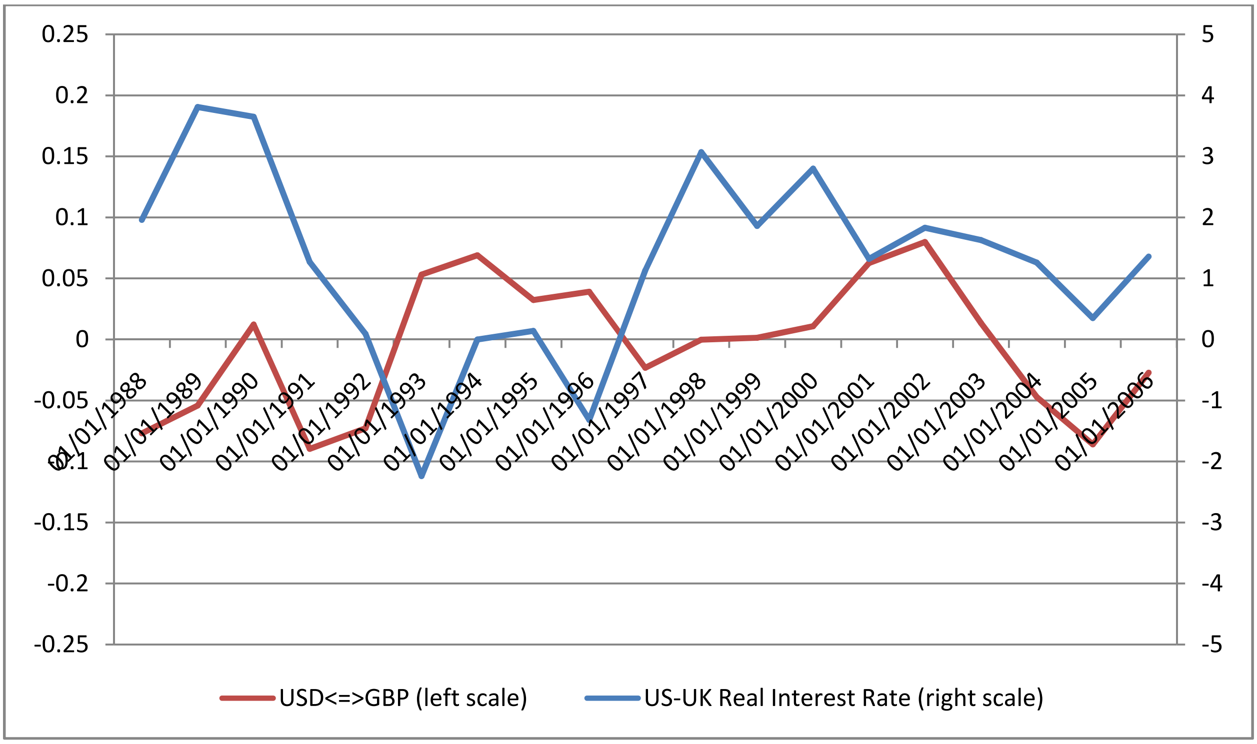

Figure 3: 1988-2006 US & UK exchange rate and Real Interest Rate

[2] Source: http://www.measuringworth.com/ and http://www.ecb.eu/. I was unable to find a comprehensive history for Brazil's economic indicators and so it is not mentioned here again.

