The Big Mac Index 21 Years On:
An Evaluation of Burgereconomics

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Abstract

The Big Mac Index, introduced by The Economist magazine 21 years ago, claims to provide the "true value" of a large number of currencies. This paper assesses the economic value of this index. We show that (i) the index suffers from a substantial bias; (ii) once the bias is allowed for, the index tracks exchange rates reasonably well over the medium to longer term in accordance with relative purchasing power parity theory; (iii) the index is at least as good as the industry standard, the random walk model, in predicting future currency values for all but short-term horizons; (iv) future nominal exchange rates are more responsive than prices to currency mispricing, but this split is difficult to determine precisely. While not perfect, at a cost of less than $US10 per year, the index seems to provide good value for money.

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1. Introduction

In 1972, just prior to the collapse of the Bretton-Woods system of fixed exchange rates, the US dollar cost about 40 British pence. By 1985, the dollar had appreciated to 90 pence, but by the end of February 2006 it had fallen back to 57 pence. As such substantial changes in currency values over the longer term are commonplace in a world of floating exchange rates, the understanding of the valuation of currencies is a significant intellectual challenge and of great importance for economic policy, the smooth functioning of financial markets, and the financial management of many international companies.

While exchange-rate economics is a controversial area, a substantial body of research now finds that over the longer term exchange rates are "anchored" by price levels. This idea is embodied in purchasing power parity (PPP) theory, which states that the exchange rate is proportional to the ratio of price levels in the two countries. To illustrate, Figure 1.1 uses annual data to plot the exchange rate (relative to the US dollar) of the United Kingdom and Japan and the ratio of their price level to that of the US. British prices increased relative to those in the US over the past 30 years, while those of Japan decreased. According to PPP theory, the British pound should have depreciated (an increase in the pound cost of the dollar), and the Japanese yen should have appreciated. This is what in fact happened. Even though at times the exchange rate deviates substantially from the price ratio, there is a distinct tendency for this ratio to play the role of the underlying trend, or anchor, for the exchange rate. That is to say, while the exchange rate meanders around the price ratio, over time it has a tendency to revert to this trend value, so the ratio can be thought of as the "underlying value" of the currency. Figure 1.1 thus provides some *prima facie* evidence in favour of PPP over the long term.

A new and simple way of making PPP comparisons was introduced in 1986 by The Economist magazine. This involves using the price of a Big Mac hamburger at home and abroad as the price ratio that reflects the underlying value of the currency. This price ratio is known as the "Big Mac Index" (BMI), which forms the basis for "burgernomics". When compared to the actual exchange rate, the BMI purports to give an indication of the extent to which a currency is over- or under-valued according to the law of one price. "[Seeking] to make exchange-rate theory more digestible" (The Economist, 9th April 1998), the Index has been published for 21 years for an increasing number of currencies (now more than 30) and is claimed to be a successful new product from a number of perspectives. In the words of The Economist:

> The [Big Mac] Index was first served up in September 1986 as a relatively simple way to calculate the over- and under-valuation of currencies against the dollar. It soon caught on. Such was its popularity that it was updated the following January, and has now become the best-known regular feature in The Economist.[1]

In an instructive metaphor, The Economist (26th August 1995) describes the approach underlying the BMI in the following terms:

> Suppose a man climbs five feet up a sea wall, then climbs down twelve feet. Whether he drowns or not depends upon how high above sea-level he was when he started. The same problem arises in deciding whether currencies are under- or over-valued."

[1] From "Ten Years of the Big Mac Index", published on The Economist web site (http://www.economist.com). The Economist also publishes other similar PPP gauges. The "Coca-Cola map" appeared in the magazine in 1997 and shows a strong positive correlation between per capita consumption of Coke in a country and that country's quality of life. In 2004, the "Tall Latte Index" was proposed, which is based on the price of a cup of Tall Latte coffee at Starbucks in more than 30 countries. This index provides roughly similar, albeit not identical, results to the BMI. Inspired by such single-good indices, other institutions have devised similar indices, such as the "iTunes Index" featured in Business Review Weekly, an Australian business magazine, in August 2006, and the "iPod Index" compiled by CommSec Australia in January 2007 (James, 2007a, b).

The current exchange rate is analogous to the position of the man on the sea wall and the PPP rate is the sea-level, so that whether the currency is correctly priced by the market is determined by reference to its PPP value. The identification of the PPP value of a currency with the sea-level also accords with the idea that "water finds its own level", so that over time the currency should tend to revert to its PPP value. While an informal currency pricing model, the BMI is rooted in PPP theory and provides a fascinating example of the productive interplay between fundamental economic research, journalism and financial markets.

The literature on PPP in general is large and growing, and several good surveys are available, including Froot and Rogoff (1995), Lan and Ong (2003), MacDonald (2007), Rogoff (1996), Sarno and Taylor (2002), Taylor and Taylor (2004) and Taylor (2006). Early contributors to academic research on the BMI include Annaert and Ceuster (1997), Click (1996), Cumby (1996), Ong (1997) and Pakko and Pollard (1996), while more recent papers include Chen et al. (2005), Clements and Lan (2006), Lan (2006) and Parsley and Wei (2007); a comprehensive review of the burgernomics literature is provided later in the paper. As a way of illustrating professional interest in PPP, we conducted a keyword search for the term "purchasing power parity" or "PPP" in Factiva.[2] As a basis for comparison, we also searched for four additional broad economic terms -- "inflation", "unemployment", "interest rate" and "exchange rate" -- and another relatively narrow term, "foreign direct investment" (or "FDI"), together with the "Big Mac Index". Figure 1.2 plots, on the left-hand axis, the number of articles published on each topic in each of the past three decades. As this axis uses a logarithmic scale, the change in the height of the bars from one decade to the next indicates the exponential rate of growth for each topic. The right-hand vertical axis gives the average growth rate, on an annual basis, for each topic. It can be seen that PPP has grown at an average annual rate of 32 percent p.a., which ranks immediately below FDI, while the BMI has the highest annual growth rate of nearly 40 percent. Thus while PPP and the BMI are still smaller than the four broader areas, they are clearly of substantial professional importance and growing rapidly.

This paper uses the occasion of the 21st anniversary of the introduction of the Big Mac Index to provide a broad evaluation of its workings and performance. We show that although it is not perfect, the Index offers considerable insight into the operation of currency markets. In Section 2, we set the scene by discussing PPP theory in some detail. Then follows in Section 3 an account of the workings of the BMI, where it is established that it is subject to a serious bias. Once the Index is adjusted for this bias, we show in Section 4 that exchange rates tend to revert to the mean, roughly speaking, after a period of about 4 years. Section 5 examines the predictive ability of the BMI and establishes that over- (under-) valued currencies subsequently appreciate (depreciate). How this effect is split between a future change in the nominal rate and inflation is discussed in Section 6. The possible role of the United Sates dollar in generating common shocks to all other currencies is explored in Section 7. Section 8 contains a survey of the literature on the Burgernomics and concluding comments are given in Section 9.

2. Three Versions of PPP

This section gives an account of PPP theory by presenting the three versions: (i) absolute PPP; (ii) relative PPP; and (iii) stochastic deviations from relative PPP. This material provides the theoretical underpinnings for the remainder of the paper.

Let P_i denote the domestic price of good i in terms of domestic currency and P_i^* the price of the same good in the foreign country in terms of foreign currency. With zero transaction costs and no barriers to international trade, arbitrage equalises the cost of the good expressed in terms of a common currency:

[2] For an earlier analysis along these lines, see Lan (2002).

(2.1) $$P_i = SP_i^*$$

where S is the spot exchange rate (the domestic currency cost of a unit of foreign currency). Equation (2.1) is known as the law of one price. The 2×2 structure of prices can be summarised as follows:

Currency	Location	
	Home	Foreign
Home	P_i	SP_i^*
Foreign	P_i / S	P_i^*

As prices in a given row are expressed in terms of the same currency, they are comparable "row-wise", not "column-wise".

Further, let w_i and w_i^* denote the share of good i in the economy at home and abroad, with $\sum_{i=1}^n w_i = \sum_{i=1}^n w_i^* = 1$, where n is the number of goods. Then multiplying both sides of equation (2.1) by w_i and summing over $i = 1,\ldots,n$, we obtain

$$\sum_{i=1}^{n} w_i P_i = S\sum_{i=1}^{n} w_i P_i^*.$$

As the left-hand side of this equation is a share-weighted average of the n prices at home, it is interpreted as a price index, which we write as $P = \sum_{i=1}^n w_i P_i$. But as the right-hand side of the above equation applies domestic weights to foreign prices, it is not a conventional price index. To make some progress, we need the simplifying assumption that the foreign and domestic weights coincide, so that $\sum_{i=1}^n w_i P_i^* = \sum_{i=1}^n w_i^* P_i^* = P^*$, an index of the price level abroad. Thus we have

(2.2) $$P = SP^*,$$

which is an economy-wide version of condition (2.1). We can interpret P as the domestic currency cost of a basket of goods at home, while P^* is the cost of the same basket abroad. Thus SP^* converts this foreign currency cost into domestic currency units and the ratio $P/(SP^*)$ is a measure of the relative price of the two baskets. Expressing equation (2.2) as $S = P/P^*$, we obtain the absolute version of PPP, whereby the exchange rate is the ratio of domestic to foreign prices. Using lowercase letters to denote logarithmic values of variables, we obtain

(2.3) $$s = p - p^*.$$

Writing $r = p - p^*$ for relative prices, the above can be expressed as $s = r$.

Next, we define the home country's real exchange rate as

(2.4) $$q = \log\frac{P}{SP^*},$$

which is the logarithmic relative price of the two baskets. According to absolute PPP, the real exchange rate $q = p - s - p^* = r - s = 0$, and is constant. When $q > 0$, prices at home are too high relative to those abroad, and the currency is said to be "overvalued in real terms", and vice-versa. If there is a tendency for the real rate to revert to it PPP value, a non-zero value of q signals some form of disequilibrium calling for future readjustments of prices and/or the exchange rate.

Before proceeding, it is worthwhile to emphasise the restrictive conditions under which absolute parity holds. The assumption of zero transport costs and other barriers to trade rules out a "wedge" between foreign and domestic prices. It also serves to exclude from PPP considerations all non-traded goods, those goods that do not enter into international trade due to prohibitive transport costs. As in a developed economy non-traded goods constitute something like 70 percent of GDP, their exclusion would seem to limit drastically the applicability of PPP theory, at least in its absolute form. Below we return to transport costs and in the next section, we return to the related issue of non-traded goods. A further restrictive condition underlying PPP is the assumption that the market basket associated with the price index is identical in the two countries.

We now present a geometric exposition of PPP theory. The left graph of Panel A of Figure 2.1 presents the absolute PPP relationship, which is a 45-degree line passing through the origin. As this PPP line has a unit slope, any combination of s and r that lies on the line satisfies $s = r$, so that the real exchange rate $q = r - s = 0$. On this PPP line, an increase in the relative price from r_1 to r_2, for example, leads to an equi-proportional depreciation of the nominal exchange rate s, as is illustrated by the movement from point A to B, whereby $s_2 - s_1 = r_2 - r_1$. The PPP ray acts as a boundary that divides up the exchange rate/price space into two regions of mispricing. As shown on the right-hand graph of Panel A, points above the ray indicate an undervaluation of the home-country currency $(q < 0)$, where s is too high and/or r is too low. In this region, the price of the domestic basket (P) is below that of the foreign basket SP^*. Conversely, points below the PPP ray represent an overvalued domestic currency $(q > 0)$. Only at the boundary between these two regions is the currency correctly priced $(q = 0)$.

Let us now consider transport costs and any other barriers to the free flow of goods across borders that inhibit the equalisation of prices. With transport costs and other barriers, rather than having equation (2.1), we now have a generalisation $P_i = S(1+T_i)P_i^*$, where T_i measures the proportionate wedge between domestic and foreign prices, which for short we term "transport costs". If these costs are approximately constant over time, then

(2.5) $$\hat{P}_i = \hat{S} + \hat{P}_i^*,$$

where a circumflex ("^") represents relative change $(\hat{x} = dx/x)$. Equation (2.5) represents a weaker version of the law of one price as it is formulated in terms of changes not levels. We can then weight as before and aggregate over goods to obtain

(2.6) $$\hat{P} = \hat{S} + \hat{P}^*,$$

where $\hat{P} = \sum_{i=1}^{n} w_i \hat{P}_i$ is the change in the cost of the basket of goods at home and $\hat{P}^*$ is the corresponding change for the foreign country. As these measures are share-weighted averages of the (infinitesimal) changes in the n individual prices, they are interpreted as Divisia price indexes. Integrating equation (2.6) we obtain $P = KSP^*$, where K is a constant of integration, or in logarithmic form

(2.7) $$s = p - p^* - k.$$

This is the <u>relative version of PPP</u>. As $\hat{x} = dx/x = d(\log x)$, equation (2.7) implies

(2.8) $$\hat{S} = \hat{P} - \hat{P}^*,$$

where $\hat{P}$ and $\hat{P}^*$ are interpreted as inflation at home and abroad, respectively. In words, the proportionate change in the exchange rate is equal to the inflation differential. Thus high-inflation countries experience depreciating currencies and vice-versa, which is the open-economy version of the quantity theory of money. It is to be noted that equation (2.8) is just a rearrangement of equation (2.6). Note also that relative PPP expressed in (2.7) includes absolute PPP as a special case where k = 0, or $K = 1$ in $P = KSP^*$. To summarise, relative parity implies that the exchange rate is proportional to the price ratio, with the factor of proportionality not necessarily equal to unity. Under absolute parity, the proportionality factor is unity so that the exchange rate equals the price ratio.[3]

Geometrically, under relative PPP the relationship between s and the relative price $r = p - p^*$ is a straight line of the form $s = r - k$, which is presented on the left graph of Panel B of Figure 2.1. Along this line, the real exchange rate is $q = r - s = k$, which is constant. This relative PPP line also has a unit slope, but an intercept $-k \neq 0$. Again as we move up the line from A to B, an increase in the relative price still leads to an equiproportional depreciation in the nominal exchange rate, so that $s_2 - s_1 = r_2 - r_1$. As before, points above the relative PPP line correspond to an undervaluation of the domestic currency $(q - k < 0)$ and those below the line correspond to an overvaluation $(q - k > 0)$, but in comparison with absolute PPP, the boundary between the two regions is now "vertically displaced", as indicated by the graph given on the right-hand side of Panel B in Figure 2.1.

Panel C for Figure 2.1 gives the case of <u>stochastic PPP</u>.[4] If we denote the stochastic deviation from relative parity by e with $E(e) = 0$ and variance σ^2, the real exchange rate is then the random variable $q = k - e$ with $\text{var}(q) = \sigma^2 > 0$, so that q is obviously not constant. Initially, suppose for simplicity that e is a discrete random variable and that $e_1 < 0$ and $e_2 > 0$ are its only possible values. When the shock is $e_1 < 0$, we obtain a new, lower 45-degree line, $s = -k + e_1 + r$, which has an intercept of $-k + e_1$; similarly, $e_2 > 0$ results in the upper line on the left graph of Panel C. Consider the situation in which $\underline{s}$ is the exchange rate and r_1 is the relative price, so that we are located at the point W on the left graph of Panel C. If there is now the same increase in the relative price as before, so that r rises from r_1 to r_2, then, in the presence of the shock e_1, we move from W to the point X with the rate depreciating to s_0. But if the shock is e_2, the same relative price r_2 leads to an exchange rate of $\bar{s}$, as indicated by the point Y. More generally, if relative prices change within the range $[r_1, r_2]$ and if the shocks can now vary continuously within the range $[e_1, e_2]$, then the exchange-rate/relative-price points lie somewhere in the shaded parallelogram WXYZ. Thus the relationship between the exchange rate and prices is $s = r - k + e$, which is the stochastic version of PPP. Due to the random shocks e, the exchange rate and prices are no longer proportionate. It is to be noted that the height of the shaded parallelogram exceeds its base, which accords with the idea that exchange rates are much more volatile than prices in the short run (Frenkel and Mussa, 1980). However in the long run, as $E(e) = 0$ and thus $E(s) = r - k$, relative PPP holds and the expected value of the real exchange rate $E(q) = k$ is constant. Here k is the long-run, or equilibrium value of the real exchange rate.

Therefore in the case of stochastic PPP, the real exchange rate q is not constant and fluctuates around k, so that exchange rates and prices are scattered around the 45-degree line. This is in contrast to relative PPP, in which q is a constant value for any combination of s and r and all (s, r) pairs locate exactly on the 45-degree line. In other words, stochastic PPP means that there exists a "neutral band" around the 45-degree line that contains values of the exchange rate and prices that identify the currency as being "correctly priced". Under relative PPP, these points are interpreted as deviations from parity. Obviously, the width of the band is the key to this approach: if it is sufficiently wide, then all possible

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[3] A further issue about the distinction between absolute and relative PPP should be noted. Almost invariably statistical agencies publish information on the cost of a basket of goods in the form of a price index that has an arbitrary base, which determines the proportionality constant K. Such indexes can only be used for calculations of relative parity, not absolute.

[4] For an earlier rendition of stochastic PPP, see Lan (2002). For related work, see MacDonald and Stein (1999). Note also that MacDonald (2007, p. 42) considers PPP within an environment in which there are transaction costs in moving goods from one country to another. According to this broader version of PPP, there exists a "neutral band" within which exchange rates and prices can fluctuate.

configurations of exchange rates and prices would be contained in the band, and the approach would be vacuous. On the other hand, if the band is sufficiently narrow, all observations would locate outside it, and the approach would always be rejected. One way to strike a balance between the "too wide" and "too narrow" band problems is to proceed probabilistically.

Consider the probability distribution of the real exchange rate q with $E(q) = k$ and $var(q) = \sigma^2$. We commence with the symmetric case in which the probability of the exchange rate being undervalued $(q-k<0)$ is $\alpha/2$ and the same $\alpha/2$ is the probability of the currency being overvalued $(q-k>0)$, where $0<\alpha<1$. In other words, we can interpret $\alpha/2$ as the mass in each tail of the distribution, so that our task is to characterise the location of the tails. According to Chebyshev's inequality

$$\Pr\left(|q-k| > c\right) \le \frac{\sigma^2}{c^2},$$

where c is a positive constant. We interpret c as defining the boundary, so that $\alpha = \sigma^2/c^2$, or $c=\sqrt{\sigma^2/\alpha}$. Thus the lower bound is $k-\sqrt{\sigma^2/\alpha}$ and the upper bound is $k+\sqrt{\sigma^2/\alpha}$. The region of correct pricing is indicated in the area between the lines DD' and FF' on the right graph of Panel C, which is defined by

(2.9) $$k-\underline{z} \le q \le k+\overline{z},$$

where $\underline{z}=\overline{z}=\sqrt{\sigma^2/\alpha}$. The points above the line DD', which correspond to the case $q<k-\underline{z}$, indicate that the currency is undervalued, while points below the line FF' $(q>k+\overline{z})$ identify overvaluation. Statistically, if we have a number of observations on q, $\alpha\times 100$ percent of these would lie outside the band and the remaining $(1-\alpha)\times 100$ percent inside it. In the above situation, the deviations are symmetric around the mean, so that there are equal probabilities of currency undervaluation and overvaluation and $\underline{z} = \overline{z}$. In the more general case, the distribution of q is asymmetric and the long-run relative PPP line, EE', does not lie mid-way between the two boundaries DD' and FF'.

The above analysis does not hinge on q following any particular probability distribution -- it is distribution free. If we have information on the form of the distribution, then this additional information can be used to tighten the neutral band. Consider for the purpose of illustration the case of the normal distribution whereby $q \sim N(k,\sigma^2)$ and $\alpha = 0.05$. Under normality

$$\Pr\left[-1.96 < \frac{q-k}{\sigma} < 1.96\right] = 1-\alpha = 0.95,$$

so that the neutral band for q is $[k-1.96\sigma, k+1.96\sigma]$. Contrast the width of this band with that implied by the Chebyshev's inequality, expression (2.9). With $\alpha = 0.05$ as before, we have $\underline{z}=\overline{z}=\sqrt{\sigma^2/\alpha}=\sqrt{20}\sigma = 4.47\sigma$, so that the neutral band is $[k-4.47\sigma, k+4.47\sigma]$. Thus the width of the band under normality is $2\times 1.96\sigma$, while under Chebyshev's inequality, it is $2\times 4.47\sigma$, so that the additional information that the distribution is normal results in a shrinkage of the band by about 50 percent.

It is worth noting that this approach to currency valuation resembles hypothesis testing. To see this, imagine the existence of an unknown "true" state of the world in which the currency is either correctly or incorrectly priced, and we observe only whether or not the exchange-price configuration is located within the neutral band. There are four possible outcomes of the application of the approach:

(i) When the currency is in fact correctly priced and stochastic PPP identifies this situation accurately, i.e., the (s, r) point is located in the neutral band. As the inference is correct, the procedure works satisfactorily.
(ii) When the currency is in fact correctly priced, but stochastic PPP yields the conclusion that it is undervalued or overvalued. There is an $\alpha \times 100$ percent probability of this incorrect inference being drawn, which is analogous to a Type I error.
(iii) When the currency is in fact incorrectly priced, but stochastic PPP indicates that the currency is correctly priced. This is similar to the case of a Type II error.
(iv) When the currency is in fact incorrectly priced, and stochastic PPP accurately indicates that the currency is incorrectly priced. In this situation, the correct inference is drawn.

The above taxonomy is summarised in the following table:

True currency pricing	Does (s, r) lie in the neutral band?	
	Yes	No
Correct	Reliable inference	Type I error
Incorrect	Type II error	Reliable inference

To conclude this section, consider an arbitrary combination of s and r, which is represented by the same point C in all three right-hand graphs of Figure 2.1. As C lies above the PPP ray in Panels A and B, both absolute and relative PPP indicate that the currency is undervalued. However, according to stochastic PPP (Panel C), the currency is correctly priced as the point C lies within the neutral band. This situation is likely to be frequently encountered in practice with many apparent departures from parity simply associated with the inherent volatility of currency markets. For example, some departures may be insufficient to justify the costs of moving goods internationally and/or taking a currency position, especially if they are expected to soon reverse themselves. Therefore, to value a currency, it is crucial that the proper distinction be made between the three versions of PPP.

3. The Workings of the Big Mac Index

The previous section highlighted the restrictive conditions under which absolute parity holds, viz., (i) the absence of barriers to international trade, which also implies the absence of nontraded goods; and (ii) identical baskets underlying the price indexes in the home and foreign countries. The weaker condition of relative PPP largely avoids the first problem, which accounts for its more frequent use in practice, but the problem of identical baskets remains. Surprisingly, the Big Mac Index (BMI) uses absolute parity in the context of a single-good basket, a Big Mac hamburger. In this section, we illustrate the workings of the BMI and as it purports to have much to say about the workings of the real-world currency markets, we assess how the Index deals with the above two restrictive conditions and how it performs in practice.

Though just a single good, a McDonald's Big Mac hamburger has a variety of tradable ingredients such as ground beef, cheese, lettuce, onions, bread, etc., and non-tradable ingredients such as labour, rent, and electricity, as well as other ingredients such as cooking oil, pickles and sesame seeds. By estimating the Big Mac cost function using the prices of the various ingredients, Parsley and Wei (2007) recover the recipe in "broad" basket form. They find that the shares of important ingredients are:

Ingredient	Cost share (%)
Tradable	
Beef	9.0
Cheese	9.4

Bread	12.1	
		30.5
Nontradable		
Labour	45.6	
Rent	4.6	
Electricity	5.1	
		55.3
Other		14.2
Total		100.0

We can thus regard the price of a Big Mac as being the cost of a basket of inputs, just like P of the previous section is the cost of a market basket of goods. By comparing the price of a Big Mac in the US and other countries, The Economist magazine judges whether currencies are correctly priced based on the idea that a Big Mac should cost the same everywhere around the world when using a common currency. As the basket associated with the prices can be considered as being close to being identical in the home and foreign countries, the BMI cleverly avoids problem (ii) above associated with absolute PPP. But as transport costs and other trade barriers are not allowed when comparing prices, this is an application of absolute PPP.

As discussed in the previous section, the arbitrage foundation of absolute parity applies to traded goods only. But non-traded goods prices can also be related across countries for at least two reasons. First, if there is substitution between traded and nontraded goods in production and consumption, then in a broad class of general equilibrium models, the change in the price of non-traded goods $\left(\hat{P}_N\right)$ is a weighted average of the changes in the prices of importables and exportables $\left(\hat{P}_M, \hat{P}_X\right)$: $\hat{P}_N = \omega\hat{P}_M + (1-\omega)\hat{P}_X$, where $0 \leq \omega \leq 1$. Thus if nontraded goods are good substitutes for importables, the weight ω is large, so that the relative price P_N/P_M is approximately constant, while a large value of $1-\omega$ implies P_N/P_X is approximately constant (see Sjaastad, 1980, for details). Provided the weight ω is approximately the same at home and abroad, if PPP equalises the prices of traded goods across countries, then there is at least a tendency for the same to be true for their weighted average, the price of non-traded goods. However, as this link is based on substitution in production and consumption, it could possibly take some time for these relative price changes to work themselves through the economy and for there to be full adjustment. Second, there is an expectations mechanism that may be quite rapid in its operation. If producers of non-traded goods know of the above link between their prices and those of traded goods, they may reasonably base their price expectations on it. This could then mean that in setting prices, these producers could employ as a short-cut the rule that they change their prices as soon as the exchange rate varies. An example is the plumber in Buenos Aires who puts up his prices as soon as the peso falls. These arguments provide a rationale for the inclusion of elements of the cost of non-traded goods in PPP calculations, such as the Big Mac Index.

Figure 3.1 reproduces the Big Mac article published in The Economist of 27th May 2006. As can be seen from column 3 of the table, the implied PPP of the dollar is just the ratio of the domestic Big Mac price in domestic currency (column 1) to that in the US in terms of dollars (first entry in column 1). This ratio is the purchasing power of one US dollar in terms of Big Macs. However, the actual exchange rate, presented in column 4, may not be the same as this PPP exchange rate. Column 5 is the percentage difference between the PPP exchange rate and the actual exchange rate, a positive (negative) value of which indicates over (under) -valuation of a currency. An overvalued currency indicates that domestic prices are higher than foreign prices [$P/(SP^*) > 1$], and vice-versa. Take as an example Argentina, the second country from the top of the list in the table. The first and second entries in column 1 of the table within Figure 3.1 show that it costs US$3.10 to buy a Big Mac in the US, and 7.00 pesos in Argentina. Thus the implied PPP exchange rate is 7.00/3.10 = 2.26, as indicated by the second entry of column 3. As the actual exchange rate is 3.06, the Argentine peso is undervalued by $(2.26-3.06)/3.06=-26$ percent (see the first entry in the last column of the table). Given the value of the peso and US prices, Argentine prices are too low, so that a movement towards parity would require some combination of a rise in Argentine prices and an appreciation of the peso.

Tables A1 and A2 contain the implied PPP exchange rates and nominal exchange rates of all countries that have their Big Mac data published at least once in The Economist since the inception of the Big Mac Index in 1986. Tables 3.1 and 3.2 are the companion tables for the 24 countries that have all data available over the period of 1994-2006; these data will be used in all computations that follow. In the previous paragraph, we showed that for Argentina in 2006 the BMI is as much as 26 percent below the market exchange rate. An element-by-element comparison of the first row of Table 3.1 with that of Table 3.2 reveals that there are similar large differences in most other years for this country. As will be discussed further below, the same problem of large deviations from parity occurs for most other countries. As under absolute parity these differences should be zero, this is not particularly encouraging for the proposition that BMI has economic content.

One other feature of Tables 3.1 and 3.2 is worthy of note. The last columns of these tables give the coefficients of variations of the implied PPPs and exchange rates in each country, and Figure 3.2 is the associated scatter. The points corresponding to Brazil, Poland and Russia are located far away from those for the other countries, due to the volatility of monetary conditions in these countries associated with currency redenominations. The left panel of Figure 3.2 shows that in 17 out of the remaining 21 countries, as the points lie above the 45-degree line, the implied PPPs are less volatile than the corresponding exchange rates. This difference between the behaviour of exchange rates and prices was noted long ago by Frenkel and Mussa (1980) who attributed it to the essential distinction between the nature of asset and goods markets. The exchange rate is the price of foreign money and as such, behaves like the prices of other assets traded in deep, organised markets such as shares, bonds and some commodities. The determination of asset prices tends to be dominated by expectations concerning the future course of events. As expectations change due to the receipt of new information, which is unpredictable, the net result is that changes in asset prices themselves are largely unpredictable, giving rise to the substantial volatility of these prices. By contrast, goods prices tend to be determined in flow markets in which expectations play a much less prominent role. It is for this reason that goods prices tend to be more tranquil over time, reflecting changes in the familiar microeconomic factors of incomes, supply conditions, etc. The Big Mac data reflect this difference between the volatility of asset and goods prices.

Under PPP, $P=SP^{*}$, or $P/SP^{*}=1$. It is convenient to measure disparity logarithmically, so that for country c in year t, we define $q_{ct}=\log\left(P_{ct}/S_{ct}P_{t}^{*}\right)$, as in equation (2.4) where we referred to this measure as the real exchange rate. This q_{ct}, when multiplied by 100, is approximately the percentage difference between P_{ct}/P_{t}^{*} and S_{ct}, the measure of disparity (or under- or over-valuation) used by The Economist (given in column 5 of the table in Figure 3.1). Under absolute PPP, $q_{ct}=0$. Table 3.3 and Figure 3.3 give q_{ct} for each of the 24 countries over the 13-year period and as can be seen, there are frequent departures from absolute PPP. Additionally, in the majority of countries q_{ct} fluctuates a lot around its mean over the 13-year period; the exceptions to this general rule are Britain, China, Hong Kong and Poland. One striking pattern is the one-sided nature of the disparities. Among the 24 countries under investigation, ten countries -- Australia, China, the Czech Republic, Hong Kong, Hungary, Malaysia, Poland, Russia, Singapore and Thailand -- always have undervalued currencies.

The currencies of Britain, Demark and Switzerland are always overvalued, while the Canadian dollar, the Mexican peso and the New Zealand dollar are undervalued in all but one year. Moreover, the Swedish krona is overvalued in all years except one. Thus for almost $10+3+3+1=17$ cases out of a total of 24, the BMI declares the currencies to be continuously (or almost continuously) over- or under-valued for each of the 13 years. These strings of persistent disparities over a fairly lengthy period in two-thirds of the cases raise serious questions about the credibility of the BMI as a pricing rule for currencies. To assess the current value of a currency, it would seem desirable for a robust pricing rule to incorporate appropriately past mispricing. The sustained nature of the departures from PPP, departures that are distinctly one-sided, means that past mispricing is ignored by the BMI. Below, we explore further this problem.

To test the significance of the pattern of deviations from parity, we employ two tests, one based on a contingency table and the other a runs test. Consider again the signs of successive pricing errors. If these are independent, then the probability of the currency being over- or under-valued in year $t+1$ is unaffected by mispricing in year t. To examine this hypothesis, in Table 3.4 we tabulate the mispricing for all currencies in all years, cross-classified by sign in consecutive years t and $t+1$. As the observed χ^2 value is 183.8 (given in the last entry of the last column of the table), we reject the hypothesis of independence on a year-on-year basis. Next, we repeat this test with the horizon extended from 1 year to 2, 3, …, 12, and Table 3.5 reveals that independence is again rejected over most of these longer horizons whether or not overlapping observations are omitted.

Now consider a runs test. A run is a subsequence of consecutive numbers of the same sign, immediately preceded and followed by numbers of the opposite sign, or by the beginning or end of the sequence. If a currency is correctly priced, it is expected that the number of runs in the signs of the deviation is consistent with that of a random series. For example, the first row of Table 3.6 shows that for Argentina the signs of its q are $++++-+-------$, which comprise four runs. If there are T observations and positive and negative values occur randomly, then the number of runs, R, is a random variable with mean $E(R)=(T+2T_+T_-)/T$ and variance $\operatorname{var}R=2T_+T_-(2T_+T_- - T)/T^2(T-1)$, where T_+ and T_- are the total number of observations with positive and negative signs, respectively, with $T_+ + T_- = T$. Asymptotically, the distribution of R is normal and the test statistic $Z=\left[R-E(R)\right]/\sqrt{\operatorname{var}R} \sim N(0,1)$. The results, given in Table 3.6, show that the null of randomness is rejected for almost all of the 24 countries. Although this result is subject to the qualification that this test has only an asymptotic justification, the evidence against randomness seems to be reasonably compelling.

Next we test whether or not the disparities are significantly different from zero, which amounts to a test of bias in the BMI. The shaded regions of Figure 3.3 are the two-standard-error bands for the mean exchange rates. These bands include zero only for Argentina, Chile, Japan and South Korea, so we can reject the hypothesis that $q=0$ for the remaining 20 countries. In Figure 3.4 we present the mean real exchange rates with countries grouped into four regions. This figure reveals that all currencies except those for the five high-income European regions/countries -- the euro area, Britain, Sweden, Denmark and Switzerland -- are undervalued. It is notable that among the Asians, the currencies of China, Hong Kong, Malaysia and Thailand are all substantially undervalued.[5] As exchange rates are expressed relative to the US dollar, some inferences about the value of the dollar can

[5] The productivity-bias hypothesis of Balassa (1964) and Samuelson (1964) says that the currencies of rich (poor) countries are over (under) valued. While it is true that in Figure 3.4 the five countries (regions) with $q>0$ all have high incomes, countries with $q<0$ include Canada, Australia, New Zealand, Hong Kong and Singapore, all of which should probably also be classified as rich. Thus the evidence in Figure 3.4 does not provide unambiguous support for the productivity-bias hypothesis.

be drawn by averaging disparities over all non-dollar currencies, as is done in the third last row of Table 3.3. Thus we see that in 2006 on average the 24 currencies were undervalued by about 20 percent, which is equivalent to saying that the US dollar is overvalued by this amount. The value of the dollar over time is thus given by the entries of the third last row of Table 3.3 with the signs changed. Figure 3.5 plots these values of the dollar and as can be seen, it was most overvalued around 2001 and has been falling since then. The obvious qualification to this measure is that all 24 countries are equally weighted in valuing the dollar; more complex weighting schemes could be easily explored, but these would be unlikely to change the broad conclusion of an overvalued, but falling dollar.

Due to the 1997 Asian financial crisis, it is natural to divide the whole 13-year period into sub-periods, before and after 1997, as in Table 3.7. There are two notable features here. (i) In all but one country (Hong Kong, whose real exchange rate remains virtually unchanged), currencies become more undervalued (or less overvalued) following the Asian crisis. (ii) The changes in the means over the two periods are significant in 16 out of 24 countries. The results of testing the hypothesis that the real exchange rate is zero can be summarised as follows:

	Period		
	1994-1997 (%)	1998-2006 (%)	1994-2006 (%)
Significantly positive	38	17	21
Significantly negative	54	79	71
Insignificant	8	4	8
Total	100	100	100

Thus we see that sustained mispricing is almost the rule for the BMI. The BMI is meant to play the role of the long-term, or equilibrium exchange rate, to which the actual rate is attracted; in other words, an under- or overvaluation is meant to signal subsequent equilibrating adjustments of the exchange rate and/or prices. But lengthy periods of substantial, sustained and significant mispricing demonstrate that such a mechanism is not at work. In a fundamental sense the Big Mac Index fails, so that the Big Mac metric of currency mispricing cannot be taken at face value. In large part, the reason for this failure is that the BMI relies on absolute PPP, which ignores barriers to international trade. Fortunately, a simple modification to the BMI restores its predictive power, as is shown in the section after the next.

To summarise this section, we have established the following:

- The BMI uses the cost of a Big Mac hamburger as the metric for judging whether or not the currency is mispriced. As this product is made according to approximately the same recipe in all countries, the BMI avoids one of the major problems usually associated with absolute PPP. That problem is that the baskets underlying price indexes at home and abroad are likely to be substantially different, so that the ratio of the indexes reflects a combination of compositional disparities, as well as currency fundamentals.
- A well-known empirical regularity is that exchange rates are more volatile than prices. The Big Mac prices reflect this regularity.
- There are substantial, sustained and significant deviations of exchange rates from the BMI. The under- and over-valuations of currencies based on the BMI published by The Economist cannot be accepted as a reliable measure of mispricing. The BMI needs to be enhanced before it has substantial practical power.

4. The Bias-Adjusted BMI and the Speed of Adjustment

The above discussion implies that the BMI is a biased indicator of absolute currency values. Thus rather than absolute PPP holding in the form of $S = P/P^*$, we have $S = B\left(P/P^*\right)$, where B is the bias, or $s = b + p - p^*$ in logarithmic terms. This, of course, is just relative PPP of Section 2 with $B = 1/K$ or $b = -k$. In this section, we analyse the extent to which the bias-adjusted BMI tracks exchange rates by formulating it in terms of changes over time, $\Delta s = \Delta p - \Delta p^*$.

To proceed we have to specify the length of the horizon for exchange-rate and price changes.[6] For any positive variable X_t $(t = 1,\ldots,T)$, define $\Delta_{(h)}x_t = \log X_t - \log X_{t-h}$ as the logarithmic h-year change and $\Delta^{(h)}x_t = (1/h)\Delta_{(h)}x_t$ as the corresponding annualised change, $h = 1,\ldots, T-1$, $t = h+1,\ldots,T$. As $\Delta^{(h)}x_t = (1/h)\sum_{s=0}^{h-1}\Delta_{(1)}x_{t-s} = (1/h)\sum_{s=0}^{h-1}(x_{t-s} - x_{t-s-1})$, the annualised change over a horizon of h years is the average of the h one-year changes. Writing $r_{ct} = p_{ct} - p_t^*$ for the Big Mac price in country c in terms of that in the US (as before), relative PPP implies that, for horizon h, $\Delta_{(h)}s_{ct} = \Delta_{(h)}r_{ct}$, or dividing both sides by h,

$$\Delta^{(h)}s_{ct} = \Delta^{(h)}r_{ct}. \tag{4.1}$$

Equation (4.1) states that exchange-rate changes are equal to the relative price changes. To examine the content of this equation, we initially set h = 1 and plot one-year exchange rates changes against the corresponding price changes for all countries. The graph on the top left-hand corner of Figure 4.1 contains the results. As can be seen, there is considerable dispersion around the solid 45-degree line, with a root-mean-squared error (RMSE) of 14 percent. This RMSE is the square root of the ratio of $\sum_c\sum_t\left(\Delta_{(1)}r_{ct} - \Delta_{(1)}s_{ct}\right)^2$ to the number of observations, which measures the dispersion of real exchange rate changes over a one-year horizon. In the other panels of the figure, the horizon h increases, the points become noticeably closer to the 45-degree line and the RMSE falls continuously to end up at 2 percent for $h = 12$ years. To clarify matters, Figure 4.2 provides a blow up of the graphs for h = 1, 6 and 12. This reveals that the European countries (the darker points) tend to lie closer to the PPP line.

To shed more light on the decrease in volatility as the horizon increases, consider the following parsimonious data-generating process for the real exchange rate

$$q_t = \alpha + \beta q_{t-1} + \varepsilon_t, \tag{4.2}$$

where α and β are constants and the random disturbance term ε_t is iid, independent of q_{t-1}, with a zero mean and variance σ_ε^2. Figure 3.3 showed that there is considerable persistence in the behaviour of q over time, which could be consistent with model (4.2) with a high value of β. The stationarity of the real rate implies $0 < \beta < 1$, and the variance of q is $\sigma^2 = \sigma_\varepsilon^2/(1-\beta^2)$. On the other hand, if q follows a random walk, we have $\beta = 1$, so that $q_t = \alpha + q_{t-1} + \varepsilon_t = (t - t_0)\alpha + q_{t_0} + \sum_{s=t_0+1}^{t}\varepsilon_s$, where q_{t_0} is the initial value. Hence, its variance at time t is $\sigma_t^2 = (t - t_0)\sigma_\varepsilon^2$ if the initial value is treated as fixed.

To examine the variance of the annualised change over horizon h, $\Delta^{(h)}q_t$, consider first the stationary case, in which $0 < \beta < 1$. Equation (4.2) implies $q_t - q_{t-h} = \beta(q_{t-1} - q_{t-h-1}) + \varepsilon_t - \varepsilon_{t-h}$ $(h > 0)$, which can be written as $\Delta^{(h)}q_t = \beta\Delta^{(h)}q_{t-1} + \Delta^{(h)}\varepsilon_t$, so that

$$\text{var}\left[\Delta^{(h)}q_t\right] = \beta^2\,\text{var}\left[\Delta^{(h)}q_t\right] + \frac{2}{h^2}\sigma_\varepsilon^2 - \frac{2\beta}{h}\text{cov}\left[\Delta^{(h)}q_{t-1}, \varepsilon_{t-h}\right].$$

The covariance term in the above is

$$\text{cov}\left[\Delta^{(h)}q_{t-1}, \varepsilon_{t-h}\right] = \begin{cases} \text{cov}\left[q_{t-1} - q_{t-2}, \varepsilon_{t-1}\right] = \text{cov}\left[q_{t-1}, \varepsilon_{t-1}\right] = \sigma_\varepsilon^2 & \text{if } h = 1 \\ \text{cov}\left[q_{t-1} - q_{t-h-1}, \varepsilon_{t-h}\right] = 0 & \text{if } h > 1, \end{cases}$$

[6] For related analyses, see Flood and Taylor (1996), Isard (1995, p. 49), Lothian (1985) and Obstfeld (1995).

so that

$$(4.3) \qquad \mathrm{var}\left[\Delta^{(h)} q_t\right] = \begin{cases} \dfrac{2(1-\beta)}{1-\beta^2}\sigma_\varepsilon^2 = \dfrac{2}{1+\beta}\sigma_\varepsilon^2 & \text{if } h = 1 \\ \dfrac{2}{h^2(1-\beta^2)}\sigma_\varepsilon^2 & \text{if } h > 1. \end{cases}$$

Therefore, we can see that $\mathrm{var}\left[\Delta^{(h)} q_t\right]$ decreases when the horizon h increases for the stationary case. This is represented in Panel A of Figure 4.3 by the point A and the reciprocal quadratic curve of the form $\mathrm{var}\left[\Delta^{(h)} q_t\right] \propto 1/h^2$, with $\beta = 0.6$.

If $\beta = 1$, equation (4.2) implies that $q_t - q_{t-h} = h\alpha + \sum_{s=t-h+1}^{t} \varepsilon_s$. When divided by h, we have $\Delta^{(h)} q_t = \alpha + \frac{1}{h}\sum_{s=t-h+1}^{t} \varepsilon_s$, so that

$$(4.4) \qquad \mathrm{var}\left[\Delta^{(h)} q_t\right] = \frac{1}{h^2}\,\mathrm{var}\left[\sum_{s=t-h+1}^{t} \varepsilon_s\right] = \frac{\sigma_\varepsilon^2}{h},$$

which is represented in Panel A of Figure 4.3 by the reciprocal curve of the form $\mathrm{var}\left[\Delta^{(h)} q_t\right] \propto 1/h$. We can see that here $\mathrm{var}\left[\Delta^{(h)} q_t\right]$ also declines, but at rate h, which is slower than the AR(1) case. This contrast is more apparent by considering total volatility $\mathrm{var}\left[\Delta_{(h)} q_t\right] = h^2\,\mathrm{var}\left[\Delta^{(h)} q_t\right]$. From equations (4.3) for $h > 1$ and (4.4), we have

$$(4.5) \qquad \mathrm{var}\left[\Delta_{(h)} q_t\right] = \begin{cases} \dfrac{2}{1-\beta^2}\sigma_\varepsilon^2 & \beta < 1 \\ h\sigma_\varepsilon^2 & \beta = 1, \end{cases}$$

which is constant when $\beta < 1$ and increases linearly when $\beta = 1$, as indicated in Panel B of Figure 4.3.

Equation (4.5) is a key result that shows that when the real rate is stationary, the total volatility is constant as the length of the horizon expands, while it increases in the non-stationary case. Although this is based on the simple AR(1) model, the implications carry over to more general cases. For a given horizon h, the RMSE of Figure 4.1 is the standard deviation of the annualised changes, or an estimate of $\sqrt{\mathrm{var}\left[\Delta^{(h)} q_t\right]}$. Thus $h \times \mathrm{RMSE}$ is the standard deviation of the total changes, $\sqrt{\mathrm{var}\left[\Delta_{(h)} q_t\right]}$, which under stationarity will also be constant with respect to h. We use the RMSEs from Figure 4.1 in Figure 4.4 to plot $h \times \mathrm{RMSE}$ against the horizon. As can be seen, total volatility first increases and after about 3 years fluctuates within a band that is less than 10 percentage points wide. It seems not unreasonable to interpret this evidence as saying real rates are stationary, that is, relative purchasing parity holds at longer horizons.

The above analysis shows that the speed of adjustment of exchange rates to prices is not rapid, which presumably reflects transaction costs, informational costs, sticky prices due to contracts and menu costs, etc. But over the medium-term of more than three years, the tendency for exchange rates to reflect PPP is clear. In the context of the discussion of Section 2, it seems that stochastic PPP with a relatively a high value of the variance σ^2 is the way to think of the relationship between exchange rates and prices in the short term.

5. Does the BMI Predict Future Currency Movements?

In this section, we examine the predictive power of the Big Mac Index by asking the question, can a currency be expected to appreciate (depreciate) in the future if it is currently undervalued (overvalued)? And if it does mean revert in this manner, how long does it take? For an early analysis along these lines, see Cumby (1996).

As our objective is to examine the information contained in the current BMI regarding future currency values, we start by defining the horizon for future changes in the real rate as

(5.1) $$\Delta_{(h)}q_{t+h} = q_{t+h} - q_t,$$

which is the future change in q from the year t to $t+h$. This total change in q over h years is just the sum of the corresponding h annual changes, $\Delta_{(h)}q_{t+h} = \sum_{s=0}^{h-1}\Delta_{(1)}q_{t+h-s} = \sum_{s=0}^{h-1}(q_{t+h-s} - q_{t+h-s-1})$. Regarding current mispricing, the use of q_t would not be satisfactory due to the bias identified above. Instead we use

(5.2) $$d_t = q_t - \overline{q},$$

with $\overline{q}$ the sample mean, which can be interpreted as the equilibrium exchange rate. Thus now the currency is over (under) valued if $d_t > 0$ (< 0). Under PPP, deviations from parity die out, so that if $d_t > 0$ (< 0), the future value q_{t+h} decreases (increases) relative to the current value q_t. To examine whether this is the case, we plot in Figure 5.1 the subsequent changes $\Delta_{(h)}q_{t+h}$ against d_t using the 24-country Big Mac data for horizons of $h = 1,...,12$ years. PPP predicts that the points lie in the second and fourth quadrants of the graphs, and Figure 5.1 shows this is indeed mostly the case with the pattern becoming more pronounced as the horizon increases. To examine the statistical significance of this pattern, we first carry out a χ^2-test of the independence of $\Delta_{(h)}q_{t+h}$ and d_t.[7] The test statistic is contained in the top box of each graph in Figure 5.1, and is significant for all horizons except 11 and 12 years (for which there are few observations), so we can reject independence. Figure 5.2 plots the test statistic against the horizon h and it can be seen that a maximum is reached for a horizon of $h = 5$ or 6, so that in this sense the current deviation best predicts subsequent changes over a five- or six-year horizon.

In each panel of Figure 5.1 we also report the least-squares estimates of the predictive regression

(5.3) $$\Delta_{(h)}q_{t+h} = \eta^h + \phi^h d_t + u_t^h,$$

where, for horizon h, η^h is the intercept, ϕ^h the slope and u_t^h a zero-mean disturbance term. Panel A of Table 5.1 reproduces the estimates of this regression in the first line for each horizon, while column 6 reproduces the χ^2 values discussed in the previous paragraph; the information in column 7 will be discussed subsequently. To examine the effect of inclusion of an intercept, we report for each horizon the slope coefficient when the intercept is suppressed, and the results are qualitatively similar. Panel B of Table 5.1 redoes the analysis with non-overlapping observations only, and in all four sets of results -- overlapping and non-overlapping, with and without an intercept -- the slope coefficient is significantly negative, indicating that the adjustment goes in the expected direction.

To further interpret equation (5.3), we combine equations (5.1), (5.2) and (5.3) to obtain

(5.4) $$q_{t+h} = \left(\eta^h - \phi^h\overline{q}\right) + \left(\phi^h + 1\right)q_t + u_t^h.$$

Under PPP, q_{t+h} converges to the equilibrium value $\overline{q}$, so that

(5.5) $$\eta^h = 0, \qquad \phi^h = -1.$$

A test of restriction (5.5) reveals whether or not there is full adjustment to mispricing over horizon h. The F-statistics for (5.5) are presented in column 7 of Table 5.1 for the overlapping and non-overlapping cases. For the purposes of testing, the results for the non-overlapping case are more

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[7] This test is based on a 2×2 contingency table with rows the sign of d_t and columns the sign of $\Delta_{(h)}q_{t+h}$.

reliable and as can be seen from Panel B, the F-statistic is minimised for a three-year horizon and is not significant. The F-statistic is also not significant for a five- and six-year horizons, but is significant for all other horizons. These results point to the conclusion that roughly speaking, over a period of three to six years there is more or less full adjustment of the rate to mispricing.

Figure 5.3 plots the estimated intercepts and slopes, η^h and ϕ^h, against the horizon when overlapping observations are omitted. Three comments can be made. First, the intercepts are negative for most horizons, but many of the 95-percent confidence intervals include zero. Second, the slope generally decreases with h and the 95-percent confidence interval includes -1 for horizons 3 to 6 years. As the absolute value of ϕ^h is the fraction of the total adjustment that occurs over horizon h, it is reasonable for a larger share of the adjustment to be completed over a longer horizon. Third, we should possibly pay more attention to the estimated slope, rather than the intercept. If, for some reason, the equilibrium rate differs from the mean $\overline{q}$, then the difference would be absorbed into the intercept which becomes non-zero even if PPP holds.

Next, consider as an illustrative example the AR(1) case, equation (4.2), $q_t = \alpha + \beta q_{t-1} + \varepsilon_t$, so that

$$(5.6) \qquad q_{t+h} = \frac{\alpha(1-\beta^{h-1})}{1-\beta} + \beta^h q_t + \sum_{j=1}^{h} \beta^{h-j} \varepsilon_{t+j}.$$

Equating the intercepts and slopes of the right-hand-sides of equations (5.4) and (5.6), we have $\left(\eta^h - \phi^h \overline{q}\right) = \alpha\left(1-\beta^{h-1}\right) / \left(1-\beta\right)$, $\left(\phi^h + 1\right) = \beta^h$, or

$$(5.7) \qquad \eta^h = \overline{q}\beta^h \left(1 - \frac{1}{\beta}\right), \qquad \phi^h = \beta^h - 1.$$

We use $\overline{q} = -0.2$, the grand average from the Big Mac data, and $\beta = 0.6$, as before, in equation (5.7) to plot the intercept η^h and slope ϕ^h against h, and Figure 5.4 gives the results. As these plots do not match those of Figure 5.3 too well, it seems that the actual data generation process is more complex than the simple AR(1) model.

Since the work of Meese and Rogoff (1983a,b), the random walk model has become the gold standard by which to judge the forecast performance of exchange-rate models. Accordingly, we compare the forecasts from the Big Mac Index and the bias-adjusted BMI with those from a random walk. Under the BMI, absolute parity holds and the forecast real exchange rate at any horizon h is zero, $q_{t+h} = 0$; the bias-adjusted BMI, as represented by equations (5.3) and (5.5), implies $q_{t+h} = \overline{q}$; and the random walk predicts no change, $q_{t+h} = q_t$. We compute the root-mean-squared error of the forecasts over all currencies and years for horizons $h = 1,...,12$, and Figure 5.5 shows that the random walk model outperform the BMI for all horizons, which is the familiar Meese-Rogoff result.[8] However

[8] Note that in addition to the RMSEs of Figure 5.5, earlier we presented another set in Figure 4.1. These are related as follows. For simplicity, suppose there are T realisations of one exchange rate, which we forecast for all horizons by sample mean $\overline{q}$. Denote this for horizon h by

$$\text{RMSE}_1^h = \sqrt{(1/T)\Sigma_{t=1}^{T}(q_{t+h} - \overline{q})^2},$$

which is a simplified expression for the RMSEs presented in Figure 5.5 associated with the bias-adjusted BMI. The corresponding simplified expression for the RMSEs of Figure 4.1 is

$$\text{RMSE}_2^h = \left(1/h\right)\sqrt{\left(1/T\right)\Sigma_{t=1}^{T}\left(q_{t+h} - q_t\right)^2}.$$

If q_t does not deviate too much from $\overline{q}$, $\text{RMSE}_2^h \approx \left(1/h\right)\text{RMSE}_1^h$. While this is only an approximation, this relationship is likely to be the main reason that the RMSEs of Figure 4.1 decrease substantially with the horizon h, while those of Figure 5.5 do not exhibit this pattern.

the figure also reveals that beyond one-year horizons the bias-adjusted BMI beats the random walk. For example, for a 4-year horizon, the RMSE is about 40 percent for the BMI, 30 percent for the random walk and something less than 20 percent for the bias-adjusted BMI. This is an encouraging result for the bias-adjusted BMI.

This section can be summarised as follows:

- The direction of future changes in currency values is clearly not independent of current deviations from parity: Over-valued currencies subsequently depreciate, while under-valued ones appreciate.
- The adjustment to deviations from parity tends to be more or less fully complete over a period of three to six years.
- The bias-adjusted Big Max Index beats the random walk model for all but one-year horizons, demonstrating that it has considerable predictive power regarding future currency values.

6. The Split Between the Nominal Rate and Prices

In this section, we examine the relationship between mispricing and the two components of the real exchange rate -- the nominal exchange rate and inflation. We first examine empirically the behaviour of the two components over different horizons in the future, and then develop a simple geometric framework that highlights the relative flexibility of the exchange rate and prices.

From the definition of the real exchange rate, $q_t = \log\left(P_t / S_t P_t^*\right)$, and using the previous change notation of $\Delta_{(h)} x_{t+h} = \log\left(X_{t+h}/X_t\right)$ we have the identity

(6.1) $$\Delta_{(h)} q_{t+h} = -\Delta_{(h)} s_{t+h} + \Delta_{(h)} r_{t+h},$$

where, e. g., $\Delta_{(h)} r_{t+h} = \Delta_{(h)} p_{t+h} - \Delta_{(h)} p^*_{t+h}$ is the cumulative inflation differential over h years in the future. Equation (6.1) decomposes the future change in the real rate into the corresponding changes in the nominal rate and the inflation differential. A positive value of $\Delta_{(h)} q_{t+h}$ means that the inflation differential exceeds the nominal depreciation of the exchange rate, which amounts to a real appreciation over an h-year horizon.

To examine the mean-reverting behaviour of the two components over different horizons, consider predictive regressions analogous to equation (5.3):

(6.2) $$-\Delta_{(h)} s_{t+h} = \eta_s^h + \phi_s^h d_t + u_{st}^h, \qquad \Delta_{(h)} r_{t+h} = \eta_r^h + \phi_r^h d_t + u_{rt}^h,$$

In the AR(1) case, $q_t = \alpha + \beta q_{t-1} + \varepsilon_t = \overline{q} + \Sigma_{j=0}^{\infty} \beta^j \varepsilon_{t-j}$, and the simplified expression for the first version of the of the square of the RMSE is

$$\left(RMSE_1^h \mid AR(1)\right)^2 = \left(1/T\right) \sum_{t=1}^{T} \left(\sum_{j=0}^{\infty} \beta^j \varepsilon_{t+h-j} \right)^2, \text{ with } E\left[\left(RMSE_1^h \mid AR(1)\right)^2\right] = \frac{\sigma_\varepsilon^2}{1-\beta^2}.$$

The corresponding second version is

$$\left(RMSE_2^h \mid AR(1)\right)^2 = \left(1/h^2\right)\left(1/T\right) \sum_{t=1}^{T} \left[\sum_{j=0}^{\infty} \beta^j \left(\varepsilon_{t+h-j} - \varepsilon_{t-j}\right) \right]^2, \text{ with } E\left[\left(RMSE_2^h \mid AR(1)\right)^2\right] = \frac{2\left(1-2\beta^h\right)}{h^2} \frac{\sigma_\varepsilon^2}{1-\beta^2}.$$

As $E\left[\left(RMSE_2^h \mid AR(1)\right)^2\right] = \left[2\left(1-2\beta^h\right)/h^2\right] \cdot E\left[\left(RMSE_1^h \mid AR(1)\right)^2\right]$, there is a similar relationship between the two measures whereby the first is independent of the horizon, while the second declines with h.

where, for horizon h, η_s^h, ϕ_s^h, η_r^h and ϕ_r^h are parameters, d_t is current mispricing defined by equation (5.2), and u_{st}^h and u_{rt}^h are zero-mean error terms.[9] The parameters in equations (5.3) and (6.2) satisfy

$$(6.3) \qquad \eta_s^h + \eta_r^h = \eta^h, \qquad \phi_s^h + \phi_r^h = \phi^h,$$

while the errors satisfy $u_{st}^h + u_{rt}^h = u_t^h$. The least-squares estimator automatically satisfies the aggregation constraints (6.3), and Table 6.1 presents the results using the 24-country Big Mac data for horizons $h = 1,\ldots,12$. As most of the parameters are insignificant, the split between the nominal rate and inflation cannot be precisely estimated. The χ^2-values in this table test the independence between (i) $-\Delta_{(h)} s_{t+h}$ and d_t, and (ii) $\Delta_{(h)} r_{t+h}$ and d_t. As for most horizons the χ^2-values for the nominal rate are considerably higher than those for inflation, we conclude that future changes in the real rate are mainly bought about by nominal exchange rates, but recognise the uncertainty in the split. Looking at Panel B of the table, which refers to the non-overlapping case, it can be seen that the χ^2-value for the nominal rate is maximised for a horizon of 4-6 years, which is not too different to the pattern for the real rate (Table 5.1).