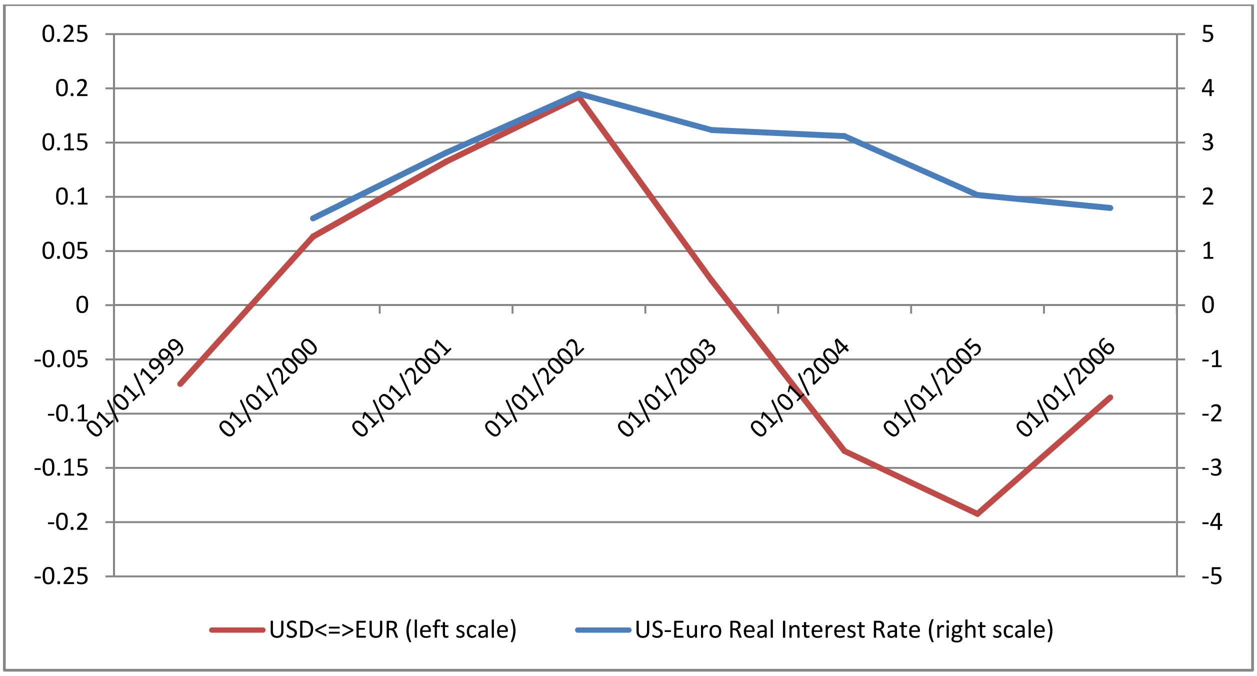

Figure 4: 1999-2006 US & Euro exchange rate and Real Interest Rate

As one can clearly see, there are short term effects of real interest rate on exchange rate, but it is clear that other factors are at play. Perhaps GDP growth rate is important[3]?

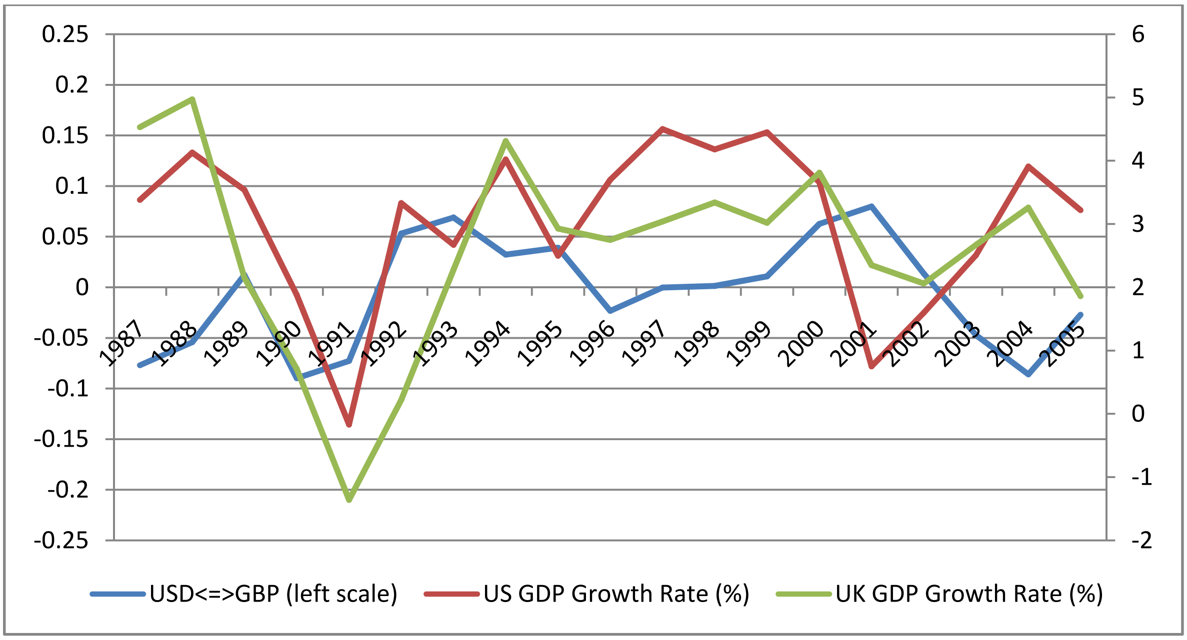

Figure 5: 1987-2005 Exchange Rate and GDP growth rates for US and UK

Here we see a strong link between US & UK GDP growth which makes sense as both are leading world economies. Furthermore, we see a clear appreciation of Sterling when US growth is low even if UK growth is also low and an appreciation of the dollar when US growth is high. This makes sense as Sterling has a lower volatility than the dollar due to a more rigid economy and therefore is more of a 'safe haven' when the world economy is doing badly.