Next, suppose that at some horizon H there is complete adjustment of the real rate to mispricing, so that

$$(6.4) \qquad \Delta_{(H)} q_{t+H} = -d_t.$$

According to this equation, if, for example, the currency is today undervalued by 10 percent $(d_t = -0.10)$, then over the next H years it appreciates by the same amount, $q_{t+H} - q_t = 0.10$. The complete adjustment restriction (5.5) then takes the form $\eta^H = 0,\ \phi^H = -1,$ so that (6.3) becomes

$$(6.3') \qquad \eta_s^H + \eta_r^H = 0, \qquad \phi_s^H + \phi_r^H = -1.$$

The hypothesis of complete adjustment restricts the equations for the nominal rate and inflation according to $(6.3')$. We use the seemingly unrelated estimator (SURE) to estimate the two equations in (6.2) as a system with the cross-equation restriction $(6.3')$ imposed, and interpret the full adjustment horizon H as being successively equal to $1,\ldots,12$ years. Table 6.2 contains the results. Compared to Table 6.1, the SURE are somewhat more precisely determined for 4-6 year horizons (which is a plausible full-adjustment period). Additionally, for the non-overlapping case, most of the estimates of ϕ_s^H for 4-6 year horizons are not too far from -1, which confirms that the nominal rate does the bulk of the adjusting. But as the standard errors are still quite high, we conclude that the precise measurement of the nominal/inflation split remains allusive.

We proceed to consider the geometry of the adjustment process. Consider model (6.2) for the complete-adjustment horizon H. Restriction $(6.3')$ means that model (6.2) then becomes

$$-\Delta_{(H)} s_{t+H} = \phi_s^H d_t, \qquad \Delta_{(H)} r_{t+H} = -\left(1 + \phi_s^H\right) d_t,$$

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[9] Model (6.2) can also be viewed as being part of the reduced form of a system of simultaneous equations. The structural equations comprise (5.3) and (using an obvious notation)

$$(6.2') \qquad -\Delta_{(h)} s_{t+h} = \eta_s^{h'} + \phi_s^{h'} \Delta_{(h)} q_{t+h} + u_{st}^{h'}, \quad \Delta_{(h)} r_{t+h} = \eta_r^{h'} + \phi_r^{h'} \Delta_{(h)} q_{t+h} + u_{rt}^{h'}$$

where the endogenous variables are $-\Delta_{(h)} s_{t+h}$, $\Delta_{(h)} q_{t+h}$ and $\Delta_{(h)} r_{t+h}$, while d_t is exogenous. Substituting the right-hand side of equation (5.3) for $\Delta_{(h)} q_{t+h}$ in $(6.2')$ then yields the reduced form, model (6.2) with

$$\eta_x^h = \eta_x^{h'} + \phi_x^{h'} \eta^h, \quad \phi_x^h = \phi_x^{h'} \phi^h, \quad u_{xt}^h = u_{xt}^{h'} + \phi_x^{h'} u_t^h \qquad x = s, r.$$

where for simplicity we have suppressed the intercepts and set the disturbances at their expected values of zero. The above equations can be written as

(6.5) $$\Delta_{(H)}s_{t+H} = \gamma d_t, \qquad \Delta_{(H)}r_{t+H} = -(1-\gamma)d_t,$$

where $\gamma = -\phi_s^H$. If the currency is undervalued $(d_t < 0)$, then prices at home are too low relative to those abroad, that is, $p_t < s_t + p_t^* + \bar{q}$. Thus we expect $d_t < 0$ to be associated with (i) a future nominal appreciation, $\Delta_{(H)}s_{t+H} \le 0$, implying that $\gamma \ge 0$, and/or (ii) a rise in relative inflation, $\Delta_{(H)}r_{t+H} \ge 0$, implying $-(1-\gamma) \le 0$. Accordingly, $0 \le \gamma \le 1$, which means that the nominal rate changes by a fraction γ of the mispricing, while relative inflation changes by the remainder $1-\gamma$. When the nominal rate does most of the adjusting, the parameter $\gamma > 0.5$, and we have the ranking of changes

$$\left|\Delta_{(H)}r_{t+H}\right| < \left|\Delta_{(H)}s_{t+H}\right| < \left|d_t\right|.$$

In words, the change in the rate is bracketed by the change in relative inflation and the initial mispricing.

Combining the two equations in (6.5) to eliminate d_t yields

(6.6) $$\Delta_{(H)}s_{t+H} = -\left(\frac{\gamma}{1-\gamma}\right)\Delta_{(H)}r_{t+H}.$$

As the parameter γ is a positive fraction, the ratio $-\gamma/(1-\gamma)$ on the right-hand side of the above falls in the range $[-\infty, 0]$. Equation (6.6) describes the simultaneous adjustment of the exchange rate and prices in the future to current mispricing, with $-\gamma/(1-\gamma)$ the elasticity of the rate with respect to the price ratio P/P^* along the adjustment path. It is to be noted that as equation (6.6) deals with the equilibrating adjustments to mispricing, or a deviation from parity, this equation does not describe a PPP-type of relation whereby the rate and prices move proportionally. It follows from the way in which the deviation from equilibrium is defined, $d_t = q_t - \bar{q}$, together with the definition of the real exchange rate, $q = p - p^* - s$, that a deviation of either sign results in equilibrating adjustments in the nominal rate and inflation that are negatively correlated. This is the reason why the elasticity in equation (6.6), $-\gamma/(1-\gamma)$, is negative. This elasticity characterises the trade-off between a higher nominal rate and a lower price level, and vice-versa, required to return the real rate back to its equilibrium value $\bar{q}$.

The schedule FF in Figure 6.1 corresponds to equation (6.6). This schedule passes through the origin and has slope $-\gamma/(1-\gamma) < 0$ that reflects the nature of the flexibility of the monetary side of the economy, that is, the relative flexibility of the rate as compared to prices. Going back to equation (6.5), when the nominal rate bears all of adjustment to mispricing, and relative inflation remains unchanged, $\gamma = 1$ and $1-\gamma = 0$, and the FF schedule is vertical. In the opposite extreme where the rate is fixed, $\gamma = 0$, $1-\gamma = 1$ and FF coincides with the horizontal axis. In a fundamental sense, the slope of FF reflects the relative cost of changes in the exchange rate, as compared to price changes. Related considerations include whether or not the country pursues inflation targeting as the objective of monetary policy, and the extent to which the value of the currency is "managed" by the monetary authorities.

One way to obtain some additional information regarding the split between the nominal rate and inflation is to employ the signal extraction technique (Lucas, 1973). Write the real exchange rate as the sum of its two components as

(6.7) $$q = r + x,$$

where $r = p - p^*$ is the relative price and $x = -s = q - r$ is the negative nominal rate, the logarithmic foreign currency cost of a unit of domestic currency.[10] Assume that (i) r is normally distributed with mean $\overline{r}$ and variance σ_r^2; (ii) x is normal with mean $\overline{x}$ and variance σ_x^2; and (iii) r and x are orthogonal. Our objective is to forecast x given q. We start with a linear conditional forecast of r,

(6.8) $$r_f = \theta + \kappa q,$$

where the subscript "f" denotes the forecast. Minimisation of the mean squared error, defined as $E(r_f - r)^2$, gives

(6.9) $$\theta = (1-\kappa)\overline{r} - \kappa\overline{x}, \qquad \kappa = \frac{\sigma_r^2}{\sigma_x^2 + \sigma_r^2}.$$

Substituting the first member of (6.9) into (6.8) yields $r_f = (1-\kappa)\overline{r} + \kappa(q - \overline{x})$. Based on equation (6.7), we then have

(6.10) $$E(x_f \mid r_f) = q - r_f = (1-\kappa)(q - \overline{r}) + \kappa\overline{x}.$$

The above equation shows that the conditional forecast of the nominal rate is a weighted average of (i) the deviation of the real rate from the long-run relative price and (ii) the historical mean of the nominal rate. If $\sigma_x^2 = \sigma_s^2 \gg \sigma_r^2$ (as seems to be the case empirically), the second member of (6.9) gives $\kappa \approx 0$, so that the real rate term in (6.10) is accorded most of the weight in forecasting the nominal rate. That is, expression (6.10) becomes $E(x_f \mid r_f) \approx q - \overline{r}$, which implies $E(\Delta x_f \mid r_f) \approx \Delta q$. In words, the future change in the real rate is almost entirely brought about by the nominal rate adjusting. In the context of the full-adjustment horizon H, we can then write equation (6.4) as $\Delta_{(H)} s_{t+H} \approx d_t$, which from equation (6.5), means $\gamma \approx 1$ and the FF schedule in Figure 6.1 is near vertical in this case.

To be able to say where the economy locates on FF, we need more information regarding the link between mispricing, the change in the exchange rate and inflation. This is provided by combining equation (6.4) and identity of (6.1) for $h = H$:

(6.11) $$\Delta_{(H)} s_{t+H} = d_t + \Delta_{(H)} r_{t+H}.$$

To interpret this equation, first consider the overvaluation case, so that $d_t > 0$. Equation (6.11) then gives the combinations of the future nominal depreciation and higher inflation at home required to eliminate the overvaluation. These combinations are represented by the schedule OO (for overvaluation) in Figure 6.1. This schedule has a slope of 45-degrees and an intercept on the vertical axis of $d_t > 0$. As the schedule indicates, the initial overvaluation could lead to (i) an equiproportional nominal depreciation with inflation unchanged $\left(\Delta_{(H)} s_{t+H} = d_t,\ \Delta_{(H)} r_{t+H} = 0\right)$; (ii) no change in the nominal rate, with all of the adjustment falling on inflation $\left(\Delta_{(H)} s_{t+H} = 0,\ \Delta_{(H)} r_{t+H} = -d_t\right)$; or (iii) any combination thereof. The overall equilibrium is given by the point E in Figure 6.1, the intersection of the OO and FF schedules. As can be seen, the overvaluation leads to a sharing of the adjustment between a depreciation and a slowing of inflation. It is to be noted that the point E is uniquely determined by (i) the initial overvaluation, which gives the location of OO; and (ii) the degree of relative flexibility of the exchange rate, as measured by the slope of FF.[11]

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[10] In this paragraph, for notational simplicity we suppress subscript t for q, r and x (or s).

[11] The intercepts in the two equations in (6.2), η_s^h and η_r^h, represent the changes in the rate and relative inflation that occur for reasons other than mispricing. For simplicity of exposition, in the above we set the intercepts to zero. When these terms are nonzero, equation (6.6) becomes

The above discussion refers to the situation in which the currency is initially overvalued. The undervalued case is represented in Figure 6.1 by the schedule UU, so that the overall equilibrium is given by the point E'. Here the undervaluation leads to a subsequent appreciation and higher inflation.

7. Is There a Dollar Effect?

In the above discussion, currency mispricing is identified with the excess of the real exchange rate q over its mean $\overline{q}$. This reflects the preponderance of nonzero means in Figure 3.3, but Figure 3.5 also reveals that the corresponding mean for the US dollar is also far away from zero and, importantly, there are large swings in the currency below and above the mean. As the 24 other currencies are all expressed in terms of the dollar, they could thus be subject to a common shock in a given year due to dollar fluctuations. In this section, we investigate the possible role of dollar shocks.

Equation (5.2) defines mispricing as $d_t = q_t - \overline{q}$. We extend this to allow for a shock that hits all currencies simultaneously at time t, x_t, by redefining mispricing as $d'_t = d_t - x_t$. As it is desirable for mispricing to have a zero expectation, we need $\sum_t x_t = 0$, so that $E(d'_t) = 0$. Replacing d_t on the right-hand side of the predictive regression (5.3) with d'_t, we then obtain

$$(7.1) \qquad \Delta_{(h)} q_{t+h} = \Sigma_\tau \alpha_{\tau,\tau+h} D_{\tau,t} + \phi^h d_t + u_t^h,$$

where $\alpha_{\tau,\tau+h} = \eta^h - \phi^h x_\tau$ is the coefficient of the time dummy variable $D_{\tau,t}$, which takes the value of one if $\tau = t$, zero otherwise. Note that $\sum_t x_t = 0$ implies $(1/N^h)\Sigma_\tau \alpha_{\tau,\tau+h} = \eta^h$, where N^h is the number of year coefficients for horizon h, so that the time effects "wash out" over the whole period.

Table 7.1 contains the estimates of equation (7.1) for $h = 1,\ldots,12$. Many of the coefficients of the time dummies are significant, and for a given horizon, they vary substantially, which points to the importance of their inclusion in the model. It can be seen from the first row of the table (which refers to $h = 1$) that the estimates of the coefficients of the time dummies are initially positive, then negative and end up positive. This pattern is the mirror image of the path of the US dollar given in Figure 3.5. The estimates of η^h given in column 14 are close to what they were before in Table 5.1. The estimated slope coefficients given in column 15 are also reasonably close to those of Table 5.1.

To interpret the time effects, consider, for example, the first entry in column 2 of Table 7.1, which is the estimate of $\alpha_{\tau,\tau+h}$ for $\tau = 1994$ and $h = 1$. This estimate is 11.6 $(\times 100^{-1})$. From equation (7.1) for this transition, we have

$$q_{1995} - q_{1994} = \alpha_{1994,1995} + \phi^1 d_{1994} = \alpha_{1994,1995} + \phi^1 (q_{1994} - \overline{q}),$$

where we have set the disturbance at its expected value of zero. From Table 3.3, the means over the 24 countries of q in 1994 and 1995 are $q_{1994} = -8.3$, $q_{1995} = -1.6$, while the grand mean over all years and

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$$\Delta_{(H)} s_{t+H} = -\frac{\eta_s^H}{1-\gamma} - \left(\frac{\gamma}{1-\gamma}\right) \Delta_{(H)} r_{t+H}.$$

Thus if $\eta_s^H < 0$, which amounts to an "autonomous" depreciation in the rate, the term $-\eta_s^H/(1-\gamma) > 0$, and the FF schedule in Figure 6.1 now has a positive intercept on the vertical axis, rather than passing through the origin. Accordingly, a given initial overvaluation is now associated with a larger subsequent depreciation of the rate and a smaller decrease in relative inflation. Vice versa when $\eta_s^H > 0$.

currencies is $\overline{q} = -19.9 \left(\text{all} \times 100^{-1}\right)$. Using these values, together with the estimate from Table 7.1 of ϕ^1 of -0.4 (first entry of column 15), we have

$$\alpha_{1994,1995} = q_{1995} - q_{1994} - \phi^1\left(q_{1994} - \overline{q}\right) = -1.6 + 8.3 + 0.4\left(-8.3 + 19.9\right) = 11.3 \quad \left(\text{all} \times 100^{-1}\right), \tag{7.2}$$

which is sufficiently close to the estimated intercept of 11.6 percent. Accordingly, the coefficient of the time dummy measures the cross-currency average of the change in q over the relevant horizon, after adjusting for the initial mispricing as measured by the term $\phi^h d_t$. Note that if $\phi^1 = -1$, as it is under the hypothesis of full adjustment, then equation (7.2) simplifies to $\alpha_{1994,1995} = q_{1995} - \overline{q}$, which is just the deviation of q in the relevant year from the grand mean. As the estimated slope coefficient for $h = 3$ in Panel A of Table 7.1 is very close to -1, we consider this case to illustrate this point. Column 2 of the table below contains the estimated coefficients of the time dummies, from the third row of Panel A of Table 7.1, corresponding to $h = 3$; column 3 below contains the cross-currency means from Table 3.3; and column 4 contains the deviations from the grand mean of -19.86:

Year t+3 (1)	Estimated time effect (2)	Cross-currency mean (3)	Deviation of cross-currency mean from grand mean (4)
1997	9.73	-10.11	9.75
1998	-5.12	-24.94	-5.08
1999	-1.78	-21.61	-1.75
2000	-7.07	-26.90	-7.04
2001	-11.93	-31.80	-11.94
2002	-10.95	-30.81	-10.95
2003	-7.57	-27.44	-7.58
2004	-7.10	-26.98	-7.12
2005	-4.49	-24.37	-4.51
2006	0.79	-19.08	0.78

Note: All entries are to be divided by 100.

The close agreement of columns 2 and 4 confirms the interpretation of the time effects as the deviations from the grand mean under the condition $\phi^h = -1$. This is why the time effects mirror the path of the dollar, mentioned in the paragraph above.

Next, we add time effects to the analysis of the split between the nominal rate and prices. In broad outline, this extension reveals little change from the results of Section 6 where the time effects are omitted. The detailed results are contained in Tables A4-A6 of the Appendix. In particular, we continue to find that it is difficult to quantity the split in a precise manner.

To summarise, the persistent swings of the dollar play a role in the adjustment to mispricing of non-dollar currencies. But even when these effects are allowed for, in broad outline the results of Sections 5 and 6 continue to hold: Within a period of three to six years, currency mispricing is more or less eliminated; but the split between changes in the nominal rate and relative prices in the adjustment process cannot be precisely estimated.

8. The Burgernomics Literature

This section reviews the literature on the Big Mac Index. Cumby (1996) is widely known as the first Burgernomics paper and was originally a 1995 Georgetown University working paper. Almost at the same time however, Ong (1995) was presented at the ANU/UWA PhD Conference in Economics and Business in Perth and later published as Ong (1997). As far as we are aware, there are in total eighteen academic papers and one book on the Big Mac Index/Burgernomics. Table 9.1 lists these publications in chronicle order. These papers can be broadly grouped into two categories, (i) the basic foundations and (ii) "adventurous" applications.

Regarding basic foundations, Cumby (1996) finds out that half-life of deviations from the Big Mac parity is about one year, and these deviations provide significant information for forecasting exchange rates and Big Mac prices. Lutz (2001) applies Cumby's methodology to 12 price series published by the bank UBS as well as aggregate CPI data. Click (1996), Fujiki and Kitamura (2003) and Caetano et al. (2004) find country incomes to be important in explaining deviations from Big Mac PPP. Yang (2004) uses the BMI to evaluate the Chinese yuan and finds that currencies of low-income countries are overvalued due to the insufficient weight accorded to nontradables. Ong (1997) finds that Big Macs are surprisingly accurate in tracking exchange rates over the long run. She also proposes the "No-Frills Index" by excluding nontradable components from the Big Mac Index, and establishes that this performs better than the BMI. Using Big Mac prices, Ong (1998a) analyses the Asian currency crisis, while Ong (1998b), Ong and Mitchell (2000), and Ashenfelter and Jurajda (2001) compare wages in different countries. Ong (2003) is the only book on Burgernomics, and this comprises a series of papers by her and coauthors. Chen et al. (2005) compare the behaviour of Big Mac prices with CPIs and find that the BMI supports the validity of PPP better than the CPI does. Pakko and Pollard (1996, 2003) conclude that Big Macs are a useful but flawed PPP measure as deviations from absolute PPP are persistent while those from relative PPP are transitory. Parsley and Wei (2007) relate the price of a Big Mac to the costs of its ingredients and find that the speed of convergence of the overall Big Mac real exchange rate is bracketed by that for its tradable and nontradable inputs.

Annaert and Ceuster (1997) pursue of different line of research in one of the first adventurous applications of Burgernomics. They construct currency portfolios selected on the basis of the Big Mac Index whereby undervalued currencies are bought and undervalued ones sold, and their results show that Big Macs can serve as a useful international asset allocator. Given their volatility, exchange rates are notoriously difficult to forecast. As the previous US Fed Chairman, Alan Greenspan (2004), puts it, "despite extensive efforts on the part of analysts, to my knowledge, no model projecting directional movements in exchange rates is significantly superior to tossing a coin." There is now an emerging stream of Burgernomics that investigates whether the BMI can be used to forecast exchange rates. Lan (2006) uses Big Mac prices to forecast the whole distribution of future exchange rates, employing a novel iterative approach to adjust for econometric problems associated with the estimation of dynamic panel models where the number of observations is not large. The provision of the whole distribution emphasises forecast uncertainty that enables users to make financial decisions in an informed manner with the appropriate degree of caution. Clements and Lan (2006) extend Lan (2006) and use Monte Carlo simulations to provide real-time exchange-rate forecasts for any horizon into the future.

9. Concluding Comments

The Economist magazine advocates as a currency pricing rule the formula $S = P/P^*$, where S is the exchange rate (the domestic currency cost of one US dollar), P is the price of a Big Mac hamburger in the country in question and P^* is the price in the US. Thus an increase in the domestic price, relative to the US price, leads to a depreciation of the domestic currency. The rule is a precise, numerical relationship between the exchange rate and the relative price that can be used to identify mispricing of the currency in a quick and convenient way. This is a novel and controversial application of the purchasing power parity theory of exchange rates that is known as the Big Mac Index and is published annually by The Economist for a large number of currencies.

The cost of a full-page advertisement in The Economist must be something like $US50,000. For the magazine to continue to publish an article on the Big Mac Index each year for 21 years means that it is worth this opportunity cost, at least in the mind of the editor. This paper assessed the broader value of the BMI by analysing its properties and ability to track exchange rates. The major findings of the paper are:

- The index is a biased predictor of currency values.
- Once the bias is allowed for, the index tracks exchange rates reasonably well over the medium to longer term in accordance with relative purchasing power parity theory.
- The index is at least as good as the industry standard, the random walk model, in predicting future currency values for all but short-term horizons.
- Future nominal exchange rates are more responsive than prices to currency mispricing, but this split is difficult to determine precisely.

Thus, while it is not perfect, as the cost of the magazine is less than $US10, the index seems to provide good value for money. In showing that relative prices act as an "attractor" or "anchor" for exchange rates over the longer term, our results also have implications for exchange-rate economics: As currencies of high (low)-inflation countries depreciate (appreciate), over longer horizons economic fundamentals tend to dominate currency pricing.

APPENDIX

The Big Mac Data

The Economist magazine has been publishing the Big Mac index on an annual basis since 1986. The data presented in Tables A1, A2 and A3 are compiled from a number of issues of the magazine from 1986 to 2006. They consist of, respectively, the implied PPP exchange rates, nominal exchange rates and real exchange rates of all countries that have appeared at least once in The Economist during the 21-year period.

We have made adjustments for three discrepancies found in the published data. First, Chile's 1999 Big Mac price and its corresponding implied PPP exchange rate are given as Peso 1,25 and 518, respectively, in The Economist. As the prices for this country in other years are about 1,250 pesos, we suspect the price should be 1,250 (rather than 1,25). Then we recompute the implied PPP exchange rate as 514.4 and use that in our table (rather than the published value 518). Second, the implied PPP exchange rate for Brazil in 1986 is given as 7.8 in The Economist. As this is inconsistent with our own calculation using the published Big Mac prices, the implied PPP exchange rate of 1.562 is used instead. Finally, the published PPP exchange rate for Denmark in 1998 is 9.28, while we have computed the rate at 9.297 using the published Big Mac prices; here again we use our internally-consistent figure.

In the text of the paper, we use the Big Mac data for 24 countries/areas over the period of 1994 to 2006, so that the total number of observations is $24 \times 13 = 312$. Tables 3.1-3.3 show the respective implied PPP exchange rates, nominal exchange rates and real exchange rates. In four instances, Big Mac prices and nominal exchange rates are missing: New Zealand (1994), China (1996), Hungary (1996), and the Czech Republic (1999). For these cases, nominal exchange rates are taken from the International Financial Statistics database published by the International Monetary Fund. The Big Mac prices are computed on the basis of the one-year percentage change in the Consumer Price Index (hereafter CPI), also taken from the IFS database. For example, we compute the price of a Big Mac hamburger in China in April 1996 as follows:

$$P_{c,1996} = \frac{P_{c,1997}}{1+\pi_{c,1997}} = \frac{9.7}{1+3.19847/100} = 9.39936,$$

where $\pi_{c,1997}$ is the percentage change in the CPI from 1996 to 1997 in China.

As the euro was not introduced until 1999, official data are unavailable for this currency from 1994 to 1998. However, the Big Mac data for the six member countries included in our data -- Belgium, France, Germany, Italy, Holland, and Spain -- exist for the pre-euro period. To calculate the implied PPP exchange rate of the euro during this period, we first convert the prices of the Big Mac hamburger to euros for these six countries using the exchange rates given on the InforEuro website.[12] We define "the" euro price of a Big Mac as the unweighted average of the euro prices for these six countries. We then divide it by the US price of a Big Mac hamburger in US dollars to obtain the implied PPP exchange rate for Euroland. We obtain the corresponding "€/$" nominal exchange rates as follows. First, we calculate the "€/$" exchange rate for each member country by dividing the "DC/$" rate by the "DC/€" rate, where DC denotes the domestic currency so that, for example, DC/$ is the domestic currency cost of one US dollar. Second, as these "€/$" rates are not necessarily the same in the six countries, we take the unweighted average. The required nominal exchange rates are from both The Economist and the InforEuro website.

Additional Results with Time Effects

[12] http://europa.eu.int/comm/budget/inforeuro/index.cfm?fuseaction=dsp_html_monthly_rates&Language=en.

Tables 6.1 and 6.2 of the text give the results for the predictive regressions when the real rate is decomposed into the nominal rate and relative inflation components. Tables A4-A6 of this appendix give the corresponding results when time effects are added.

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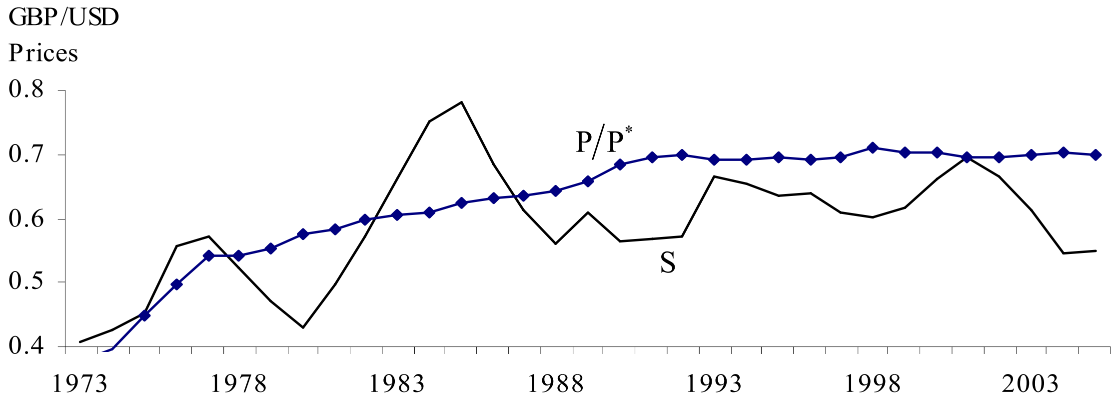
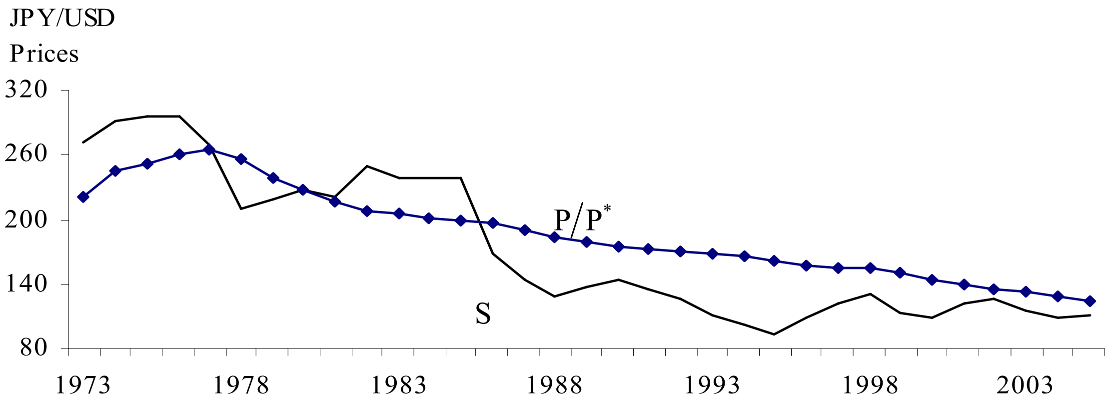
FIGURE 1.1

EXCHANGE RATES AND PRICES, 1973-2006

A. United Kingdom



B. Japan

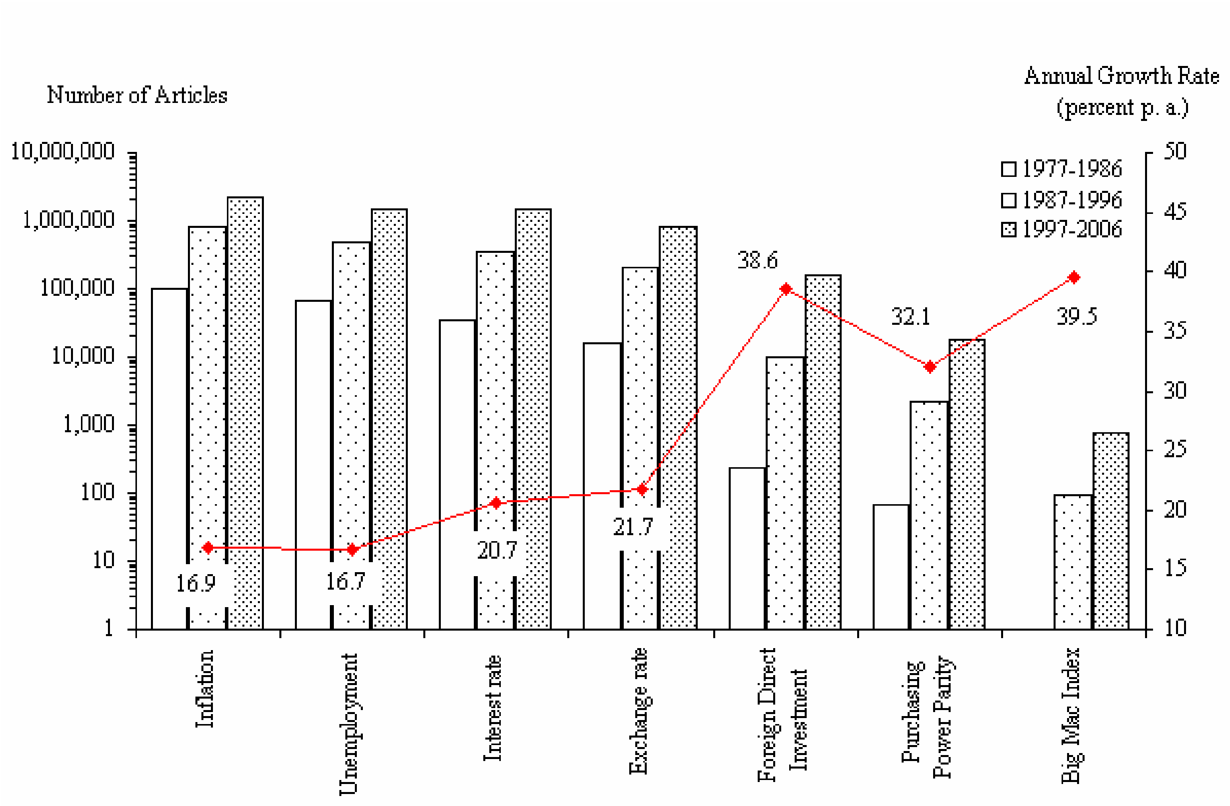


Sources: International Monetary Fund International Financial Statistics, and Pacific Exchange Rate Service (http://pacific.commerce.ubc.ca/xr/data.html).

Note: The price levels are consumer price indices. The base year for each country (Britain 2001, Japan 1980) is chosen to minimize the deviations from parity, S-P/P*. This amounts to assuming that PPP holds on average over the 33 years, and determines nothing more than the "average" height of the relative price curve.

FIGURE 1.2

THE GROWTH OF ECONOMIC RESEARCH



Source: Factiva (http://global.factiva.com/sb/default.aspx?NAPC=S&fcpil=en). Keyword search conducted in January 2007.

FIGURE 2.1

THE GEOMETRY OF PPP

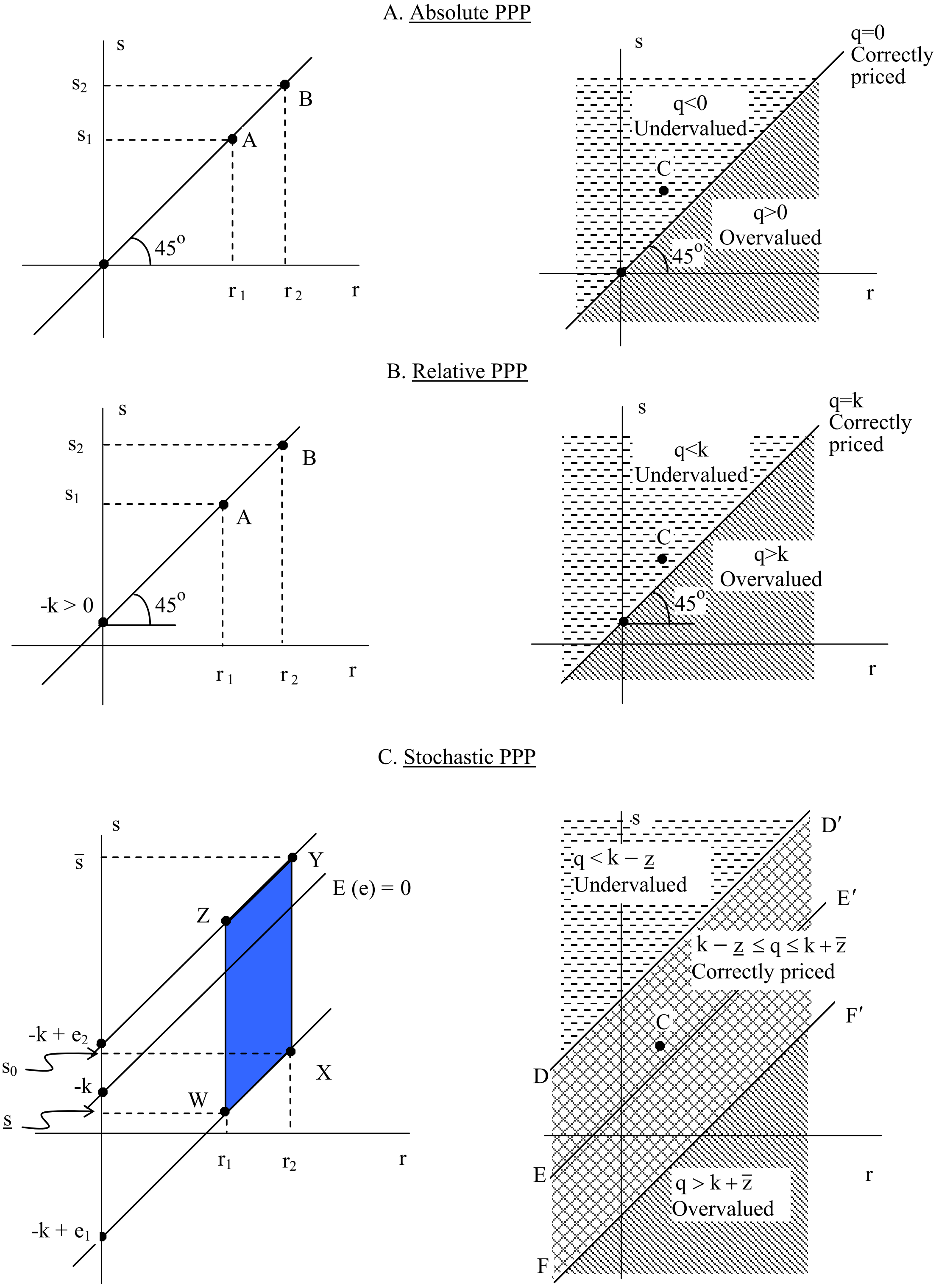


FIGURE 3.1

EXAMPLE OF BIG MAC ARTICLE

Economics focus | McCurrencies

Happy 20th birthday to our Big Mac index

WHEN our economics editor invented the Big Mac index in 1986 as a light-hearted introduction to exchange-rate theory, little did she think that 20 years later she would still be munching her way, a little less sylph-like, around the world. As burgernomics enters its third decade, the Big Mac index is widely used and abused around the globe. It is time to take stock of what burgers do and do not tell you about exchange rates.

The Economist's Big Mac index is based on one of the oldest concepts in international economics: the theory of purchasing-power parity (PPP), which argues that in the long run, exchange rates should move towards levels that would equalise the prices of an identical basket of goods and services in any two countries. Our "basket" is a McDonald's Big Mac, produced in around 120 countries. The Big Mac PPP is the exchange rate that would leave burgers costing the same in America as elsewhere. Thus a Big Mac in China costs 10.5 yuan, against an average price in four American cities of $3.10 (see the first column of the table). To make the two prices equal would require an exchange rate of 3.39 yuan to the dollar, compared with a market rate of 8.03. In other words, the yuan is 58% "undervalued" against the dollar. To put it another way, converted into dollars at market rates the Chinese burger is the cheapest in the table.

In contrast, using the same method, the euro and sterling are overvalued against the dollar, by 22% and 18% respectively; the Swiss and Swedish currencies are even more overvalued. On the other hand, despite its recent climb, the yen appears to be 28% undervalued, with a PPP of only ¥81 to the dollar. Note that all emerging-market currencies also look too cheap.

The index was never intended to be a precise predictor of currency movements, simply a take-away guide to whether currencies are at their "correct" long-run level. Curiously, however, burgernomics has an impressive record in predicting exchange rates: currencies that show up as overvalued often tend to weaken in later years. But you must always remember the Big Mac's limitations. Burgers cannot sensibly be traded across borders and prices are distorted by differences in taxes and the cost of non-tradable inputs, such as rents.

Despite our frequent health warnings, some American politicians are fond of citing the Big Mac index rather too freely when it suits their cause—most notably in their demands for a big appreciation of the Chinese currency in order to reduce America's huge trade deficit. But the cheapness of a Big Mac in China does not really prove that the yuan is being held far below its fair-market value. Purchasing-power parity is a long-run concept. It signals where exchange rates are eventually heading, but it says little about today's market-equilibrium exchange rate that would make the prices of tradable goods equal. A burger is a product of both traded and non-traded inputs.

An idea to relish

It is quite natural for average prices to be lower in poorer countries than in developed ones. Although the prices of tradable things should be similar, non-tradable services will be cheaper because of lower wages. PPPs are therefore a more reliable way to convert GDP per head into dollars than market exchange rates, because cheaper prices mean that money goes further. This is also why every poor country has an implied PPP exchange rate that is higher than today's market rate, making them all appear undervalued. Both theory and practice show that as countries get richer and their productivity rises, their real exchange rates appreciate. But this does not mean that a currency needs to rise massively today. Jonathan Anderson, chief economist at UBS in Hong Kong, reckons that the yuan is now only 10-15% below its fair-market value.

Even over the long run, adjustment towards PPP need not come from a shift in exchange rates; relative prices can change instead. For example, since 1995, when the yen was overvalued by 100% according to the Big Mac index, the local price of Japanese burgers has dropped by one-third. In the same period, American burgers have become one-third dearer. Similarly, the yuan's future real appreciation could come through faster inflation in China than in the United States.

The Big Mac index is most useful for assessing the exchange rates of countries with similar incomes per head. Thus, among emerging markets, the yuan does indeed look undervalued, while the currencies of Brazil, Turkey, Hungary and the Czech Republic look overvalued. Economists would be unwise to exclude Big Macs from their diet, but Super Size servings would equally be a mistake. ■

The hamburger standard

	Big Mac prices in local currency (1)	Big Mac prices in dollars (2)	Implied PPP* of the dollar (3)	Actual dollar exchange rate May 22nd (4)	Under (-)/ over (+) valuation against the dollar, % (5)
United States†	$3.10	3.10	–	–	–
Argentina	Peso 7.00	2.29	2.26	3.06	-26
Australia	A$3.25	2.44	1.05	1.33	-21
Brazil	Real 6.40	2.78	2.06	2.30	-10
Britain	£1.94	3.65	1.60‡	1.88‡	+18
Canada	C$3.52	3.14	1.14	1.12	+1
Chile	Peso 1,560	2.94	503	530	-5
China	Yuan 10.5	1.31	3.39	8.03	-58
Czech Republic	Koruna 59.05	2.67	19.0	22.1	-14
Denmark	DKr27.75	4.77	8.95	5.82	+54
Egypt	Pound 9.50	1.65	3.06	5.77	-47
Euro area§	€2.94	3.77	1.05**	1.28**	+22
Hong Kong	HK$12	1.55	3.87	7.75	-50
Hungary	Forint 560	2.71	181	206	-12
Indonesia	Rupiah 14,600	1.57	4,710	9,325	-49
Japan	¥250	2.23	80.6	112	-28
Malaysia	Ringgit 5.50	1.52	1.77	3.63	-51
Mexico	Peso 29.00	2.57	9.35	11.3	-17
New Zealand	NZ$4.45	2.75	1.44	1.62	-11
Peru	New Sol 9.50	2.91	3.06	3.26	-6
Philippines	Peso 85.00	1.62	27.4	52.6	-48
Poland	Zloty 6.50	2.10	2.10	3.10	-32
Russia	Rouble 48.00	1.77	15.5	27.1	-43
Singapore	S$3.60	2.27	1.16	1.59	-27
South Africa	Rand 13.95	2.11	4.50	6.60	-32
South Korea	Won 2,500	2.62	806	952	-15
Sweden	SKr33.00	4.53	10.6	7.28	+46
Switzerland	SFr6.30	5.21	2.03	1.21	+68
Taiwan	NT$75.00	2.33	24.2	32.1	-25
Thailand	Baht 60.00	1.56	19.4	38.4	-50
Turkey	Lire 4.20	2.72	1.35	1.54	-12
Venezuela	Bolivar 5,701	2.17	1,839	2,630	-30

*Purchasing-power parity: local price divided by price in United States
†Average of New York, Chicago, Atlanta and San Francisco ‡Dollars per pound
§Weighted average of prices in euro area **Dollars per euro

Sources: McDonald's; *The Economist*

Source: The Economist, 27 May 2006, p.70.

TABLE 3.1

IMPLIED PPP EXCHANGE RATES FOR 24 COUNTRIES, 1994 TO 2006

Country	Year													Mean	SD	CV (×100)
	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006			
Argentina	1.565	1.293	1.271	1.033	0.977	1.029	0.996	0.984	1.004	1.513	1.500	1.550	2.258	1.306	0.36	27.40
Australia	1.065	1.056	1.059	1.033	1.035	1.091	1.032	1.181	1.205	1.107	1.120	1.060	1.048	1.084	0.05	4.94
Brazil	652.2	1.043	1.250	1.227	1.211	1.214	1.175	1.417	1.446	1.679	1.860	1.930	2.065	51.51	173.40	336.64
Britain	0.787	0.750	0.758	0.748	0.719	0.782	0.757	0.783	0.799	0.734	0.649	0.613	0.626	0.731	0.06	8.22
Canada	1.243	1.194	1.212	1.190	1.090	1.230	1.135	1.311	1.337	1.181	1.100	1.070	1.135	1.187	0.08	6.59
Chile	412.2	409.5	402.5	495.9	488.3	514.4	502.0	496.1	562.2	516.6	483.0	490.0	503.2	482.8	45.12	9.35
China	3.913	3.879	3.983	4.008	3.867	4.074	3.944	3.898	4.217	3.653	3.590	3.430	3.387	3.834	0.24	6.21
Czech Republic	21.74	21.55	21.61	21.90	21.09	21.63	21.66	22.05	22.60	20.87	19.50	18.40	19.05	21.05	1.22	5.79
Denmark	11.20	11.53	10.91	10.64	9.297	10.19	9.861	9.744	9.940	10.24	9.570	9.070	8.952	10.09	0.77	7.65
Euro Area	1.091	1.077	1.073	1.032	0.960	1.037	1.020	1.012	1.072	1.000	0.943	0.952	0.948	1.017	0.05	5.02
Hong Kong	4.000	4.095	4.195	4.091	3.984	4.198	4.064	4.213	4.498	4.244	4.140	3.920	3.871	4.116	0.16	3.80
Hungary	73.48	82.33	96.79	112.0	101.2	123.0	135.1	157.1	184.3	180.8	183.0	173.0	180.6	137.1	39.83	29.05
Japan	170.0	168.5	122.0	121.5	109.4	121.0	117.1	115.7	105.2	96.68	90.30	81.70	80.65	115.4	26.86	23.28
Malaysia	1.639	1.621	1.593	1.599	1.680	1.860	1.801	1.780	2.024	1.860	1.740	1.720	1.774	1.745	0.12	6.84
Mexico	3.522	4.698	6.314	6.157	6.992	8.189	8.327	8.622	8.795	8.487	8.280	9.150	9.355	7.453	1.73	23.23
New Zealand	1.236	1.272	1.250	1.343	1.348	1.399	1.355	1.417	1.586	1.458	1.500	1.450	1.435	1.388	0.10	7.04
Poland	13478	1.466	1.610	1.777	2.070	2.263	2.191	2.323	2.369	2.325	2.170	2.120	2.097	1039	3591	345.61
Russia	1261	3491	4025	4545	4688	13.79	15.74	13.78	15.66	15.13	14.50	13.70	15.48	1394	1908	136.89
Singapore	1.296	1.272	1.292	1.240	1.172	1.317	1.275	1.299	1.325	1.218	1.140	1.180	1.161	1.245	0.06	4.95
South Korea	1000	991.4	974.6	950.4	1016	1235	1195	1181	1245	1218	1103	817.0	806.5	1056	146.03	13.83
Sweden	11.09	11.21	11.02	10.74	9.375	9.877	9.562	9.449	10.44	11.07	10.30	10.10	10.65	10.37	0.63	6.08
Switzerland	2.478	2.543	2.500	2.438	2.305	2.428	2.351	2.480	2.530	2.325	2.170	2.060	2.032	2.357	0.17	7.05
Taiwan	26.96	28.02	27.54	28.10	26.56	28.81	27.89	27.56	28.11	25.83	25.90	24.50	24.52	26.95	1.34	4.97
Thailand	20.87	20.69	20.34	19.30	20.31	21.40	21.91	21.65	22.09	21.77	20.30	19.60	19.35	20.74	0.94	4.51

Notes: 1. The implied PPP exchange rate for country c in year t is defined as P_{ct}/P_t^*, where P_{ct} is the price of a Big Mac hamburger in country c during t and P_t^* is the corresponding price in the US.

2. SD stands for standard deviation, and CV is the coefficient of variation.

Source: The Economist. See Appendix for details.

TABLE 3.2

NOMINAL EXCHANGE RATES FOR 24 COUNTRIES, 1994 TO 2006

Country	Year													Mean	SD	CV (×100)
	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006			
Argentina	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	3.130	2.880	2.941	2.870	3.060	1.760	0.96	54.75
Australia	1.420	1.350	1.270	1.290	1.510	1.590	1.680	1.980	1.860	1.610	1.436	1.293	1.330	1.509	0.22	14.39
Brazil	949.0	0.900	0.990	1.060	1.140	1.730	1.790	2.190	2.340	3.070	3.153	2.474	2.300	74.78	252.37	337.48
Britain	0.685	0.621	0.662	0.613	0.602	0.621	0.633	0.699	0.690	0.633	0.560	0.548	0.532	0.623	0.05	8.24
Canada	1.390	1.390	1.360	1.390	1.420	1.510	1.470	1.560	1.570	1.450	1.375	1.244	1.120	1.404	0.12	8.37
Chile	414.0	395.0	408.0	417.0	455.0	484.0	514.0	601.0	655.0	716.0	644.0	590.4	530.0	524.9	103.36	19.69
China	8.700	8.540	8.331	8.330	8.280	8.280	8.280	8.280	8.280	8.280	8.349	8.366	8.030	8.333	0.15	1.78
Czech Republic	29.70	26.20	27.60	29.20	34.40	35.59	39.10	39.00	34.00	28.90	26.71	24.53	22.10	30.54	5.20	17.04
Denmark	6.690	5.430	5.850	6.520	7.020	6.910	8.040	8.460	8.380	6.780	6.214	6.047	5.820	6.782	0.94	13.92
Euro Area	0.881	0.742	0.793	0.873	0.927	0.926	1.075	1.136	1.124	0.909	0.835	0.814	0.781	0.909	0.12	13.65
Hong Kong	7.730	7.730	7.740	7.750	7.750	7.750	7.790	7.800	7.800	7.800	7.811	7.840	7.750	7.772	0.03	0.44
Hungary	103.0	121.0	150.9	178.0	213.0	237.0	279.0	303.0	272.0	224.0	210.3	203.5	206.0	207.8	56.89	27.38
Japan	104.0	84.20	107.0	126.0	135.0	120.0	106.0	124.0	130.0	120.0	112.9	106.1	112.0	114.4	12.95	11.32
Malaysia	2.690	2.490	2.490	2.500	3.720	3.800	3.800	3.800	3.800	3.800	3.783	3.822	3.630	3.394	0.57	16.85
Mexico	3.360	6.370	7.370	7.900	8.540	9.540	9.410	9.290	9.280	10.53	11.50	10.89	11.30	8.868	2.16	24.36
New Zealand	1.736	1.510	1.470	1.450	1.820	1.870	2.010	2.470	2.240	1.780	1.630	1.394	1.620	1.769	0.31	17.36
Poland	22433	2.340	2.640	3.100	3.460	3.980	4.300	4.030	4.040	3.890	3.875	3.312	3.100	1729	5977	345.68
Russia	1775	4985	4918	5739	5999	24.70	28.50	28.90	31.20	31.10	29.00	28.54	27.10	1819	2451	134.76
Singapore	1.570	1.400	1.410	1.440	1.620	1.730	1.700	1.810	1.820	1.780	1.727	1.662	1.590	1.635	0.14	8.63
South Korea	810.0	769.0	779.0	894.0	1474	1218	1108	1325	1304	1220	1173	1009	952.0	1080	220.10	20.38
Sweden	7.970	7.340	6.710	7.720	8.000	8.320	8.840	10.28	10.30	8.340	7.574	7.426	7.280	8.162	1.05	12.84
Switzerland	1.440	1.130	1.230	1.470	1.520	1.480	1.700	1.730	1.660	1.370	1.284	1.248	1.210	1.421	0.19	13.29
Taiwan	26.40	25.70	27.20	27.60	33.00	33.20	30.60	32.90	34.80	34.80	33.64	31.01	32.10	31.00	3.10	10.00
Thailand	25.30	24.60	25.30	26.10	40.00	37.60	38.00	45.50	43.30	42.70	40.60	40.83	38.40	36.02	7.43	20.63

Notes: 1. The nominal exchange rate is the domestic currency cost of one US dollar. An increase thus implies a depreciation of the domestic currency and vice versa.
2. SD stands for standard deviation, and CV is the coefficient of variation.

Source: The Economist. See Appendix for details.

FIGURE 3.2

THE VOLATILITY OF EXCHANGE RATES AND PRICES

(Coefficients of variation; percentages)

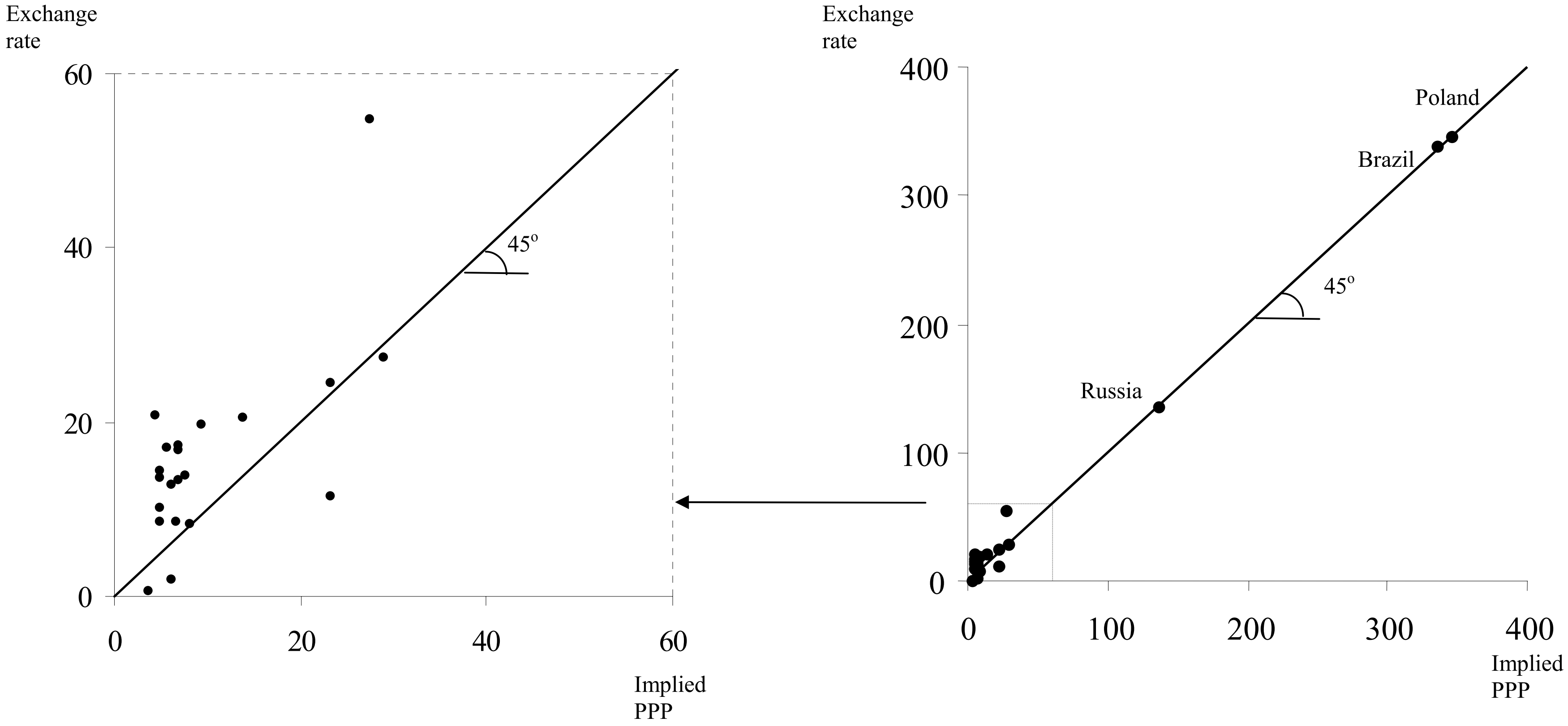


TABLE 3.3

REAL EXCHANGE RATES FOR 24 COUNTRIES, 1994 TO 2006

Country	Year													Mean	SE	t-value
	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006			
Argentina	44.80	25.70	24.00	3.25	-2.37	2.84	-0.40	-1.59	-113.70	-64.38	-67.33	-61.62	-30.39	-18.55	12.69	-1.46
Australia	-28.75	-24.56	-18.14	-22.21	-37.76	-37.71	-48.74	-51.66	-43.42	-37.46	-24.85	-19.85	-23.79	-32.22	3.11	-10.35
Brazil	-37.51	14.76	23.32	14.65	6.04	-35.42	-42.07	-43.51	-48.15	-60.35	-52.76	-24.85	-10.80	-22.82	8.02	-2.84
Britain	13.89	18.86	13.57	19.81	17.66	23.02	17.90	11.36	14.74	14.86	14.84	11.33	16.26	16.01	0.93	17.13
Canada	-11.14	-15.20	-11.53	-15.53	-26.46	-20.47	-25.82	-17.39	-16.04	-20.54	-22.31	-15.08	1.37	-16.63	2.01	-8.27
Chile	-0.44	3.60	-1.35	17.32	7.06	6.09	-2.36	-19.19	-15.27	-32.64	-28.77	-18.63	-5.18	-6.90	4.13	-1.67
China	-79.90	-78.91	-73.80	-73.15	-76.13	-70.92	-74.16	-75.35	-67.48	-81.83	-84.40	-89.16	-86.32	-77.81	1.76	-44.33
Czech Republic	-31.20	-19.53	-24.47	-28.76	-48.91	-49.82	-59.06	-57.04	-40.83	-32.53	-31.47	-28.77	-14.86	-35.94	3.90	-9.23
Denmark	51.49	75.30	62.33	48.98	28.09	38.80	20.41	14.13	17.07	41.23	43.18	40.55	43.05	40.36	4.87	8.29
Euro Area	21.39	37.17	30.17	16.77	3.50	11.33	-5.28	-11.61	-4.67	9.53	12.22	15.70	19.39	11.97	3.89	3.08
Hong Kong	-65.88	-63.54	-61.25	-63.89	-66.53	-61.32	-65.07	-61.60	-55.05	-60.87	-63.49	-69.31	-69.42	-63.63	1.07	-59.60
Hungary	-33.77	-38.51	-44.40	-46.34	-74.45	-65.55	-72.55	-65.69	-38.90	-21.42	-13.93	-16.25	-13.13	-41.92	6.16	-6.80
Japan	49.14	69.39	13.15	-3.65	-21.05	0.82	9.99	-6.89	-21.15	-21.61	-22.31	-26.14	-32.84	-1.01	8.46	-0.12
Malaysia	-49.54	-42.94	-44.65	-44.68	-79.51	-71.44	-74.68	-75.87	-62.99	-71.45	-77.65	-79.85	-71.59	-65.14	3.99	-16.32
Mexico	4.70	-30.44	-15.47	-24.93	-20.00	-15.27	-12.23	-7.46	-5.37	-21.57	-32.85	-17.44	-18.89	-16.71	2.83	-5.90
New Zealand	-33.93	-17.19	-16.21	-7.67	-30.05	-29.01	-39.46	-55.54	-34.50	-19.98	-8.34	3.92	-12.09	-23.08	4.42	-5.22
Poland	-50.95	-46.79	-49.44	-55.66	-51.36	-56.44	-67.41	-55.10	-53.36	-51.48	-57.98	-44.63	-39.10	-52.28	1.92	-27.28
Russia	-34.20	-35.61	-20.03	-23.32	-24.67	-58.31	-59.39	-74.07	-68.91	-72.06	-69.31	-73.40	-55.97	-51.48	5.78	-8.90
Singapore	-19.21	-9.62	-8.71	-14.98	-32.38	-27.29	-28.78	-33.16	-31.72	-37.96	-41.55	-34.25	-31.42	-27.00	2.93	-9.22
South Korea	21.07	25.40	22.40	6.12	-37.25	1.35	7.58	-11.50	-4.63	-0.19	-6.19	-21.07	-16.59	-1.04	5.05	-0.21
Sweden	33.01	42.32	49.58	33.05	15.86	17.15	7.85	-8.43	1.37	28.32	30.75	30.75	38.00	24.58	4.66	5.27
Switzerland	54.29	81.12	70.93	50.59	41.62	49.50	32.40	36.03	42.14	52.88	52.47	50.08	51.85	51.22	3.63	14.09
Taiwan	2.09	8.63	1.25	1.79	-21.70	-14.19	-9.28	-17.71	-21.34	-29.81	-26.14	-23.57	-26.95	-13.61	3.63	-3.75
Thailand	-19.25	-17.31	-21.83	-30.20	-67.76	-56.37	-55.05	-74.25	-67.31	-67.36	-69.31	-73.40	-68.51	-52.92	6.16	-8.59
Mean	-8.32	-1.58	-4.19	-10.11	-24.94	-21.61	-26.90	-31.80	-30.81	-27.44	-26.98	-24.37	-19.08	-19.86	2.86	-6.94
SE	7.83	8.73	7.61	6.79	7.04	7.29	7.03	6.64	7.01	7.53	7.75	7.70	7.40	6.77	2.10	-
t-value	-1.06	-0.18	-0.55	-1.49	-3.54	-2.96	-3.83	-4.79	-4.40	-3.64	-3.48	-3.16	-2.58	-2.93	-	-9.47

Notes:
1. The real exchange rate for country c in year t is defined as $q_{c,t} = \log\left(P_{c,t} / S_{c,t} P_t^*\right)$, where $P_{c,t}$ is the price of a Big Mac hamburger in country c during t, P_t^* is the corresponding price in the US and $S_{c,t}$ is the nominal exchange rate, defined as the domestic currency cost of $US1. A positive value of $q_{c,t}$ implies that the domestic currency is overvalued in real terms and vice versa.
2. All entries, except those in the last row and column, are to be divided by 100.
3. SE is standard error of the mean, which is a multiple $1/\sqrt{k}$ of the corresponding standard deviation, where $k=13$ is the number of observations for the row means and $k=24$ for the columns means. The t-values provide a test of the hypothesis that the means are zero.
4. The second to last entry in the second to last row/column is the standard error of the grand average, calculated as the standard deviation of all 24×13=312 observations divided by $\sqrt{312}$. The corresponding t-value is presented in the right-bottom entry of the table.