[3] Source: http://www.measuringworth.com/

Another fundamental of an economy is the current account[4]:

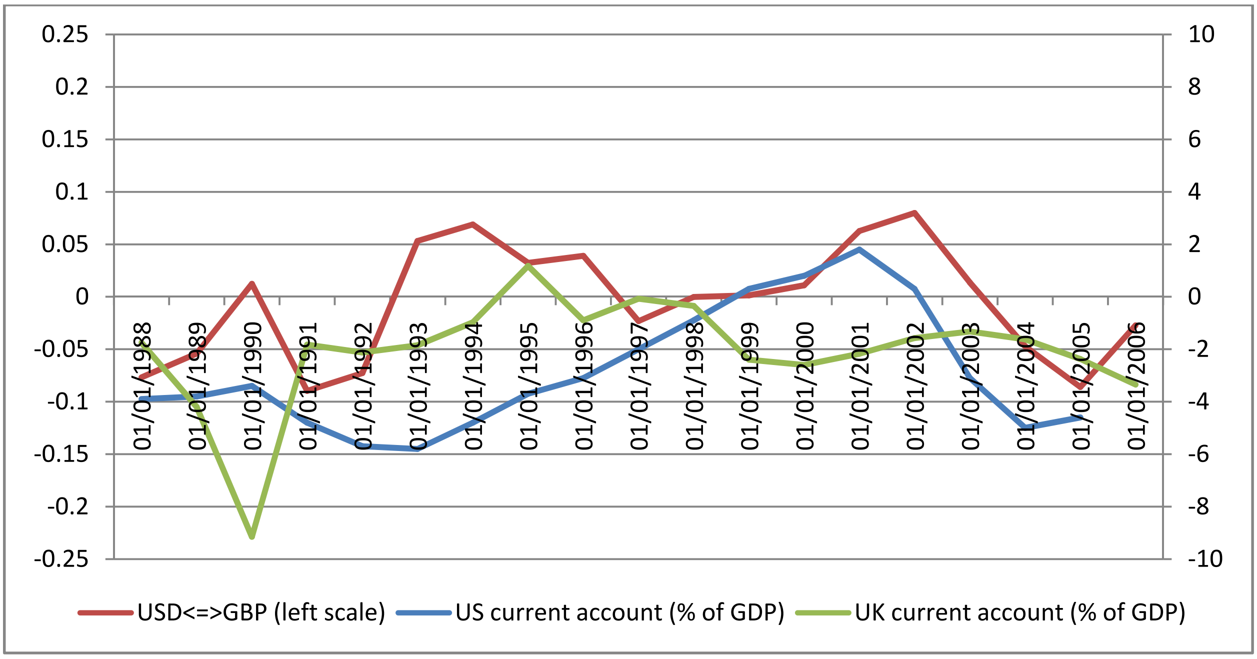

Figure 6: 1988-2006 US & UK Exchange Rate and Current Accounts

There is also some effect of the current accounts on the exchange rate, but less so than the real exchange rate differential or GDP growth in the US. These last four graphs all plot an annualised view of the exchange rate, so clearly there is both more volatility in the short term AND in the long term where the exchange rate deviates substantially from these three fundamentals. Another important fundamental is the real oil price, but as all economies pay the same price for oil, this tends to retard growth uniformly except in the case of the US which can use its dollar hegemony to borrow against the rest of the world (Tavlas, 1998).

Modelling the Excess Volatility

According to the IMF (Jerome, 1995), four factors are held as fundamental determinants of long-run real US dollar exchange rates with other currencies:

- The international real interest rate differential
- Relative prices in the traded and non-traded goods sectors
- The real oil price
- The relative fiscal position

These four fundamentals generate a Natural Real Exchange Rate (NATREX) which according to the author, captures the essential behaviour of the exchange rate over the long-term. Excess volatility is seen effectively as nearly random noise. Yet as we shall shortly see, the empirical evidence is poor for even the G-7 countries, and non-existent for developing nation currencies where very large deviations from fundamentals persist for as long as we have records. So from where did this established theory arise[5]?

The original Hicks (1937) reformulation of Keynes' *General Theory* (1936) proposed an IS-LM model which does not account for any excess volatility – the exchange rate should exactly account for saving and investment differentials. This very obviously does not match real world behaviour, so Dornbusch (1976) proposed a model which allowed exchange rates to overshoot a Pareto efficient equilibrium due to a phenomenon called 'price stickiness' whereby menu costs for changing prices may introduce an inefficiency which causes long-term deviation from fundamentals.

[4] Source: http://www.whitehouse.gov/omb/budget/fy2006/pdf/hist.pdf and http://www.statistics.gov.uk/.
[5] Some of the following discussion is based on the preamble to Sergio Da Silva's seminal 2004 paper.

The problem with the Dornbusch model, as noted by Obstfeld & Rogoff (1995), is that its empirical support is weak. There are regularities in the exchange rate movements which cannot be explained by the Dornbusch model – also, the Dornbusch model cannot be reduced easily to microeconomic foundations which is a problem for some Economists (Froot & Rogoff, 1995).