Source: Derived from Tables 3.1 and 3.2.

FIGURE 3.3

BIG MAC REAL EXCHANGE RATES FOR 24 COUNTRIES, 1994-2006

(Mean indicated by dashed-dotted lines; two standard-error band shaded; all × 100)

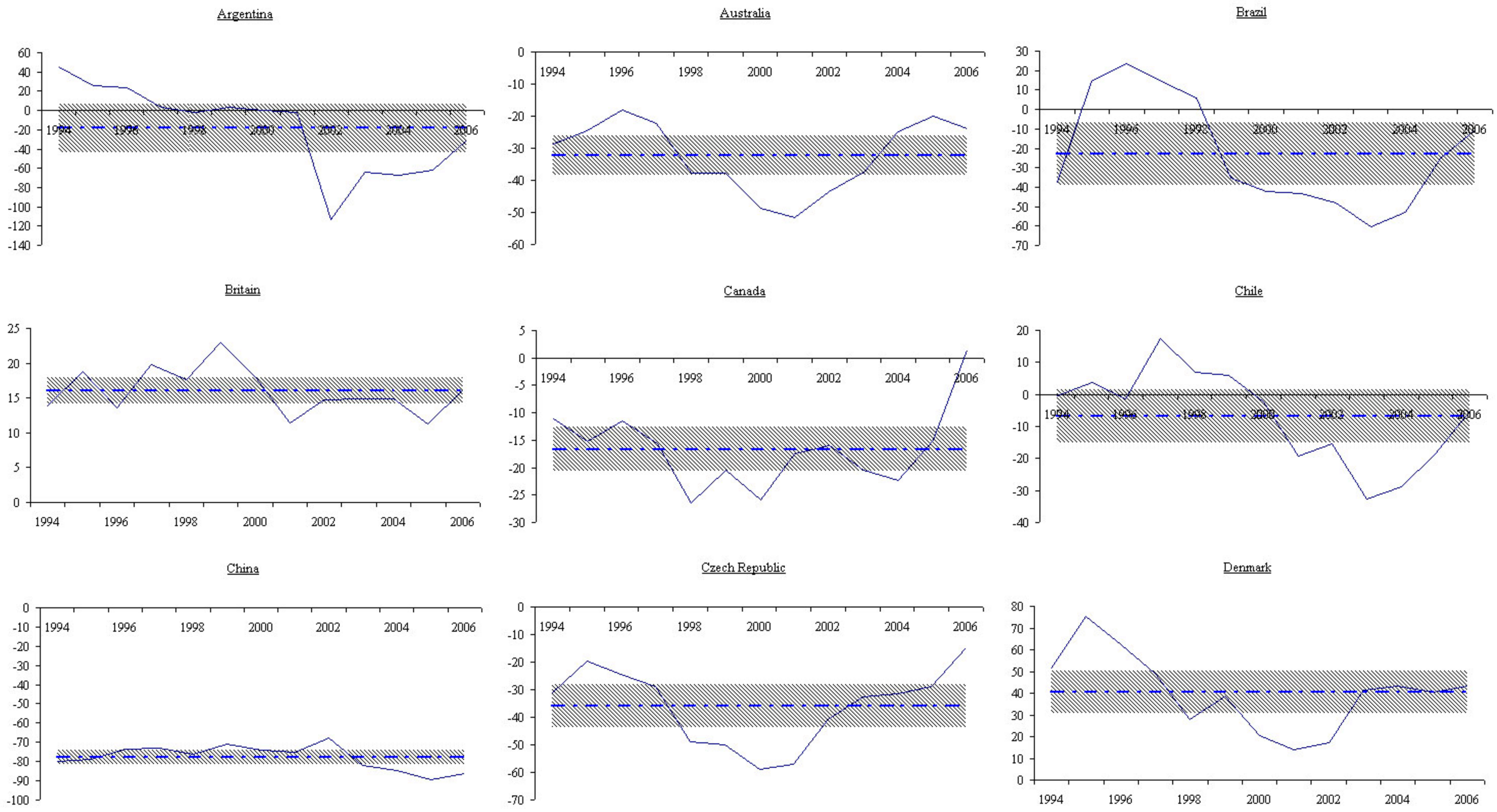


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FIGURE 3.3 (continued)

BIG MAC REAL EXCHANGE RATES FOR 24 COUNTRIES, 1994-2006

(Mean indicated by dashed-dotted lines; two standard-error band shaded; all × 100)

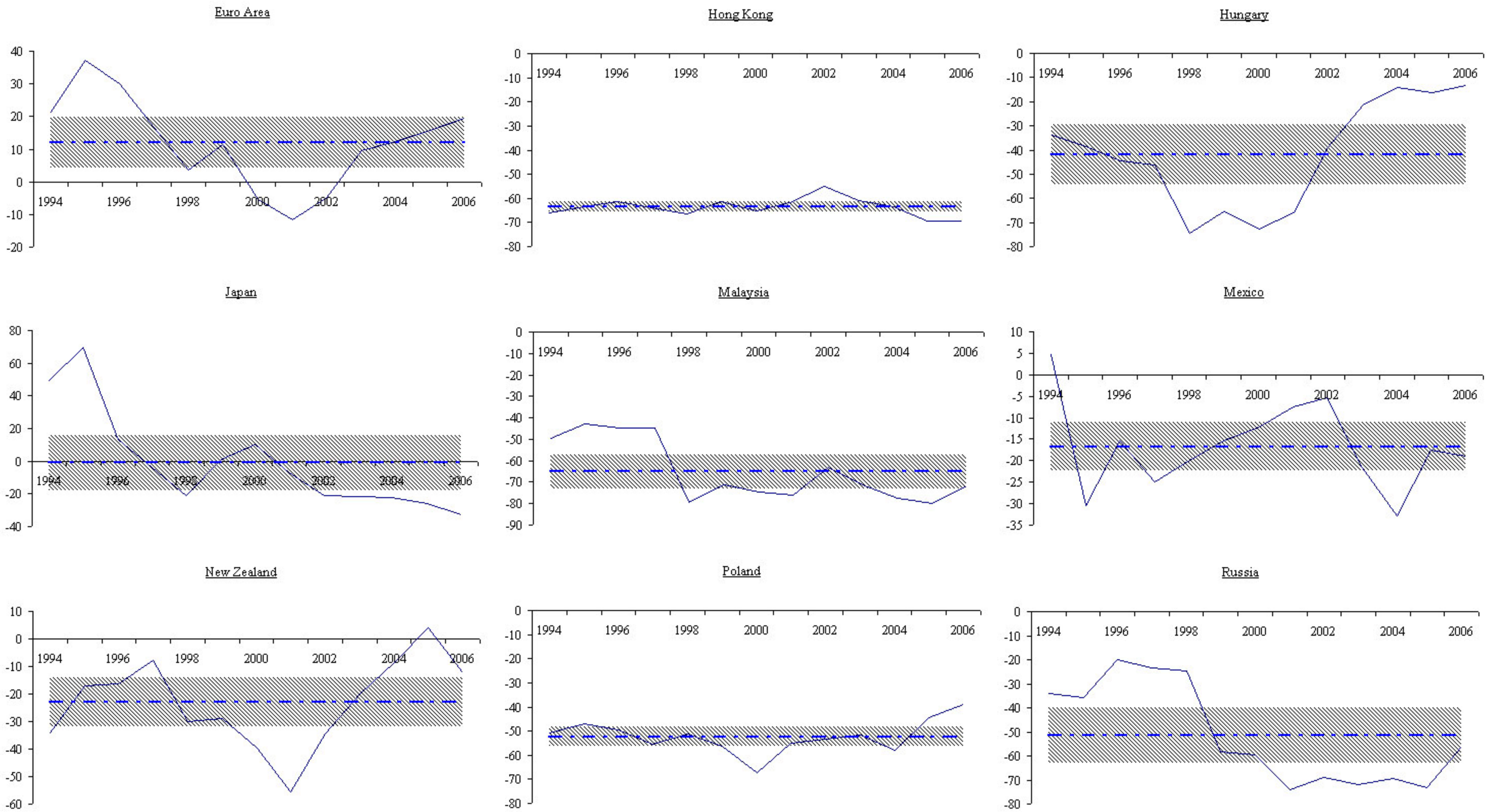

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FIGURE 3.3 (continued)

BIG MAC REAL EXCHANGE RATES FOR 24 COUNTRIES, 1994-2006

(Mean indicated by dashed-dotted lines; two standard-error band shaded; all × 100)

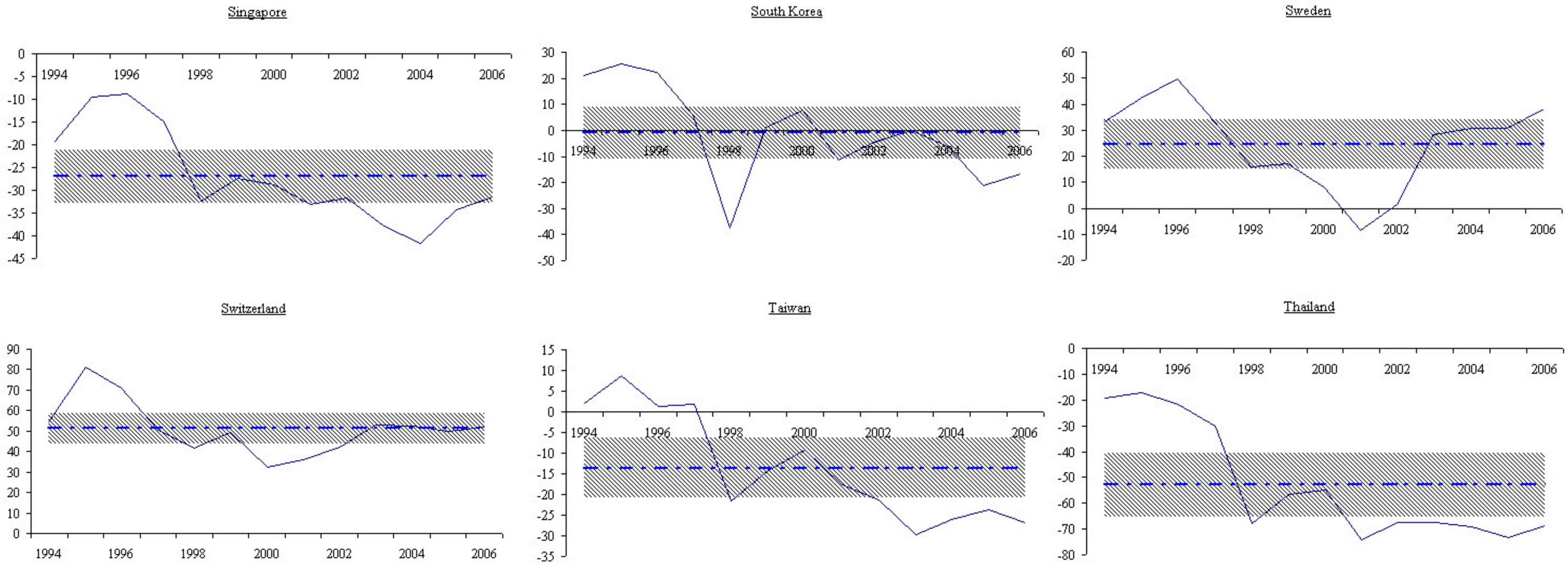

TABLE 3.4

CONTINGENCY TABLE TEST OF
SERIAL INDEPENDENCE OF MISPRICING,
ONE YEAR HORIZON

Mispricing in year t	Mispricing in year t+1		Total
	Undervalued	Overvalued	
	I. Observed		
Undervalued	192	10	202
Overvalued	14	72	86
Total	206	82	288
	II. Expected under independence		
Undervalued	144	58	202
Overvalued	62	24	86
Total	206	82	288
	III. Squared deviations		
Undervalued	15.6	39.3	54.9
Overvalued	36.7	92.2	128.9
Total	52.3	131.5	183.8

Note: The (i, j)th element of Panel III is $(O_{ij} - E_{ij})^2 / E_{ij}$, where O_{ij} and E_{ij} are the corresponding observed and expected values.

TABLE 3.5

TESTS OF SERIAL INDEPENDENCE
OVER VARIOUS HORIZONS

Horizon (Years)	Observed χ^2 value, with overlapping observations	
	Included	Excluded
1	183.8	183.8
2	142.2	75.7
3	104.4	41.6
4	82.1	24.1
5	68.4	23.5
6	54.9	18.0
7	43.5	4.8
8	37.8	6.7
9	27.1	8.8
10	18.5	8.8
11	10.2	5.7
12	5.7	5.7

Notes: Under the null of independence, the test statistic follows a χ^2 distribution with 1 degree of freedom. The critical value of $\chi^2_{.05}(1)$ is 3.8 and $\chi^2_{.01}(1)$ is 6.6.

TABLE 3.6

RUNS TESTS FOR ABSOLUTE PARITY

Country	Sequence of signs of disparities	Number of runs		Standard deviation $\sqrt{\text{var R}}$	Test statistic Z
		Observed R	Expected $E(R)$		
Argentina	++++−+−−−−−−−	4	7.15	1.63	-1.94
Australia	−−−−−−−−−−−−−	1	1.00	0.00	+∞
Brazil	−++++−−−−−−−−	3	6.54	1.45	-2.44
Britain	+++++++++++++	1	1.00	0.00	+∞
Canada	−−−−−−−−−−−−+	2	2.85	0.36	-2.35
Chile	−+−+++−−−−−−−	4	6.54	1.45	-1.75
China	−−−−−−−−−−−−−	1	1.00	0.00	+∞
Czech Republic	−−−−−−−−−−−−−	1	1.00	0.00	+∞
Denmark	+++++++++++++	1	1.00	0.00	+∞
Euro Area	++++++−−−++++	3	5.62	1.18	-2.22
Hong Kong	−−−−−−−−−−−−−	1	1.00	0.00	+∞
Hungary	−−−−−−−−−−−−−	1	1.00	0.00	+∞
Japan	+++−−++−−−−−−	4	7.15	1.63	-1.94
Malaysia	−−−−−−−−−−−−−	1	1.00	0.00	+∞
Mexico	+−−−−−−−−−−−−	2	2.85	0.36	-2.35
New Zealand	−−−−−−−−−−−−+	2	2.85	0.36	-2.35
Poland	−−−−−−−−−−−−−	1	1.00	0.00	+∞
Russia	−−−−−−−−−−−−−	1	1.00	0.00	+∞
Singapore	−−−−−−−−−−−−−	1	1.00	0.00	+∞
South Korea	++++−++−−−−−−	4	7.46	1.71	-2.02
Sweden	+++++++−+++++	2	2.85	0.36	-2.35
Switzerland	+++++++++++++	1	1.00	0.00	+∞
Taiwan	++++−−−−−−−−−	2	6.54	1.45	-3.14
Thailand	−−−−−−−−−−−−−	1	1.00	0.00	+∞

FIGURE 3.4

THE GEOGRAPHY OF MONEY

OVER/UNDER-VALUATION OF CURRENCIES, 1994-2006 AVERAGES

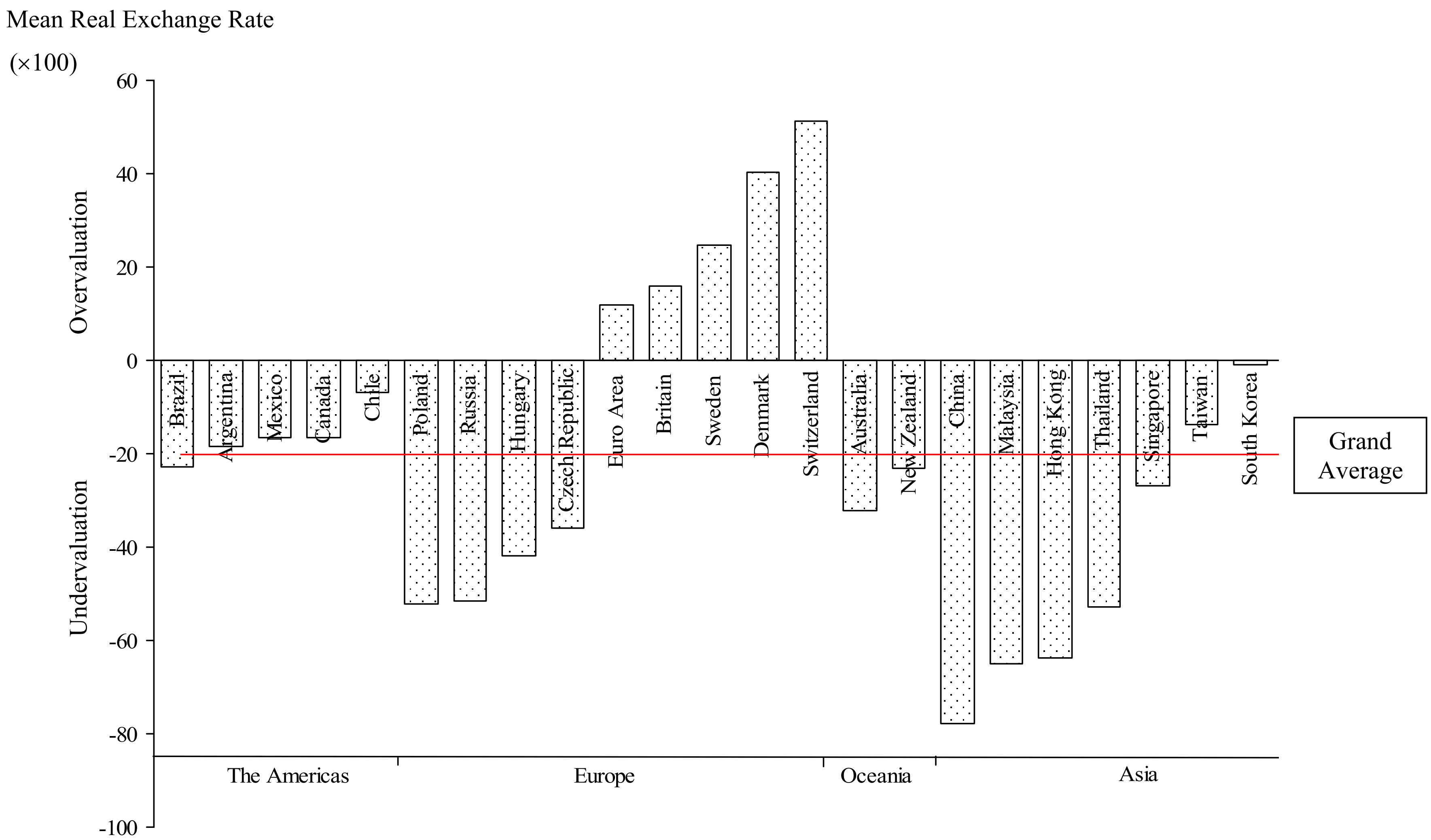

FIGURE 3.5

THE VALUE OF THE US DOLLAR, 1994-2006

(Mean indicated by dashed-dotted lines; two standard error band shaded; all × 100)

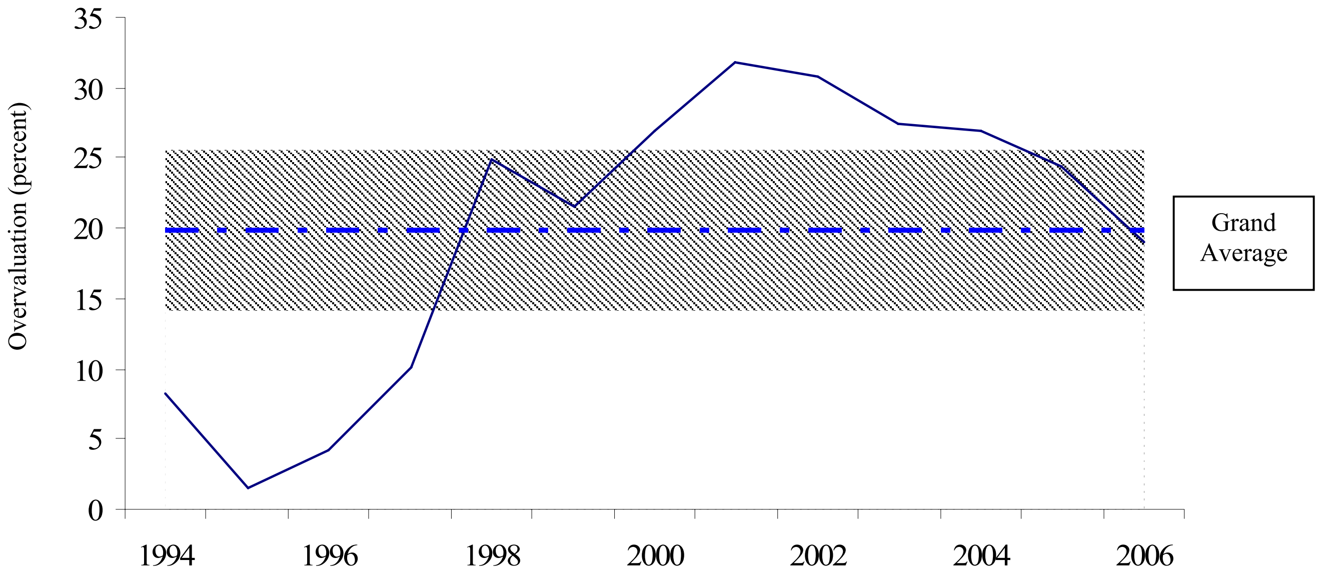

TABLE 3.7

MEAN REAL EXCHANGE RATES

(Logarithmic ratios $\times 100$; standard errors $\times 100$ in parentheses)

Country	Period						t-value for equality of means
	1994-1997		1998-2006		1994-2006		
(1)	(2)		(3)		(4)		(5)
Argentina	24.44	(8.49)	-37.66	(13.73)	-18.55	(12.69)	3.85
Australia	-23.41	(2.22)	-36.14	(3.74)	-32.22	(3.11)	2.93
Brazil	3.80	(13.92)	-34.65	(7.10)	-22.82	(8.02)	2.46
Britain	16.53	(1.63)	15.77	(1.19)	16.01	(0.93)	0.38
Canada	-13.35	(1.17)	-18.08	(2.77)	-16.63	(2.01)	1.57
Chile	4.78	(4.32)	-12.10	(4.78)	-6.90	(4.13)	2.62
China	-76.44	(1.73)	-78.42	(2.46)	-77.81	(1.76)	0.66
Czech Republic	-25.99	(2.56)	-40.36	(4.88)	-35.94	(3.89)	2.61
Denmark	59.53	(6.00)	31.83	(3.98)	40.36	(4.87)	3.85
Euro Area	26.38	(4.55)	5.57	(3.55)	11.97	(3.89)	3.61
Hong Kong	-63.64	(0.95)	-63.63	(1.52)	-63.63	(1.07)	-0.01
Hungary	-40.76	(2.86)	-42.43	(8.99)	-41.92	(6.16)	0.18
Japan	32.01	(16.63)	-15.69	(4.64)	-1.01	(8.46)	2.76
Malaysia	-45.45	(1.42)	-73.89	(1.76)	-65.14	(3.99)	12.58
Mexico	-16.53	(7.72)	-16.79	(2.73)	-16.71	(2.83)	0.03
New Zealand	-18.75	(5.49)	-25.01	(5.99)	-23.08	(4.42)	0.77
Poland	-50.71	(1.86)	-52.98	(2.68)	-52.28	(1.92)	0.70
Russia	-28.29	(3.89)	-61.79	(5.17)	-51.48	(5.78)	5.18
Singapore	-13.13	(2.45)	-33.17	(1.46)	-27.00	(2.93)	7.03
South Korea	18.75	(4.31)	-9.83	(4.55)	-1.04	(5.05)	4.56
Sweden	39.49	(4.01)	17.96	(5.16)	24.58	(4.66)	3.29
Switzerland	64.23	(7.16)	45.44	(2.55)	51.22	(3.63)	2.47
Taiwan	3.44	(1.74)	-21.19	(2.18)	-13.61	(3.63)	8.83
Thailand	-22.15	(2.84)	-66.59	(2.22)	-52.92	(6.16)	12.33
Mean	-6.05	(3.84)	-25.99	(2.39)	-19.86	(2.10)	4.41

FIGURE 4.1

SCATTER PLOTS OF EXCHANGE RATES AND PRICES,
24 COUNTRIES, 1994-2006
(Annualised logarithmic changes $\times 100$)

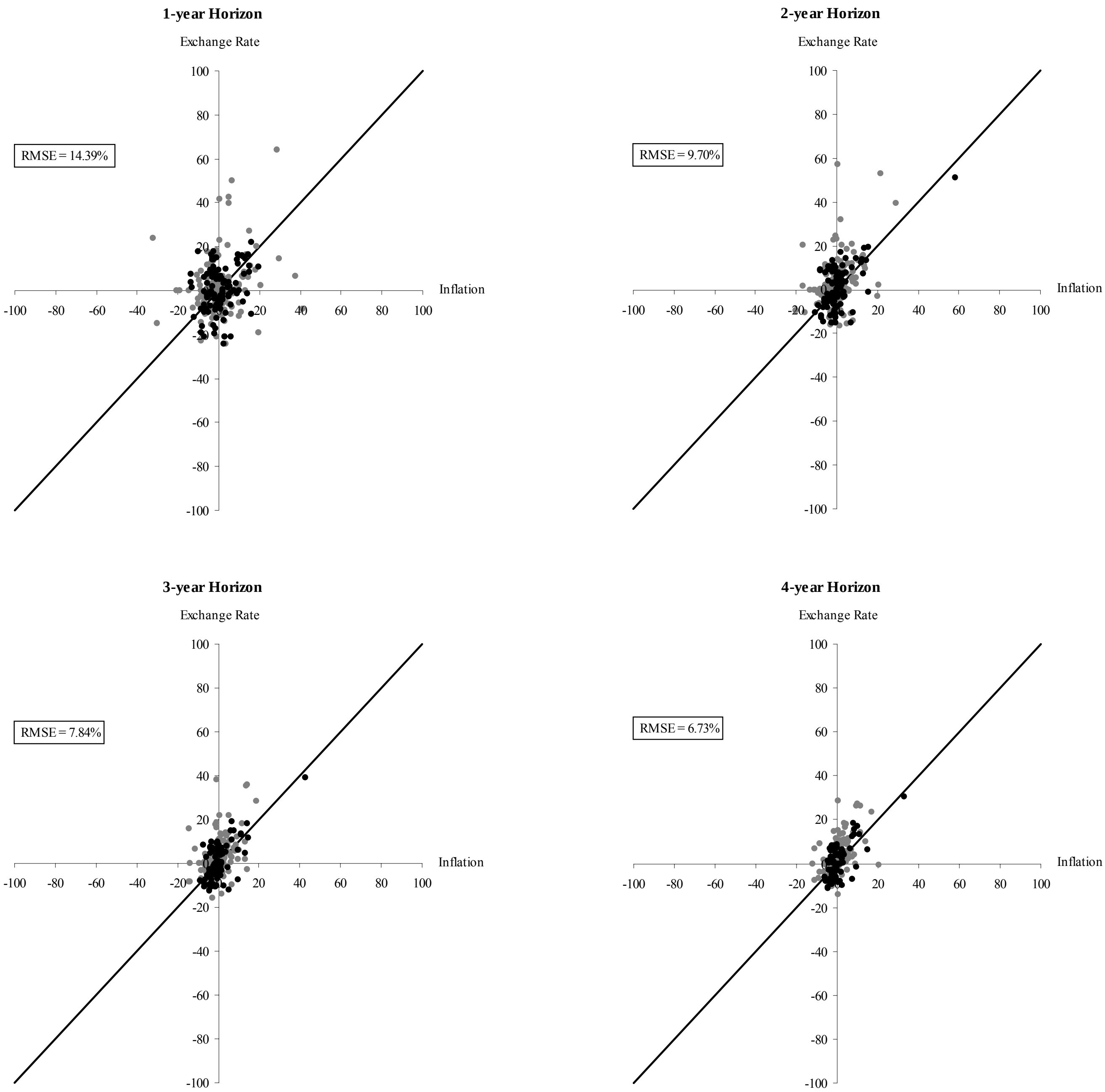

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FIGURE 4.1 (continued)

SCATTER PLOTS OF EXCHANGE RATES AND PRICES,
24 COUNTRIES, 1994-2006
(Annualised logarithmic changes $\times 100$)

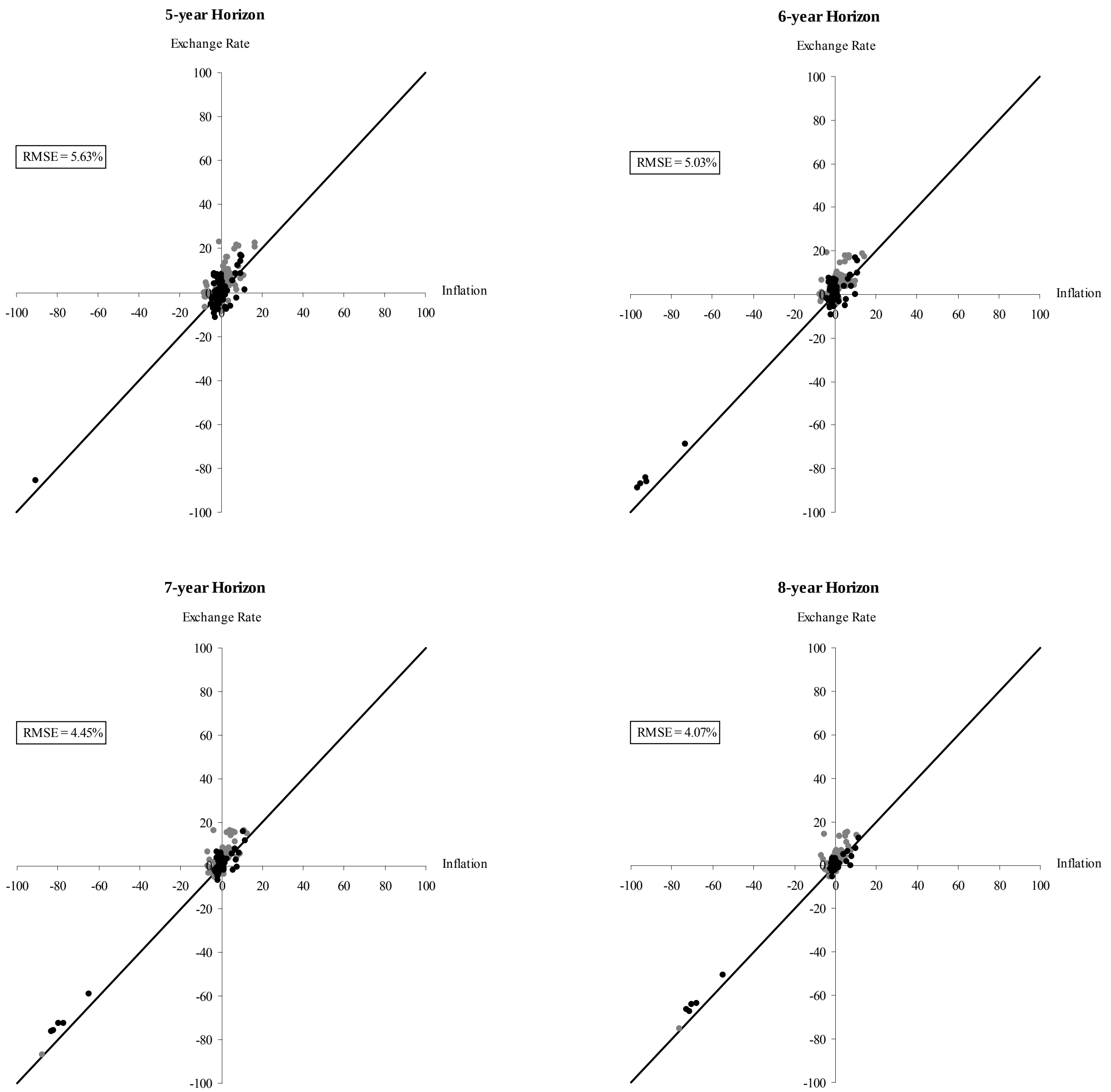

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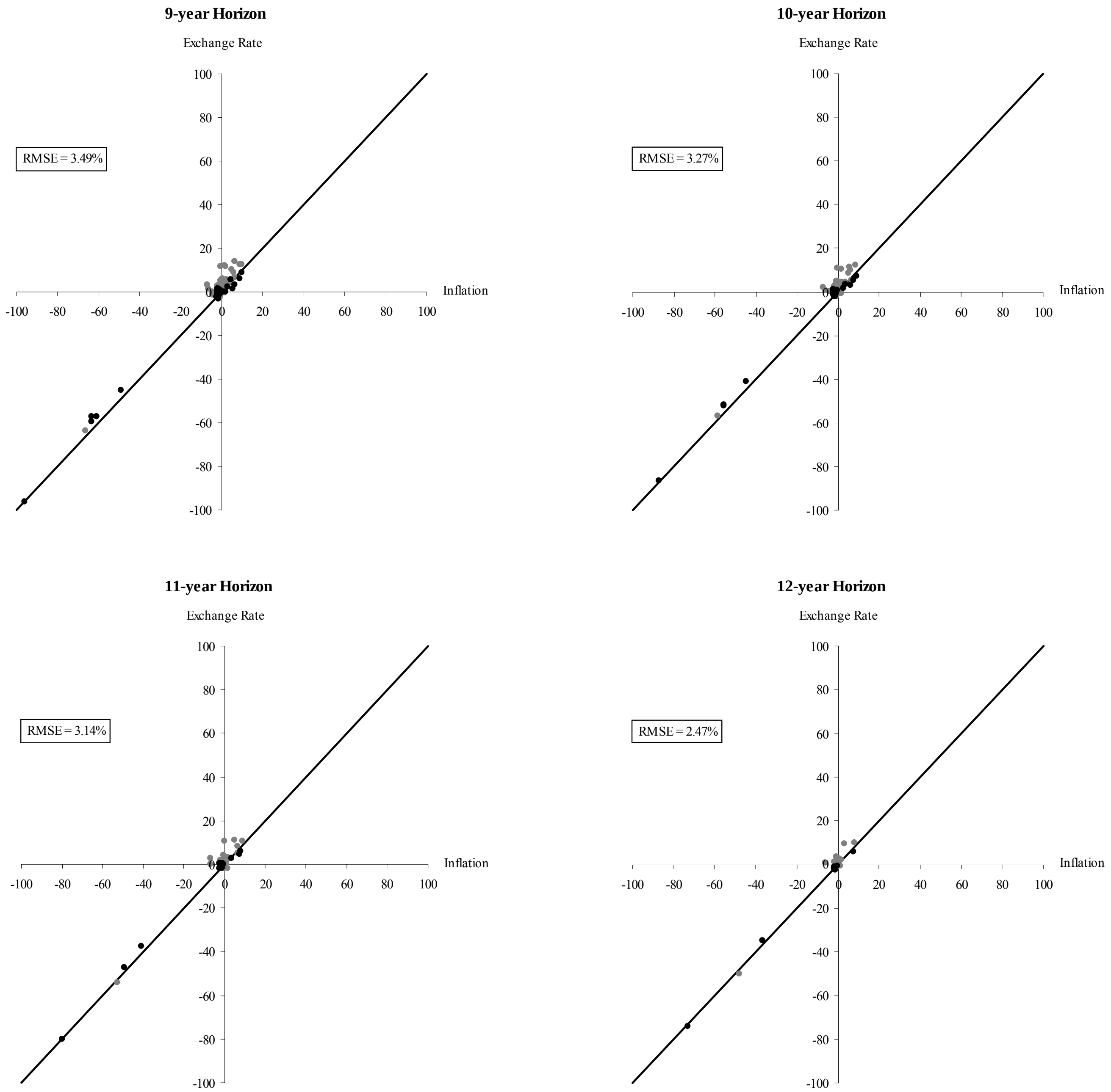
FIGURE 4.1 (continued)

SCATTER PLOTS OF EXCHANGE RATES AND PRICES,
24 COUNTRIES, 1994-2006
(Annualised logarithmic changes $\times 100$)



Notes: 1. To facilitate presentation, the cases in which the annualised logarithmic changes ($\times 100$) exceeded 100% have been omitted. These cases are included in the computation of the RMSEs.
2. The dark dots refer to the 9 European countries, while the lighter ones refer to the other countries.

FIGURE 4.2

BLOW-UP OF SCATTER PLOTS OF EXCHANGE RATES AND PRICES, 24 COUNTRIES, 1994-2006
(Annualised logarithmic changes×100)

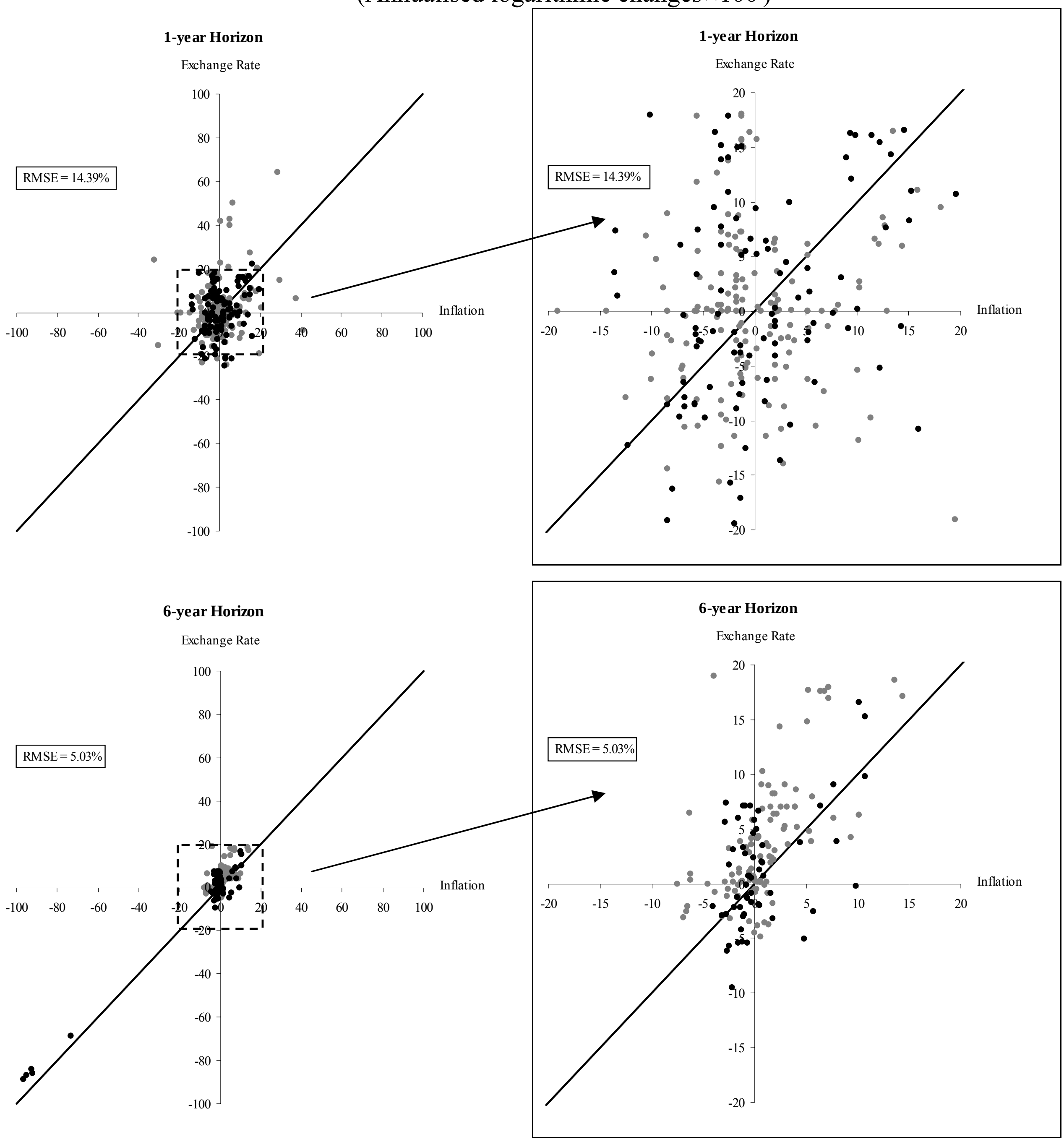


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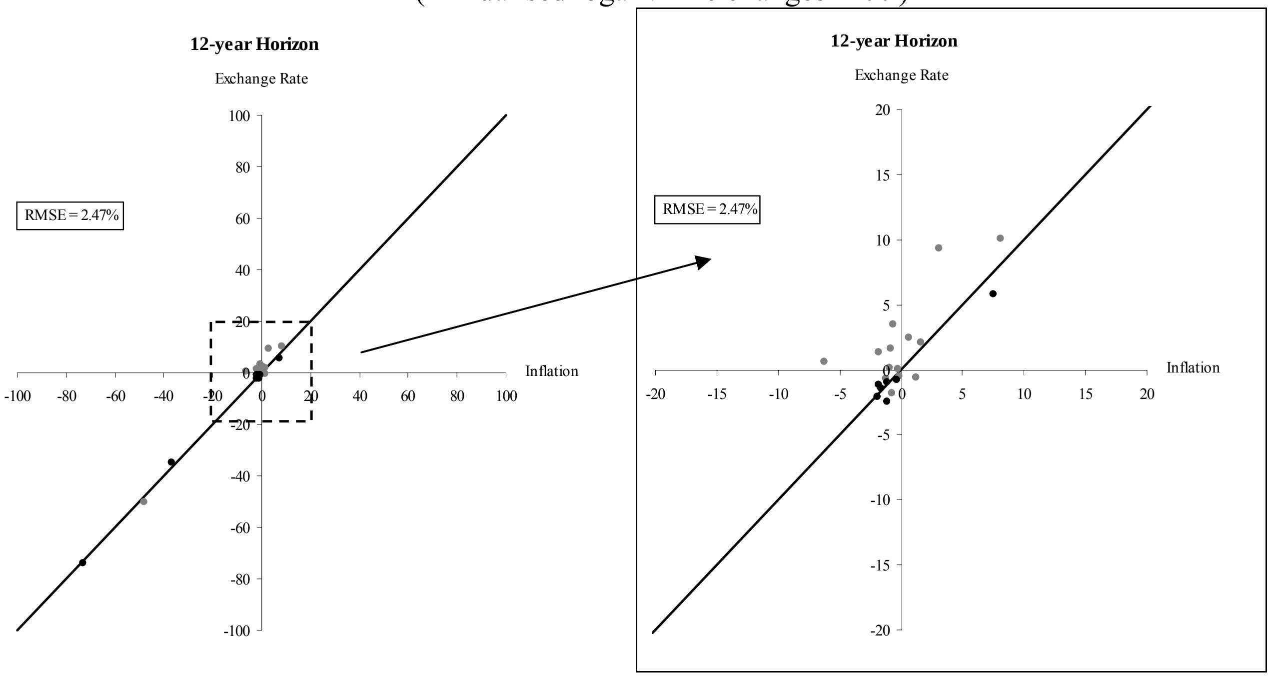
FIGURE 4.2 (continued)

BLOW-UP OF SCATTER PLOTS OF EXCHANGE RATES AND PRICES, FOR 24 COUNTRIES, 1994-2006
(Annualised logarithmic changes$\times 100$)



Notes: 1.To facilitate presentation, the cases in which the annualised logarithmic changes ($\times 100$) exceeded 20% have been omitted. These cases are included in the computation of the RMSEs.
2. The dark dots refer to the 9 European countries, while the lighter ones refer to the other countries.

FIGURE 4.3

VARIANCES OF EXCHANGE RATE CHANGES

A. Annualised changes B. Total changes

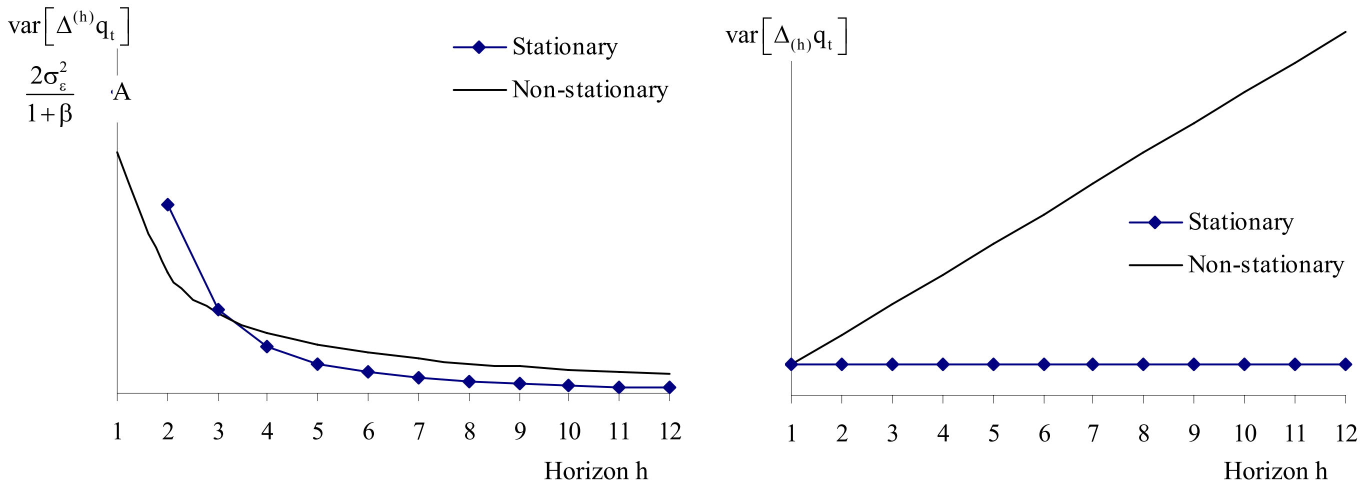


FIGURE 4.4

TOTAL VOLATILITY AND THE HORIZON

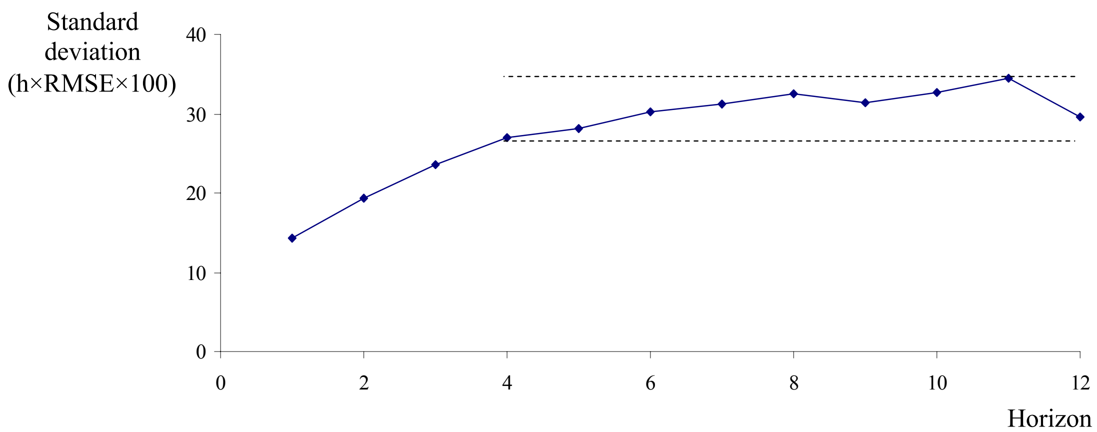


FIGURE 5.1

SCATTER PLOTS OF FUTURE REAL EXCHANGE RATES AGAINST CURRENT DEVIATIONS FROM PARITY, 24 COUNTRIES, 1994-2006
(Logarithmic changes × 100)

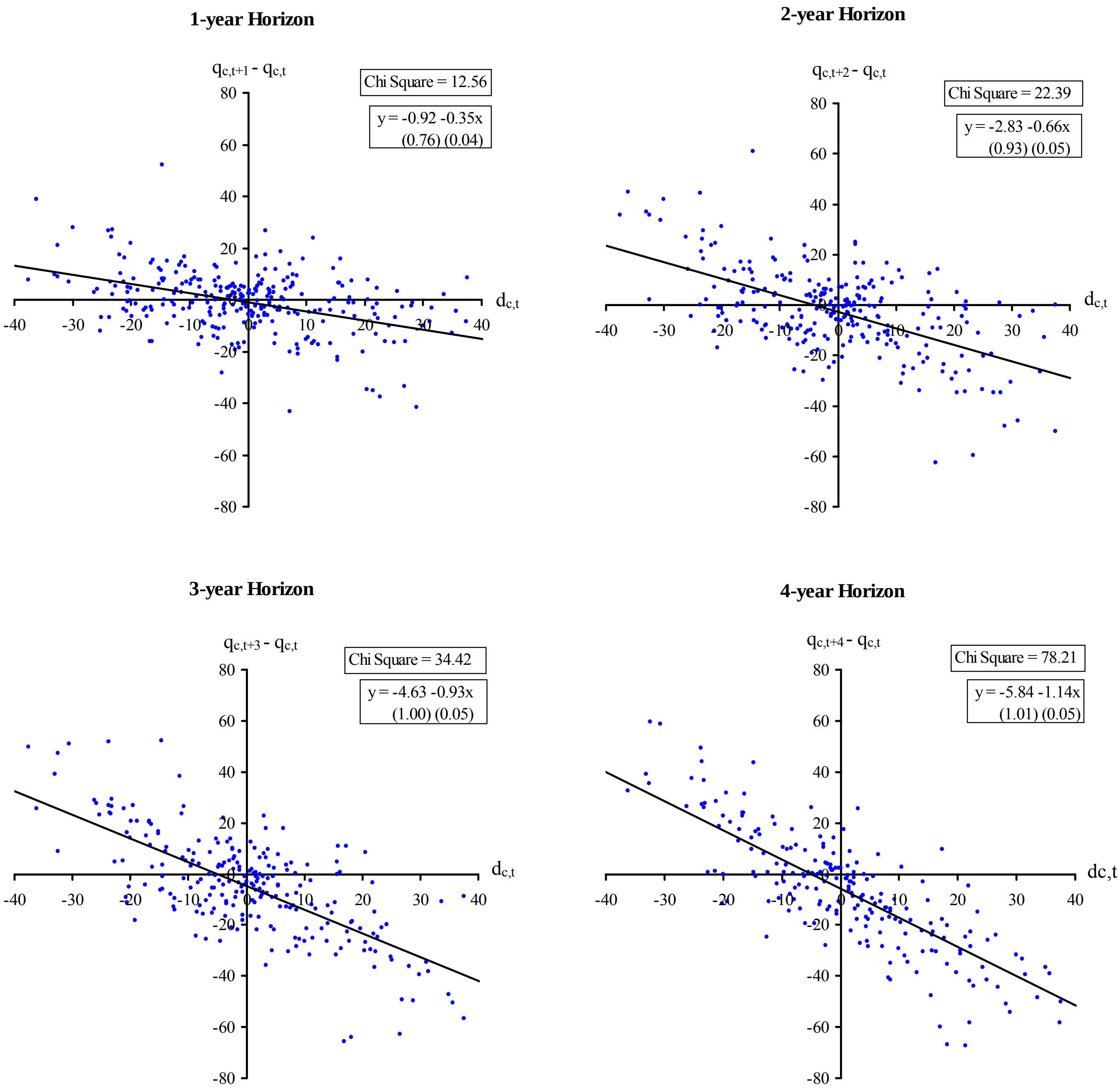


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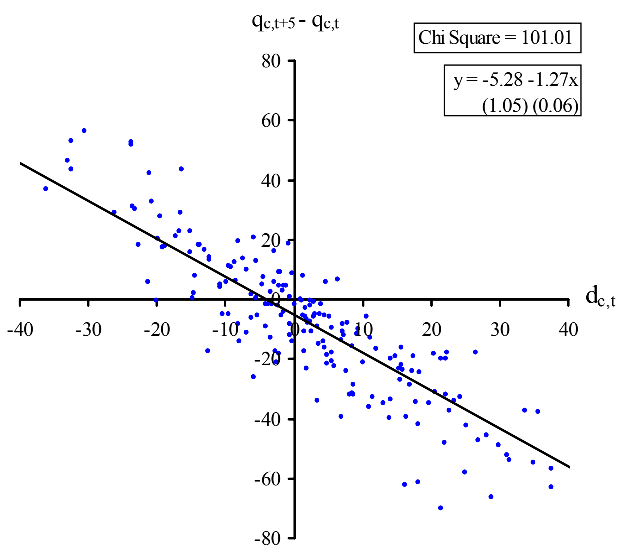
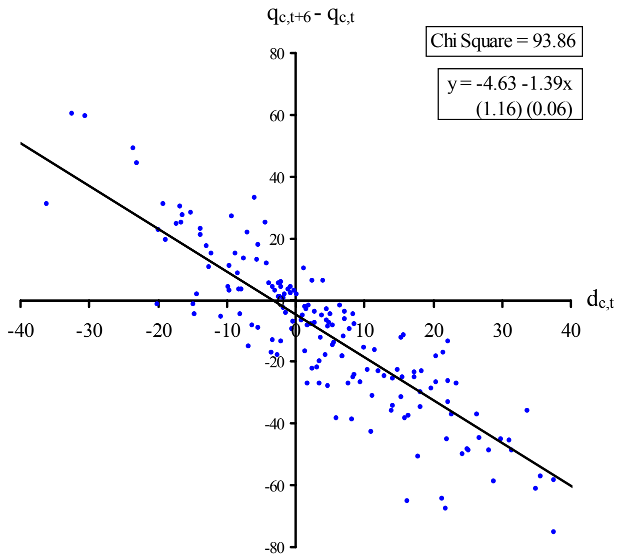
FIGURE 5.1 (continued)

SCATTER PLOTS OF FUTURE REAL EXCHANGE RATES AGAINST CURRENT DEVIATIONS FROM PARITY, 24 COUNTRIES, 1994-2006
(Logarithmic changes × 100)

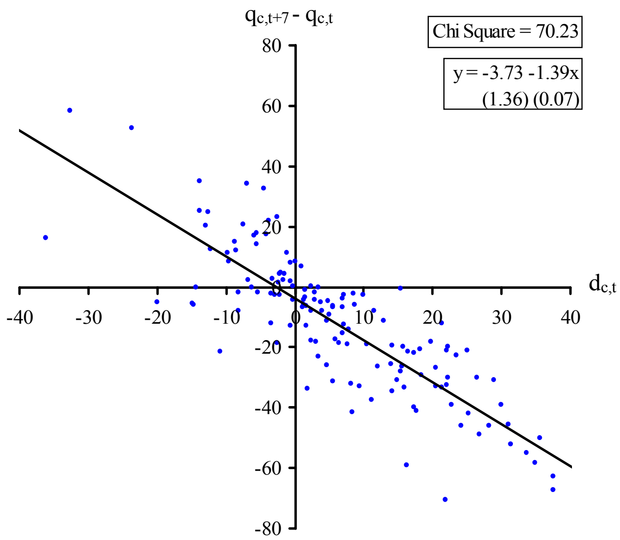
5-year Horizon



6-year Horizon



7-year Horizon



8-year Horizon

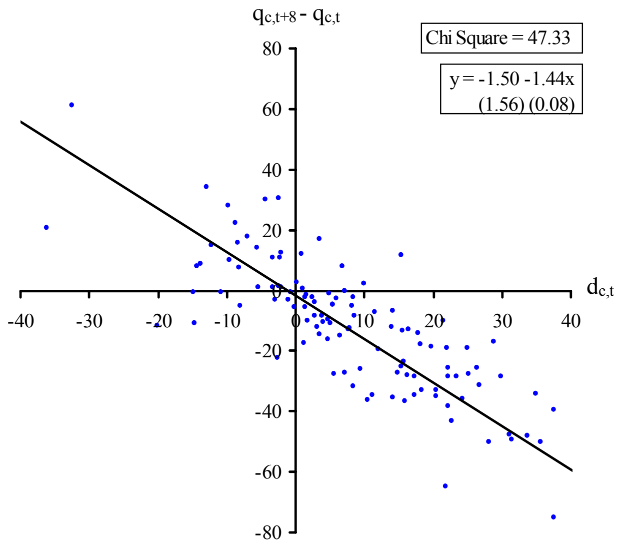


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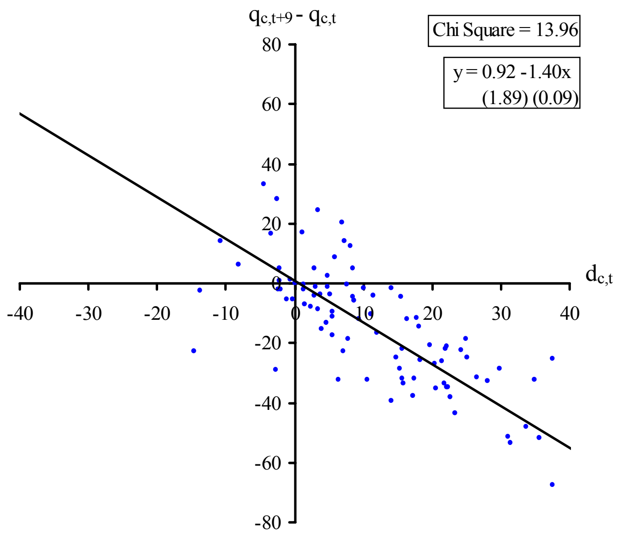
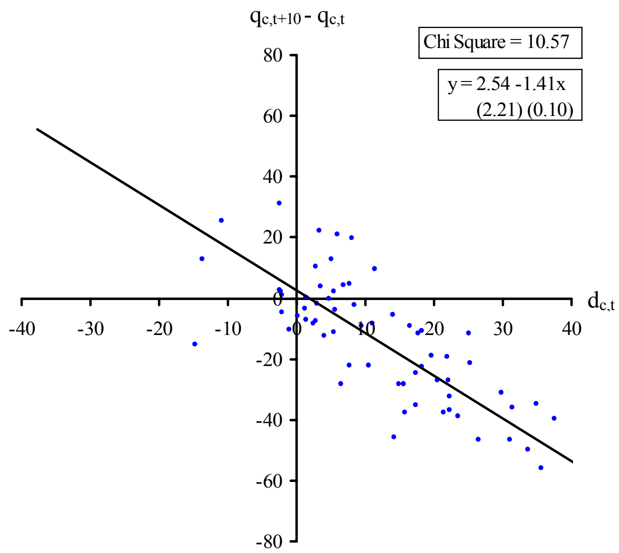
FIGURE 5.1 (continued)