An alternative approach is to inter-temporally model the current account of the country as proposed by Sachs (1981). A variant on this is to model the marginal rate of transformation between traded and non-traded goods. As shown in our empirical analysis earlier, the current account has the weakest correlation to actual exchange rates of any of the fundamentals above and it does no more than the Dornbusch model to explain excess volatility.

Most damming of all for these orthodox models was that a random walk was found to predict the data better than these models based on fundamentals (Meese & Rogoff, 1983, 1998). Some enhancement to the complexity of the error term has returned these models to predicting better than a random walk over a long-term (e.g.; Mark 1995, or Obstfeld & Rogoff's [1995] "redux" model), but I personally think that more is at work here.

Everything in Nature has been found to observe a non-linear fractal topology (Capra 1997; Ormerod 1998, 2005) which often approximates a Gaussian distribution at smaller ranges and thus gives the impression of linearity. At wider ranges, power laws will begin to emerge due to the inherent properties of fractal topologies (*emergent properties*). As noted as early as Hotelling (1929) and more recently by Arthur (1999), non-linear dynamic systems will behave "properly" until the feedback loops become sufficiently violent to generate out-of-equilibrium outcomes. This precise "problem" also affects micro-economics as my EC3201 essay illustrated, causing fundamental indeterminacy unless the extremely restrictive Sonnenshein-Mantel-Debreu (SMD) assumptions are made. As Mas-Colell's (1995) *Microeconomic Theory* says in Section 20F (Equilibrium and Time), indeterminacy from relaxing the SMD conditions really means *chaotic* behaviour – multiple points of equilibrium, and total unpredictability from starting conditions.

Thankfully, there is now a growing body of research in Econophysics incorporating this reality and it offers far more powerful explanations of excess volatility. Da Silva (2004) is unpublished but heavily cited by other published papers and it shows that exchange rates follow a Lévy Distribution. My own research for my MN3101 (Corporate Finance) essay on Market Efficiency showed the disparity between what a rational investor in an efficient stock market should generate as a system versus reality:

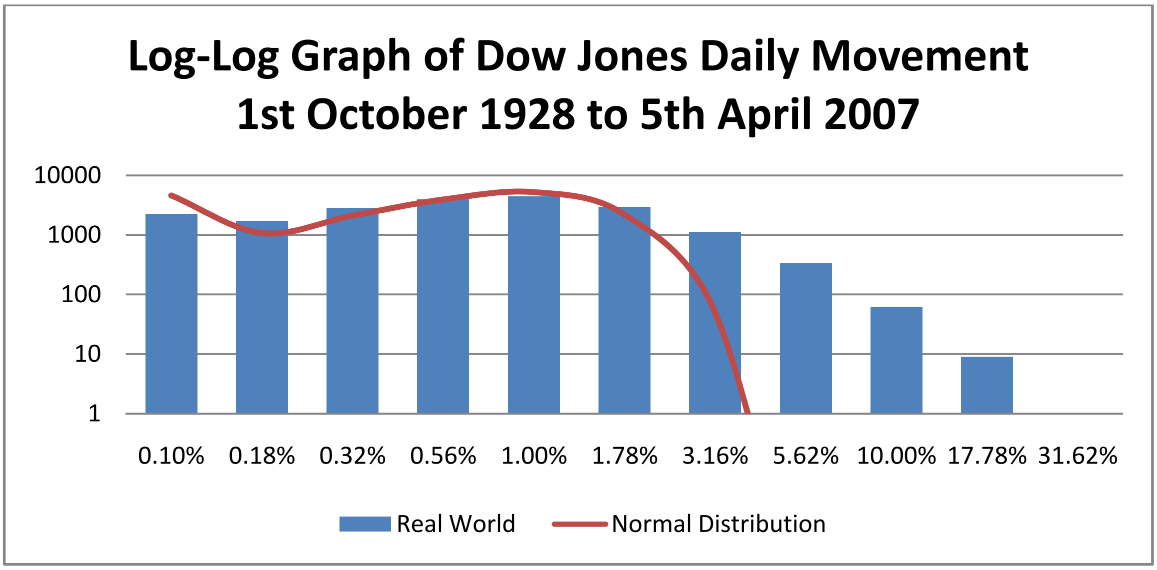

Figure 7: Predicted versus Actual behaviour in the US stock market

As one can see, large movements in the stock market happen far more often than they should, and all stock markets have this property. This behaviour fits a power law distribution, typical of a non-linear fractal system such as cognition itself (Capra 1997). Exchange Rates are a far more complex and dynamic system and unfortunately do not lend themselves to such easy analysis – hence I have not attempted the same here.

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