SCATTER PLOTS OF FUTURE REAL EXCHANGE RATES AGAINST CURRENT DEVIATIONS FROM PARITY, 24 COUNTRIES, 1994-2006
(Logarithmic changes $\times 100$)

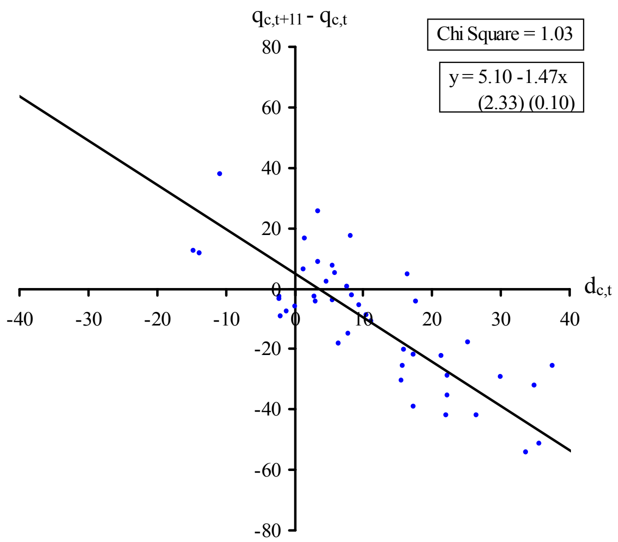
9-year Horizon



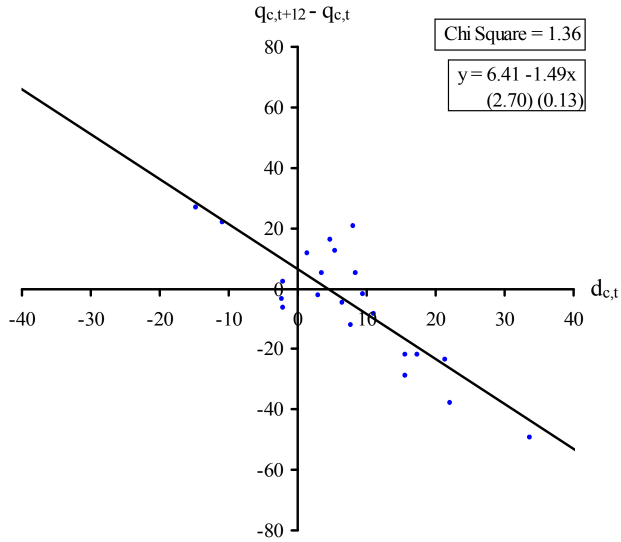
10-year Horizon



11-year Horizon



12-year Horizon



Note: 1. To facilitate presentation, the cases in which the annualised logarithmic changes ($\times 100$) exceeded 80% have been omitted. These cases are included in the regression and the chi square value.

FIGURE 5.2
PREDICTIVE VALUE OF DEVIATIONS FROM PARITY:
CHI SQUARE VALUE AGAINST HORIZON

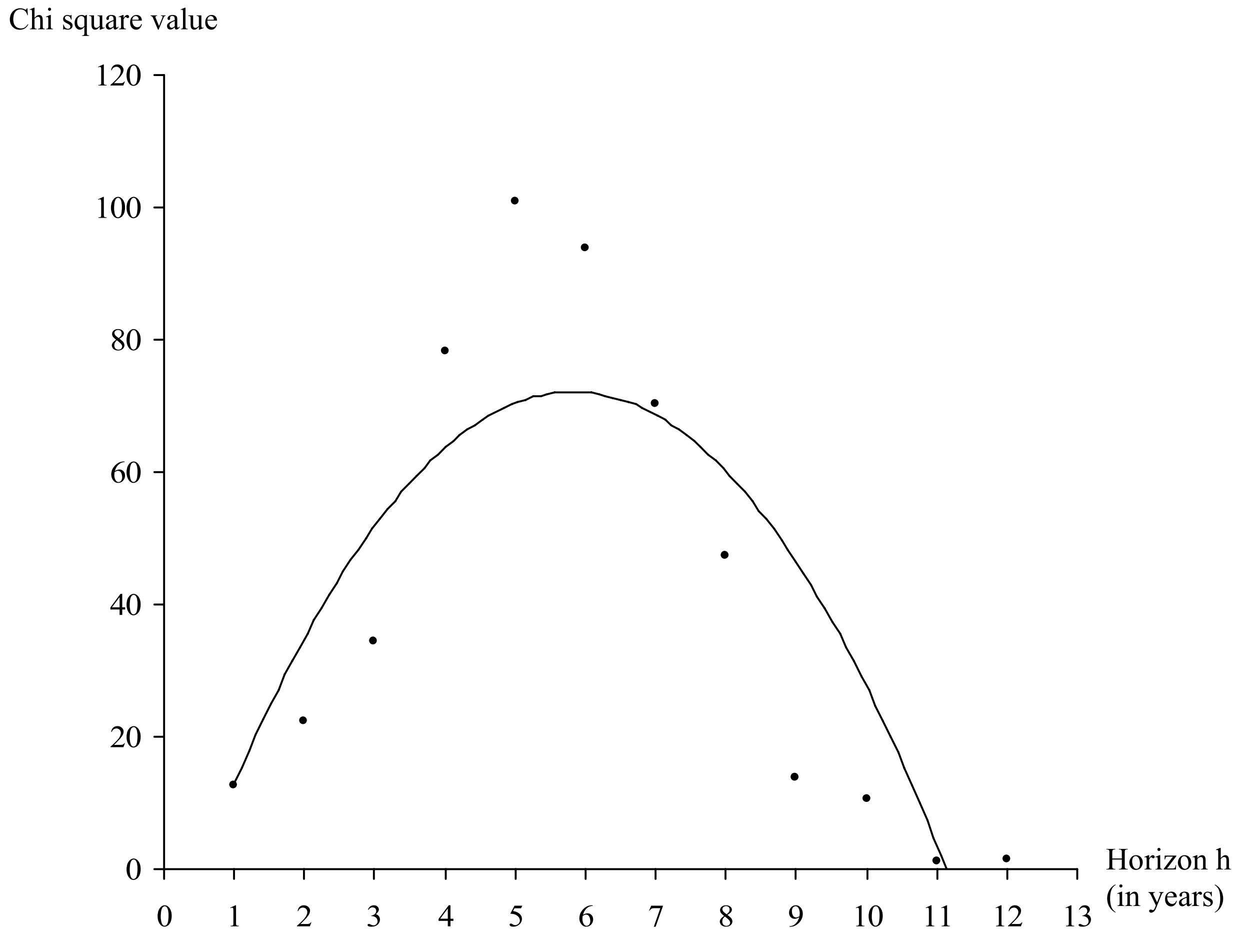


TABLE 5.1

PREDICTIVE REGRESSIONS, REAL EXCHANGE RATES, 24 COUNTRIES, 1994-2006

$$q_{c,t+h}-q_{c,t}=\eta^h+\phi^h d_{c,t}+u^h_{c,t}$$

(Standard errors in parentheses)

Horizon h (1)	Intercept $\eta^h\times 100$ (2)	Slope ϕ^h (3)	No of observations (4)	R^2 (5)	χ^2 (6)	F (7)
		A. With overlapping observations				
1	-0.919 (0.762)	-0.352 (0.042)	288	0.194	12.563*	117.812*
	-	-0.352 (0.042)	288	-		-
2	-2.827 (0.927)	-0.655 (0.051)	264	0.386	22.393*	27.052*
	-	-0.658 (0.052)	264	-		-
3	-4.625 (0.996)	-0.928 (0.054)	240	0.550	34.418*	11.337*
	-	-0.943 (0.057)	240	-		-
4	-5.844 (1.013)	-1.143 (0.055)	216	0.671	78.210*	21.972*
	-	-1.178 (0.058)	216	-		-
5	-5.276 (1.051)	-1.270 (0.059)	192	0.710	101.010*	29.065*
	-	-1.331 (0.061)	192	-		-
6	-4.629 (1.157)	-1.387 (0.065)	168	0.735	93.855*	37.951*
	-	-1.472 (0.064)	168	-		-
7	-3.734 (1.364)	-1.391 (0.074)	144	0.714	70.226*	29.817*
	-	-1.480 (0.068)	144	-		-
8	-1.498 (1.557)	-1.437 (0.079)	120	0.740	47.328*	25.075*
	-	-1.475 (0.068)	120	-		-
9	0.923 (1.889)	-1.401 (0.091)	96	0.715	13.957*	15.024*
	-	-1.371 (0.068)	96	-		-
10	2.536 (2.212)	-1.406 (0.099)	72	0.742	10.572*	10.878*
	-	-1.329 (0.073)	72	-		-
11	5.102 (2.330)	-1.468 (0.100)	48	0.823	1.033	11.421*
	-	-1.327 (0.080)	48	-		-
12	6.406 (2.702)	-1.488 (0.131)	24	0.855	1.364	7.048*
	-	-1.316 (0.119)	24	-		-

(continued on next page)

TABLE 5.1 (continued)

PREDICTIVE REGRESSIONS, REAL EXCHANGE RATES, 24 COUNTRIES, 1994-2006

Horizon h (1)	Intercept $\eta^h \times 100$ (2)	Slope ϕ^h (3)	No of observations (4)	R^2 (5)	χ^2 (6)	F (7)
		B. Without overlapping observations				
1	-0.919 (0.762)	-0.352 (0.042)	288	0.194	12.563*	117.812*
	-	-0.352 (0.042)	288	-	-	-
2	-2.130 (1.375)	-0.673 (0.073)	144	0.373	12.355*	11.324*
	-	-0.670 (0.074)	144	-	-	-
3	-1.187 (1.509)	-0.904 (0.091)	96	0.514	19.703*	0.795
	-	-0.911 (0.090)	96	-	-	-
4	-5.246 (2.050)	-1.106 (0.102)	72	0.628	23.074*	3.639*
	-	-1.087 (0.105)	72	-	-	-
5	-4.643 (1.973)	-0.958 (0.124)	48	0.565	19.368*	2.851
	-	-1.047 (0.123)	48	-	-	-
6	-2.846 (1.970)	-1.129 (0.111)	48	0.691	30.857*	1.960
	-	-1.149 (0.112)	48	-	-	-
7	-15.246 (3.000)	-0.713 (0.145)	24	0.524	8.291*	13.447*
	-	-1.124 (0.174)	24	-	-	-
8	-2.773 (4.186)	-1.709 (0.202)	24	0.764	13.029*	11.116*
	-	-1.784 (0.166)	24	-	-	-
9	-3.228 (3.237)	-1.378 (0.156)	24	0.779	8.539*	6.907*
	-	-1.465 (0.130)	24	-	-	-
10	-1.370 (3.257)	-1.499 (0.157)	24	0.805	5.874*	8.491*
	-	-1.536 (0.128)	24	-	-	-
11	2.991 (2.722)	-1.651 (0.132)	24	0.877	0.758	14.234*
	-	-1.570 (0.110)	24	-	-	-
12	6.406 (2.702)	-1.488 (0.131)	24	0.855	1.364	7.048*
	-	-1.316 (0.119)	24	-	-	-

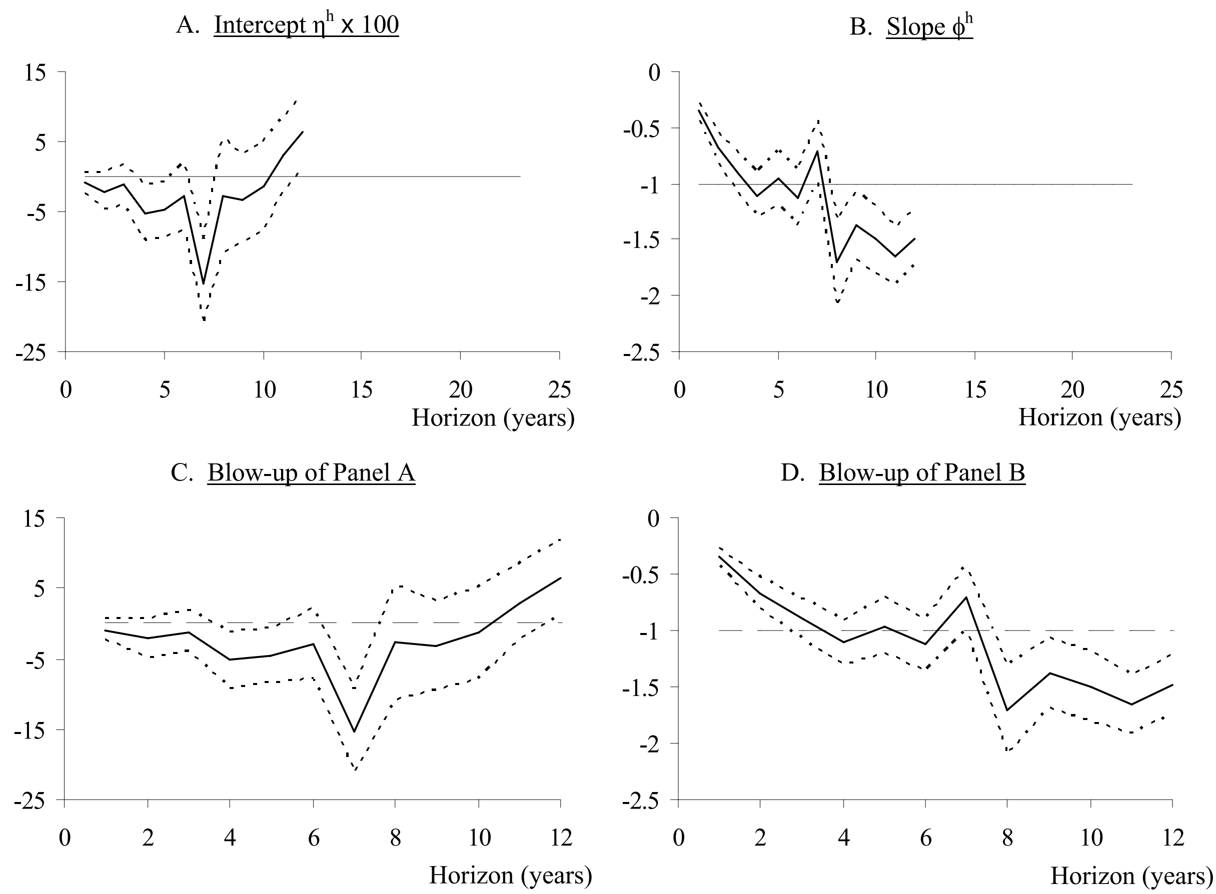
Notes: 1. The χ^2 statistics of column 6 test the hypothesis of the independence of $q_{c,t+h} - q_{c,t}$ and $d_{c,t}$. Under the null, χ^2 has 1 degree of freedom.

2. The F statistics of column 7 test the joint hypothesis of $\eta^h = 0$ and $\phi^h = -1$. Under the null, F has degrees of freedom equal to 2 and N-2, where N is the number of observations.

3. An asterisk (*) indicates significant at the 5 percent level.

FIGURE 5.3

TIME PATHS OF ESTIMATED PARAMETERS OF PREDICTIVE REGRESSIONS



Note: The solid lines are the estimated parameters, while the broken lines are the 95 percent confidence limits.

FIGURE 5.4

TIME PATHS OF PARAMETERS OF PREDICTIVE REGRESSIONS IN AR(1) CASE

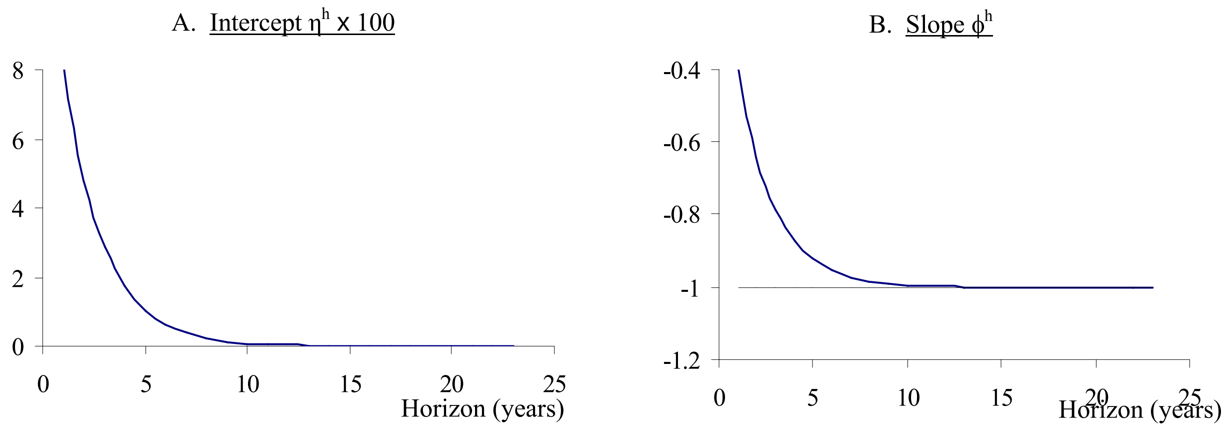
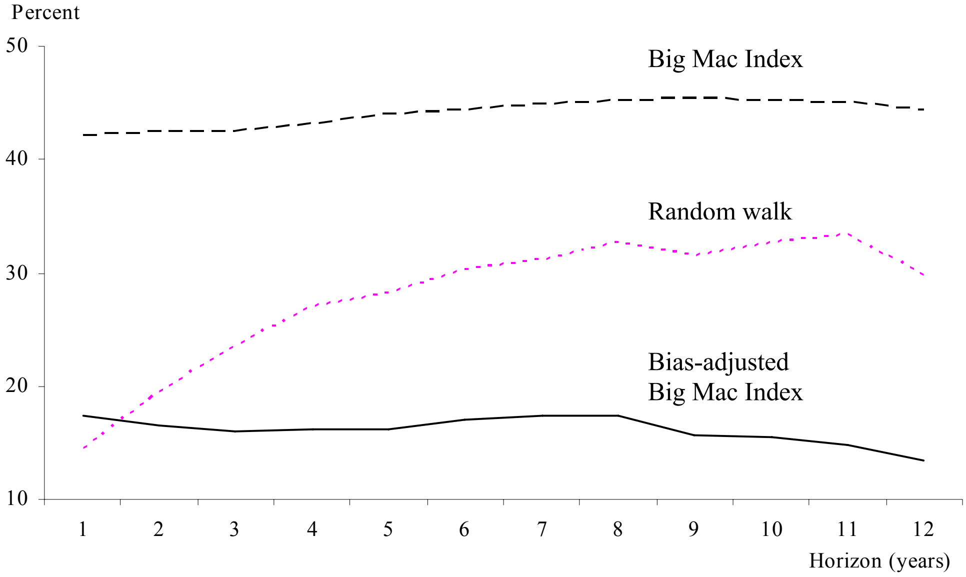


FIGURE 5.5

THE QUALITY OF THREE SETS OF EXCHANGE-RATE FORECASTS

(Root-Mean-Squared Errors)

A. With overlapping observations



B. Without overlapping observations

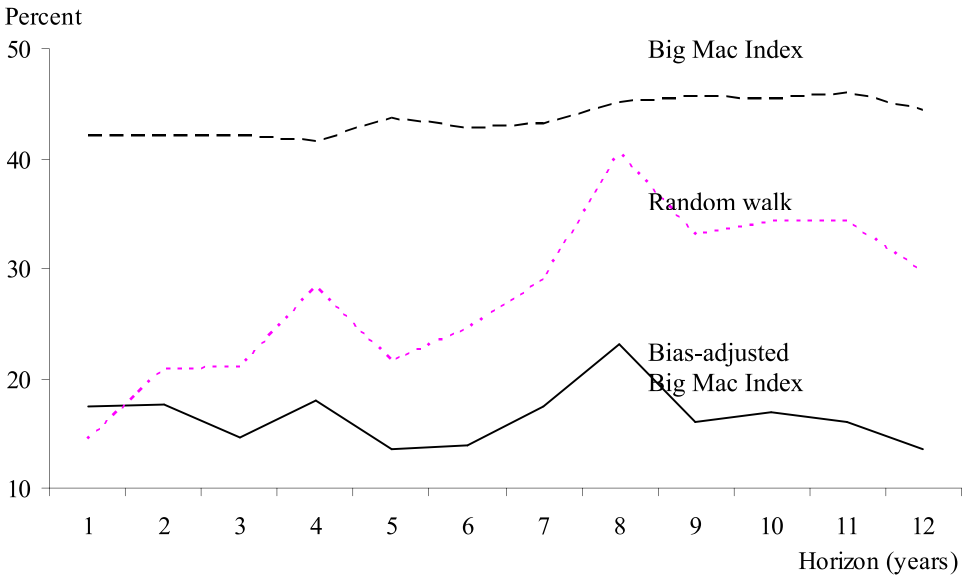


TABLE 6.1

MORE PREDICTIVE REGRESSIONS, 24 COUNTRIES, 1994-2006

(Standard errors in parentheses)

	(i) Negative change in nominal exchange rate $-(s_{c,t+h}-s_{c,t})=\eta_s^h+\phi_s^h d_{ct}+u_{s,ct}^h$					(ii) Inflation differential $r_{c,t+h}-r_{c,t}=\eta_r^h+\phi_r^h d_{ct}^h+u_{r,ct}^h$				
Horizon h (1)	Intercept $\eta_s^h\times100$ (2)	Slope ϕ_s^h (3)	No of observations (4)	R^2 (5)	χ^2 (6)	Intercept $\eta_r^h\times100$ (7)	Slope ϕ_r^h (8)	No of observations (9)	R^2 (10)	χ^2 (11)
				A. With overlapping observations						
1	5.603 (4.511)	-0.123 (0.251)	288	0.001	1.343	-6.522 (4.408)	-0.229 (0.245)	288	0.003	7.660
	-	-0.124 (0.251)	288	-		-	-0.227 (0.245)	288	-	
2	6.045 (5.343)	-0.207 (0.294)	264	0.002	8.727	-8.873 (5.217)	-0.449 (0.287)	264	0.009	8.038
	-	-0.200 (0.294)	264	-		-	-0.458 (0.288)	264	-	
3	6.500 (6.292)	-0.245 (0.344)	240	0.002	21.502	-11.125 (6.184)	-0.683 (0.338)	240	0.017	1.968
	-	-0.224 (0.344)	240	-		-	-0.720 (0.339)	240	-	
4	7.461 (7.434)	-0.347 (0.402)	216	0.003	44.172	-13.305 (7.307)	-0.795 (0.395)	216	0.019	0.101
	-	-0.303 (0.399)	216	-		-	-0.875 (0.394)	216	-	
5	9.732 (8.639)	-0.428 (0.484)	192	0.004	41.741	-15.009 (8.618)	-0.842 (0.483)	192	0.016	0.224
	-	-0.316 (0.474)	192	-		-	-1.015 (0.475)	192	-	
6	11.027 (10.177)	-0.561 (0.568)	168	0.006	42.624	-15.655 (10.243)	-0.826 (0.572)	168	0.012	0.193
	-	-0.358 (0.537)	168	-		-	-1.114 (0.542)	168	-	
7	14.509 (12.398)	-0.683 (0.671)	144	0.007	25.299	-18.244 (12.506)	-0.708 (0.677)	144	0.008	1.389
	-	-0.340 (0.605)	144	-		-	-1.139 (0.612)	144	-	
8	21.578 (15.410)	-0.850 (0.777)	120	0.010	26.138	-23.076 (15.581)	-0.587 (0.786)	120	0.005	0.049
	-	-0.300 (0.673)	120	-		-	-1.175 (0.681)	120	-	
9	35.426 (20.626)	-1.466 (0.996)	96	0.023	7.484	-34.502 (21.007)	0.065 (1.015)	96	0.000	0.269
	-	-0.325 (0.750)	96	-		-	-1.046 (0.763)	96	-	
10	51.533 (25.606)	-2.029 (1.148)	72	0.043	3.733	-48.997 (26.223)	0.623 (1.176)	72	0.004	0.429
	-	-0.458 (0.860)	72	-		-	-0.870 (0.877)	72	-	
11	74.744 (33.705)	-2.810 (1.451)	48	0.075	2.987	-69.642 (34.129)	1.342 (1.470)	48	0.018	0.009
	-	-0.744 (1.158)	48	-		-	-0.582 (1.164)	48	-	
12	119.198 (55.326)	-4.498 (2.674)	24	0.114	1.698	-112.792 (55.255)	3.009 (2.671)	24	0.055	0.084
	-	-1.287 (2.389)	24	-		-	-0.029 (2.365)	24	-	

(continued on next page)

TABLE 6.1 (continued)

MORE PREDICTIVE REGRESSIONS, 24 COUNTRIES, 1994-2006

(Standard errors in parentheses)

	(i) Negative change in nominal exchange rate $-(s_{c,t+h}-s_{c,t})=\eta_s^h+\phi_s^h d_{ct}+u_{s,ct}^h$					(ii) Inflation differential $r_{c,t+h}-r_{c,t}=\eta_r^h+\phi_r^h d_{ct}^h+u_{r,ct}^h$				
Horizon h (1)	Intercept $\eta_s^h \times 100$ (2)	Slope ϕ_s^h (3)	No of observations (4)	R^2 (5)	χ^2 (6)	Intercept $\eta_r^h \times 100$ (7)	Slope ϕ_r^h (8)	No of observations (9)	R^2 (10)	χ^2 (11)
					B. Without overlapping observations					
1	5.603 (4.511)	-0.123 (0.251)	288	0.001	1.343	-6.522 (4.408)	-0.229 (0.245)	288	0.003	7.660
	-	-0.124 (0.251)	288	-		-	-0.227 (0.245)	288	-	
2	11.087 (8.912)	-0.269 (0.475)	144	0.002	3.334	-13.217 (8.669)	-0.404 (0.462)	144	0.005	9.017
	-	-0.285 (0.476)	144	-		-	-0.386 (0.464)	144	-	
3	17.733 (13.229)	-0.542 (0.795)	96	0.005	5.783	-18.920 (13.005)	-0.362 (0.781)	96	0.002	2.597
	-	-0.435 (0.794)	96	-		-	-0.476 (0.782)	96	-	
4	21.921 (17.500)	-0.349 (0.870)	72	0.002	7.276	-27.167 (17.166)	-0.758 (0.853)	72	0.011	0.629
	-	-0.430 (0.871)	72	-		-	-0.657 (0.860)	72	-	
5	37.162 (25.496)	-1.588 (1.601)	48	0.021	11.622	-41.804 (25.494)	0.630 (1.600)	48	0.003	0.022
	-	-0.872 (1.541)	48	-		-	-0.175 (1.550)	48	-	
6	36.518 (24.186)	-1.272 (1.365)	48	0.019	16.326	-39.364 (24.561)	0.143 (1.386)	48	0.000	0.167
	-	-1.011 (1.372)	48	-		-	-0.139 (1.398)	48	-	
7	90.569 (56.799)	-3.373 (2.745)	24	0.064	1.407	-105.816 (56.558)	2.660 (2.734)	24	0.041	0.873
	-	-0.933 (2.354)	24	-		-	-0.191 (2.390)	24	-	
8	96.846 (55.734)	-4.258 (2.694)	24	0.102	2.476	-99.619 (56.782)	2.548 (2.744)	24	0.038	0.505
	-	-1.649 (2.333)	24	-		-	-0.136 (2.379)	24	-	
9	102.990 (54.605)	-4.233 (2.639)	24	0.105	2.906	-106.218 (55.870)	2.855 (2.700)	24	0.048	0.017
	-	-1.458 (2.310)	24	-		-	-0.007 (2.366)	24	-	
10	108.263 (54.282)	-4.290 (2.624)	24	0.108	2.274	-109.633 (55.682)	2.791 (2.691)	24	0.047	0.126
	-	-1.374 (2.315)	24	-		-	-0.162 (2.370)	24	-	
11	115.903 (54.983)	-4.413 (2.657)	24	0.111	1.698	-112.912 (55.574)	2.762 (2.686)	24	0.046	0.003
	-	-1.291 (2.366)	24	-		-	-0.280 (2.377)	24	-	
12	119.198 (55.326)	-4.498 (2.674)	24	0.114	1.698	-112.792 (55.255)	3.009 (2.671)	24	0.055	0.084
	-	-1.287 (2.389)	24	-		-	-0.029 (2.365)	24	-	

Notes: The χ^2 statistics in columns 6 and 11 test the hypotheses of the independence between $-(s_{c,t+h}-s_{c,t})$ and d_{ct}, and $r_{c,t+h}-r_{c,t}$ and d_{ct}, respectively. Under the null, χ^2 has 1 degree of freedom.

TABLE 6.2

SEEMINGLY UNRELATED REGRESSIONS, 24 COUNTRIES, 1994-2006,

$$-(s_{c,t+h} - s_{c,t+h}) = \eta_s^h + \phi_s^h d_{ct}^h + u_{s,ct}^h \quad \text{and} \quad r_{c,t+h} - r_{c,t} = \eta_r^h + \phi_r^h d_{ct}^h + u_{r,ct}^h$$

(Standard errors in parentheses)

	With overlapping observations			Without overlapping observations		
Horizon h (1)	Intercept $\eta_s^h \times 100$ (2)	Slope ϕ_s^h (3)	No of observations (4)	Intercept $\eta_s^h \times 100$ (5)	Slope ϕ_s^h (6)	No of observations (7)
1	6.460 (4.405)	-0.728 (0.245)	288	6.460 (4.405)	-0.728 (0.245)	288
	-	-0.682 (0.021)	288	-	-0.682 (0.021)	288
2	9.278 (5.199)	-0.601 (0.286)	264	14.229 (8.584)	-0.751 (0.457)	144
	-	-0.565 (0.288)	264	-	-0.744 (0.461)	144
3	11.681 (6.159)	-0.325 (0.337)	240	19.839 (12.816)	-0.712 (0.770)	96
	-	-0.278 (0.339)	240	-	-0.584 (0.775)	96
4	14.819 (7.271)	-0.168 (0.393)	216	31.095 (16.854)	-0.163 (0.838)	72
	-	-0.120 (0.394)	216	-	-0.313 (0.853)	72
5	13.045 (8.566)	-0.259 (0.480)	192	39.523 (24.940)	-1.610 (1.566)	48
	-	-0.187 (0.472)	192	-	-0.891 (1.524)	48
6	11.732 (10.121)	-0.502 (0.565)	168	31.764 (23.439)	-1.487 (1.323)	48
	-	-0.376 (0.535)	168	-	-1.343 (1.335)	48
7	14.478 (12.320)	-0.687 (0.667)	144	108.589 (54.168)	-3.712 (2.618)	24
	-	-0.422 (0.603)	144	-	-1.208 (2.273)	24
8	21.179 (15.282)	-0.967 (0.771)	120	93.592 (52.982)	-5.090 (2.561)	24
	-	-0.466 (0.670)	120	-	-2.845 (2.258)	24
9	36.519 (20.258)	-1.941 (0.979)	96	91.380 (50.324)	-5.593 (2.432)	24
	-	-0.737 (0.741)	96	-	-3.550 (2.146)	24
10	56.584 (24.761)	-2.838 (1.110)	72	103.334 (49.798)	-6.085 (2.407)	24
	-	-1.020 (0.843)	72	-	-3.495 (2.169)	24
11	81.233 (32.813)	-3.405 (1.413)	48	120.155 (52.363)	-5.338 (2.531)	24
	-	-0.838 (1.146)	48	-	-1.580 (2.315)	24
12	113.894 (52.910)	-4.093 (2.557)	24	113.894 (52.910)	-4.093 (2.557)	24
	-	-0.135 (2.289)	24	-	-0.135 (2.289)	24

FIGURE 6.1

IMPLICATIONS OF MISPRICING

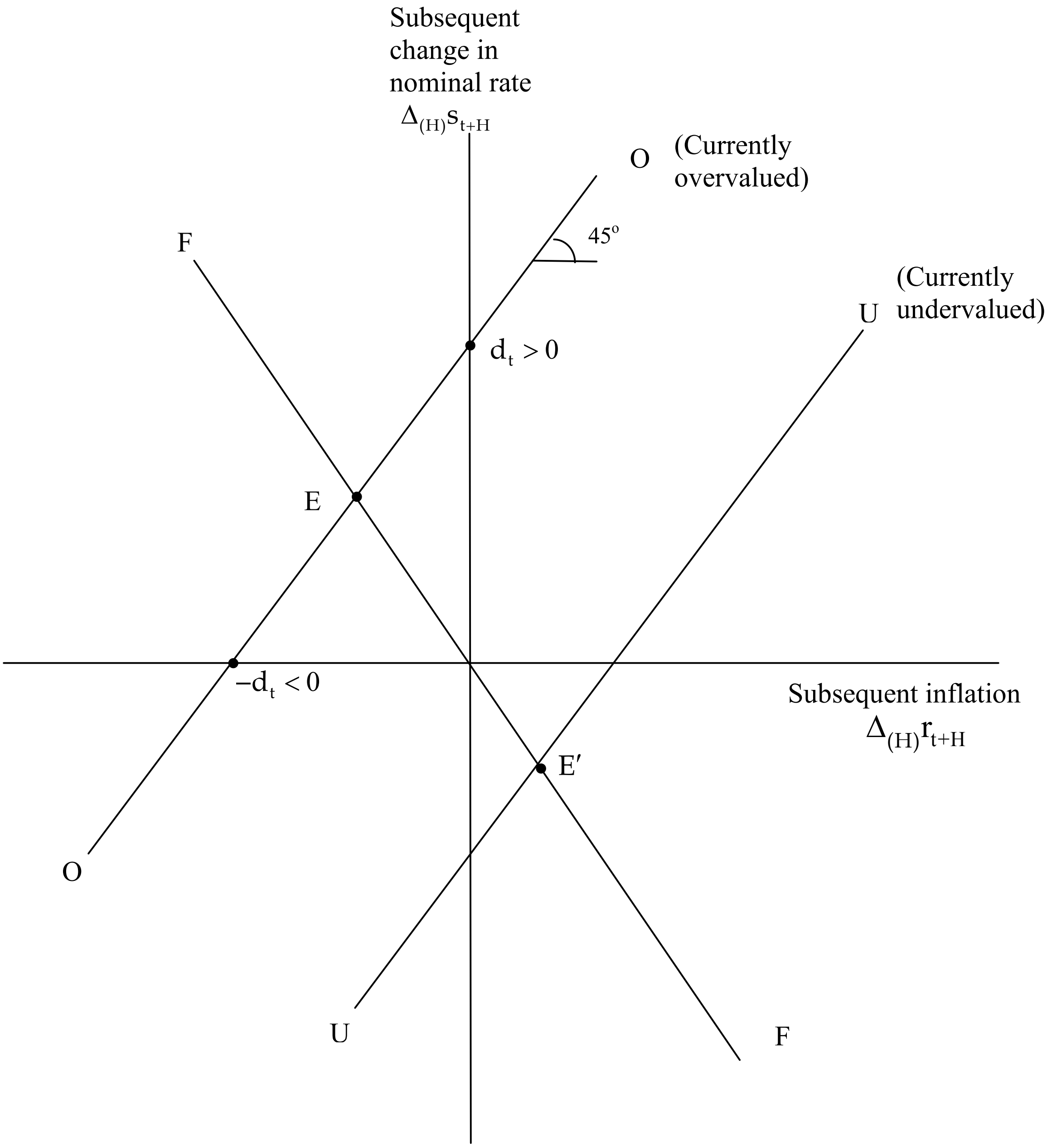


TABLE 7.1

PREDICTIVE REGRESSIONS FOR REAL EXCHANGE RATES WITH TIME DUMMIES, 24 COUNTRIES,1994-2006

$$q_{c,t+h}-q_{c,t}=\Sigma_{\tau}\,\alpha_{\tau,\tau+h}D_{\tau,t}+\phi^{h}d_{c,t}+u^{h}_{c,t}$$

(Standard errors in parentheses)

Horizon	Year dummies $\alpha_{\tau,\tau+h}$ (×100)												$\eta^h =$	Slope	No of	R^2	F
h	94, 94+h	95, 95+h	96, 96+h	97, 97+h	98, 98+h	99, 99+h	00, 00+h	01, 01+h	02, 02+h	03, 03+h	04, 04+h	05, 05+h	$(1/N^h)\Sigma_\tau \alpha_{\tau,\tau+h}$ (×100)	ϕ^h	Obs.		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
							A. With overlapping observations										
1	11.57 (2.48)	5.03 (2.57)	0.64 (2.53)	-10.75 (2.46)	1.20 (2.43)	-6.03 (2.42)	-7.84 (2.44)	-4.01 (2.49)	-1.22 (2.48)	-2.71 (2.45)	-0.37 (2.44)	3.40 (2.43)	-0.92 (0.70)	-0.418 (0.047)	288	0.349	76.234*
2	12.52 (2.90)	4.77 (3.01)	-9.35 (2.96)	-4.41 (2.87)	-5.66 (2.83)	-11.46 (2.82)	-9.03 (2.85)	-4.33 (2.90)	-4.14 (2.89)	-2.45 (2.85)	2.72 (2.85)	-	-2.80 (0.85)	-0.727 (0.058)	264	0.504	16.173*
3	9.73 (3.05)	-5.12 (3.19)	-1.78 (3.13)	-7.07 (3.03)	-11.93 (2.98)	-10.95 (2.96)	-7.57 (3.00)	-7.10 (3.06)	-4.49 (3.04)	0.79 (3.00)	-	-	-4.55 (0.94)	-0.998 (0.064)	240	0.615	11.787*
4	-2.73 (3.06)	1.97 (3.20)	-3.85 (3.14)	-9.95 (3.03)	-11.99 (2.98)	-7.94 (2.96)	-8.56 (2.99)	-6.95 (3.06)	-1.46 (3.05)	-	-	-	-5.72 (1.00)	-1.204 (0.067)	216	0.696	23.974*
5	1.84 (2.99)	-1.35 (3.17)	-7.06 (3.09)	-7.92 (2.96)	-9.17 (2.89)	-7.67 (2.87)	-6.71 (2.92)	-2.94 (3.00)	-	-	-	-	-5.12 (1.05)	-1.311 (0.074)	192	0.728	28.024*
6	-2.35 (3.05)	-4.50 (3.25)	-4.58 (3.16)	-3.62 (3.01)	-9.19 (2.94)	-5.23 (2.91)	-2.09 (2.96)	-	-	-	-	-	-4.51 (1.19)	-1.407 (0.079)	168	0.741	33.090*
7	-7.39 (3.17)	-3.75 (3.40)	-1.41 (3.30)	-3.28 (3.13)	-6.52 (3.04)	0.08 (3.01)	-	-	-	-	-	-	-3.71 (1.41)	-1.394 (0.087)	144	0.724	26.101*
8	-5.76 (3.19)	0.64 (3.43)	-0.07 (3.33)	-0.13 (3.14)	-1.51 (3.05)	-	-	-	-	-	-	-	-1.37 (1.62)	-1.450 (0.090)	120	0.746	22.094*
9	-3.07 (3.00)	0.04 (3.28)	1.63 (3.16)	4.60 (2.95)	-	-	-	-	-	-	-	-	0.80 (1.90)	-1.392 (0.093)	96	0.727	14.298*
10	-2.12 (2.95)	3.41 (3.26)	7.57 (3.13)	-	-	-	-	-	-	-	-	-	2.95 (2.16)	-1.434 (0.098)	72	0.764	12.500*
11	1.42 (2.64)	10.18 (2.97)	-	-	-	-	-	-	-	-	-	-	5.80 (2.22)	-1.514 (0.097)	48	0.845	14.799*
12	6.41 (2.70)	-	-	-	-	-	-	-	-	-	-	-	6.41 (2.70)	-1.488 (0.131)	24	0.855	7.048*
							B. Without overlapping observations										
1	11.57 (2.48)	5.03 (2.57)	0.64 (2.53)	-10.75 (2.46)	1.20 (2.43)	-6.03 (2.42)	-7.84 (2.44)	-4.01 (2.49)	-1.22 (2.48)	-2.71 (2.45)	-0.37 (2.44)	3.40 (2.43)	-0.92 (0.70)	-0.418 (0.047)	288	0.349	76.234*
2	12.49 (3.17)	-	-9.40 (3.28)	-	-5.65 (3.06)	-	-9.01 (3.08)	-	-4.10 (3.15)	-	2.74 (3.09)	-	-2.16 (1.24)	-0.725 (0.079)	144	0.509	7.844*
3	9.64 (2.91)	-	-	-7.14 (2.85)	-	-	-7.52 (2.78)	-	-	0.85 (2.79)	-	-	-1.04 (1.36)	-0.991 (0.097)	96	0.622	0.296
4	-3.92 (3.69)	-	-	-	-11.46 (3.50)	-	-	-	-0.32 (3.67)	-	-	-	-5.24 (2.00)	-1.100 (0.113)	72	0.655	3.641*
5	-1.25 (3.06)	-	-	-	-	-7.20 (2.64)	-	-	-	-	-	-	-4.22 (1.97)	-1.044 (0.136)	48	0.585	2.911
6	-6.86 (3.09)	-	-	-	-	-	0.66 (2.86)	-	-	-	-	-	-3.10 (1.94)	-1.016 (0.129)	48	0.709	1.344
7	-15.25 (3.00)	-	-	-	-	-	-	-	-	-	-	-	-15.25 (3.00)	-0.713 (0.145)	24	0.524	13.447*
8	-2.77 (4.19)	-	-	-	-	-	-	-	-	-	-	-	-2.77 (4.19)	-1.709 (0.202)	24	0.764	11.116*
9	-3.23 (3.24)	-	-	-	-	-	-	-	-	-	-	-	-3.23 (3.24)	-1.378 (0.156)	24	0.779	6.907*
10	-1.37 (3.26)	-	-	-	-	-	-	-	-	-	-	-	-1.37 (3.26)	-1.499 (0.157)	24	0.805	8.491*
11	2.99 (2.72)	-	-	-	-	-	-	-	-	-	-	-	2.99 (2.72)	-1.651 (0.132)	24	0.877	14.234*
12	6.41 (2.70)	-	-	-	-	-	-	-	-	-	-	-	6.41 (2.70)	-1.488 (0.131)	24	0.855	7.048*

Notes: 1. The F statistics of column 18 test the joint hypothesis of $\eta^h = 0$ and $\phi^h = -1$ for various values of h.

2. An asterisk (*) indicates significant at the 5 percent level.

TABLE 9.1

THE BURGERNOMICS LITERATURE

	Author	Key Results
1.	Cumby (1996)	Deviations from Big Mac PPP tend to die out; half-life is about 1 year; the Big Mac is a useful exchange-rate predictor
2.	Click (1996)	PPP holds in time-series dimension; departure is due to the productivity bias
3.	Pakko and Pollard (1996)	Deviations from absolute PPP are persistent and those from relative PPP are transitory; Big Macs are a useful but flawed PPP measure
4.	Annaert and Ceuster (1997)	Relative Big Mac PPP is a valuable international asset allocator
5.	Ong (1997)	BMI surprisingly accurate in tracking exchange rates over the long term (revision of Ong, 1995)
6.	Ong (1998a)	BMI good indicator of currency devaluations
7.	Ong (1998b)	Significant relationship between Big Mac real wages and the productivity bias, market status and location
8.	Ong and Mitchell (2000)	Big Mac academic real wages and quality-of-life indices useful for relocation decisions
9.	Ashenfelter and Jurajda (2001)	McWages highly correlated with other wage measures
10.	Lutz (2001)	Results similar to Cumby (1996) obtained using UBS price series and aggregate CPI data, but are not robust
11.	Fujiki and Kitamura (2003)	Big Mac PPP sensitive to different models, sample periods and countries
12.	Pakko and Pollard (2003)	BMI useful but imperfect PPP measure
13.	Ong (2003)	Long-run PPP supported by BMI. BMI works as well as other board price indices
14.	Caetano et al. (2004)	Income and trade openness explain failure of Big Mac PPP
15.	Yang (2004)	Big Mac PPP overestimates currency values of low-income countries
16.	Chen et al. (2005)	BMI supports PPP more than does CPI
17.	Lan (2006)	BMI used to construct entire distribution of future exchange rates
18.	Clements and Lan (2006)	Real-time exchange-rate forecasts derived from BMI; these beat random walk over medium and longer horizons
19.	Parsley and Wei (2007)	Speed of adjustment for Big Mac PPP slower than that for tradable inputs, but faster than that for nontradable inputs

TABLE A1

IMPLIED PPP EXCHANGE RATES, 1986 TO 2006

Country	Year																				
	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Argentina							1.507	1.579	1.565	1.293	1.271	1.033	0.977	1.029	0.996	0.984	1.004	1.513	1.500	1.550	2.258
Aruba																	0.940	1.513	1.410	1.620	1.597
Australia	1.094		0.816	1.040	1.045	1.089	1.160	1.075	1.065	1.056	1.059	1.033	1.035	1.091	1.032	1.181	1.205	1.107	1.120	1.060	1.048
Austria									14.78	16.81		14.05	13.28								
Bahrain																	0.341	0.314			
Belarus																	915.7	904.1	1021		
Belgium	56.25	56.25	37.66	44.55	44.09	44.44	49.32	47.81	47.39	46.98	46.19	45.04	42.58								
Brazil	1.562						1735	33772	652.2	1.043	1.250	1.227	1.211	1.214	1.175	1.417	1.446	1.679	1.860	1.930	2.065
Britain	0.688	0.706	0.498	0.624	0.636	0.742	0.795	0.785	0.787	0.750	0.758	0.748	0.719	0.782	0.757	0.783	0.799	0.734	0.649	0.613	0.626
Bulgaria																		1.100	1.030	0.980	0.965
Canada	1.181		0.858	1.064	0.995	1.044	1.260	1.211	1.243	1.194	1.212	1.190	1.090	1.230	1.135	1.311	1.337	1.181	1.100	1.070	1.135
Chile									412.2	409.5	402.5	495.9	488.3	514.4	502.0	496.1	562.2	516.6	483.0	490.0	503.2
China							2.877	3.728	3.913	3.879		4.008	3.867	4.074	3.944	3.898	4.217	3.653	3.590	3.430	3.387
Colombia																	2289	2288	2241	2124	2097
Costa Rica																	351.4	417.0	390.0	369.0	364.5
Croatia																	5.984	5.498	5.140	4.870	4.839
Czech Republic									21.74	21.55	21.61	21.90	21.09		21.66	22.05	22.60	20.87	19.50	18.40	19.05
Denmark		13.44	9.519	12.25	11.59	11.89	12.44	11.29	11.20	11.53	10.91	10.64	9.297	10.19	9.861	9.744	9.940	10.24	9.570	9.070	8.952
Dominican Rep																	20.08	22.14	20.70	19.60	19.35
Egypt																		2.952	3.450	2.940	3.065
Estonia																	11.45	10.89	10.20	9.640	9.516
Euro Area														1.037	1.020	1.012	1.072	1.000	0.943	0.952	0.948
Fiji																			1.470	1.390	1.500
France	10.25	10.87	7.238	8.762	8.045	8.000	8.265	8.114	8.043	7.974	7.415	7.231	6.836	3.498	7.371	7.283					
Georgia																		1.347	1.260	1.190	1.339
Germany						1.911	2.055	2.018	2.000	2.069	2.076	2.025	1.934	2.037	1.988	2.008					
Greece									269.6												
Guatemala																	6.426	5.904	5.520	5.470	5.565
Holland	2.719	2.812	2.029	2.525	2.386	2.333	2.443	2.390	2.370	2.349	2.309	2.252	2.129	2.243							
Honduras																		9.576	12.40	11.70	11.60
Hong Kong	4.750		3.180	3.762	3.909	3.956	4.064	3.947	4.000	4.095	4.195	4.091	3.984	4.198	4.064	4.213	4.498	4.244	4.140	3.920	3.871

(continued on next page)

TABLE A1 (continued)

IMPLIED PPP EXCHANGE RATES, 1986 TO 2006

Country	Year																				
	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Hungary						51.11	60.73	68.86	73.48	82.33		112.0	101.2	123.0	135.1	157.1	184.3	180.8	183.0	173.0	180.6
Iceland																	160.2	162.0	151.0	143.0	148.1
Indonesia										1681			3867	5967	5777	5787	6426	5941	5552	4771	4710
Ireland	0.737	0.737	0.510	0.644	0.591	0.622	0.662	0.649													
Israel										3.836	4.025	4.752	4.883	5.720	5.777		4.819				
Italy		2062	1381	1634	1773	1600	1872	1974	1978	1940	1907	1901	1758	1852	1793	1693					
Jamaica																	48.19	41.71	39.00	53.90	
Japan	231.2		154.8	183.2	168.2	168.9	173.5	171.5	170.0	168.5	122.0	121.5	109.4	121.0	117.1	115.7	105.2	96.68	90.30	81.70	80.65
Jordan																			0.890	0.850	
Kuwait																	0.261	0.240	0.740		
Latvia																			0.380	0.360	0.435
Lebanon																		1587	1483	1405	
Lithuania																		2.399	2.240	2.120	2.097
Macau																	4.498	4.133	3.860	3.660	3.581
Macedonia																		35.06	32.80	31.00	
Malaysia								1.469	1.639	1.621	1.593	1.599	1.680	1.860	1.801	1.780	2.024	1.860	1.740	1.720	1.774
Mexico								3.110	3.522	4.698	6.314	6.157	6.992	8.189	8.327	8.622	8.795	8.487	8.280	9.150	9.355
Moldova																			7.930	7.520	7.419
Morocco																	9.237	8.487	0.820	8.020	7.903
New Zealand										1.272	1.250	1.343	1.348	1.399	1.355	1.417	1.586	1.458	1.500	1.450	1.435
Nicaragua																			11.90	11.30	
Norway																	14.06	14.58	12.20	12.70	13.87
Oman																	0.361				
Pakistan																			37.90	42.50	41.94
Paraguay																				2941	2903
Peru																	3.414	2.915	3.100	2.940	3.065
Philippines																23.23	26.10	23.99	23.80	26.10	27.42
Poland									13478	1.466	1.610	1.777	2.070	2.263	2.191	2.323	2.369	2.325	2.170	2.120	2.097
Portugal									191.3												
Qatar																	3.614		0.850	0.810	
Russia							26.48	342.1	1261	3491	4025	4545	4688	13.79	15.74	13.78	15.66	15.13	14.50	13.70	15.48

(continued on next page)

TABLE A1 (continued)

IMPLIED PPP EXCHANGE RATES, 1986 TO 2006

Country	Year																				
	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Saudi Arabia																	3.614		0.830	2.940	2.903
Serbia & Montenegro																				45.80	
Singapore	1.750		1.172	1.386	1.182	1.244	2.169		1.296	1.272	1.292	1.240	1.172	1.317	1.275	1.299	1.325	1.218	1.140	1.180	1.161
Slovakia																	25.30		22.80	21.60	18.71
Slovenia																	172.7		166.0	163.0	167.7
South Africa											2.966	3.223	3.125	3.539	3.586	3.819	3.896	5.148	4.280	4.560	4.500
South Korea				1188	954.5	933.3	1050	1009	1000	991.4	974.6	950.4	1016	1235	1195	1181	1245	1218	1103	817.0	806.5
Soviet Union					1.705	4.444															
Spain	162.5		119.2	138.6	134.1	155.6	143.8	142.5	150.0	153.0	154.7	155.0	146.5	154.3	149.4	155.5					
Sri Lanka																			48.30	57.20	61.29
Suriname																	2410				
Sweden	10.31		7.741	10.40	10.91	11.56	11.64	11.18	11.09	11.21	11.02	10.74	9.375	9.877	9.562	9.449	10.44	11.07	10.30	10.10	10.65
Switzerland								2.500	2.478	2.543	2.500	2.438	2.305	2.428	2.351	2.480	2.530	2.325	2.170	2.060	2.032
Taiwan									26.96	28.02	27.54	28.10	26.56	28.81	27.89	27.56	28.11	25.83	25.90	24.50	24.52
Thailand								21.05	20.87	20.69	20.34	19.30	20.31	21.40	21.91	21.65	22.09	21.77	20.30	19.60	19.35
Turkey																	1606426	1383764	1362069	1.310	1.355
Ukraine																	3.614		0.840	2.940	2.903
UAE																	3.530		2.500	2.370	2.742
Uruguay																	11.24		10.30	14.40	13.65
Venezuela							77.63										1004	1365	1517	1830	1839
West Germany	2.656	2.562	1.715	2.129	1.955																
Yugoslavia			962.3	3465	7.273	14.22											34.14				

Note: The implied PPP exchange rate for country c in year t is defined as $P_{c,t}/P_t^*$, where $P_{c,t}$ is the price of a Big Mac hamburger in country c during t and P_t^* is the corresponding price in the US.

TABLE A2

NOMINAL EXCHANGE RATES, 1986 TO 2006

Country	Year																				
	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Argentina							0.990	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	3.130	2.880	2.941	2.870	3.060
Aruba																	1.790	1.790	1.785	1.800	1.790
Australia	1.640		1.360	1.240	1.320	1.270	1.310	1.390	1.420	1.350	1.270	1.290	1.510	1.590	1.680	1.980	1.860	1.610	1.436	1.293	1.330
Austria									12.00	9.720		12.00	12.96								
Bahrain																	0.380	0.380			
Belarus																	1745	2018	2172		
Belgium	42.00	39.13	34.80	39.50	34.65	34.50	33.55	32.45	35.20	28.40	31.20	35.30	38.00								
Brazil	13.80						2153	27521	949.0	0.900	0.990	1.060	1.140	1.730	1.790	2.190	2.340	3.070	3.153	2.474	2.300
Britain	0.670	0.679	0.540	0.590	0.610	0.560	0.570	0.641	0.685	0.621	0.662	0.613	0.602	0.621	0.633	0.699	0.690	0.633	0.560	0.548	0.532
Bulgaria																		1.780	1.609	1.607	1.540
Canada	1.390		1.240	1.190	1.160	1.150	1.190	1.260	1.390	1.390	1.360	1.390	1.420	1.510	1.470	1.560	1.570	1.450	1.375	1.244	1.120
Chile									414.0	395.0	408.0	417.0	455.0	484.0	514.0	601.0	655.0	716.0	644.0	590.4	530.0
China							5.440	5.680	8.700	8.540		8.330	8.280	8.280	8.280	8.280	8.280	8.280	8.349	8.366	8.030
Colombia																	2261	2914	2767	2334	2504
Costa Rica																	351.0	390.0	433.3	473.1	510.0
Croatia																	8.290	6.870	6.193	5.939	5.720
Czech Republic									29.70	26.20	27.60	29.20	34.40		39.10	39.00	34.00	28.90	26.71	24.53	22.10
Denmark		7.189	6.360	7.330	6.390	6.420	6.320	6.060	6.690	5.430	5.850	6.520	7.020	6.910	8.040	8.460	8.380	6.780	6.214	6.047	5.820
Dominican Rep																	17.20	23.00	45.00	28.41	32.60
Egypt																		5.920	6.161	5.765	5.770
Estonia																	17.60	14.30	13.08	12.68	12.30
Euro Area														0.926	1.075	1.136	1.124	0.909	0.835	0.814	0.781
Fiji																			1.815	1.695	1.730
France	6.650	6.302	5.630	6.370	5.630	5.650	5.550	5.340	5.830	4.800	5.130	5.760	6.170	6.100	7.070	7.440					
Georgia																		2.210	1.909	1.803	1.800
Germany						1.670	1.640	1.580	1.710	1.380	1.520	1.710	1.840	1.820	2.110	2.220					
Greece									251.0												
Guatemala																	7.900	7.870	8.000	7.597	7.590
Holland	2.280	2.132	1.860	2.130	1.880	1.880	1.840	1.770	1.910	1.550	1.700	1.920	2.070	2.050							
Honduras																		17.20	18.24	18.87	18.90
Hong Kong	7.800		7.800	7.780	7.790	7.790	7.730	7.730	7.730	7.730	7.740	7.750	7.750	7.750	7.790	7.800	7.800	7.800	7.811	7.840	7.750

(continued on next page)

TABLE A2 (continued)

NOMINAL EXCHANGE RATES, 1986 TO 2006

Country	Year																				
	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Hungary						75.12	79.70	88.18	103.0	121.0		178.0	213.0	237.0	279.0	303.0	272.0	224.0	210.3	203.5	206.0
Iceland																	96.30	75.80	72.95	65.60	72.00
Indonesia										2231			8500	8725	7945	10855	9430	8740	9102	9542	9325
Ireland	0.740	0.698	0.620	0.710	0.630	0.620	0.610	0.649													
Israel										2.950	3.170	3.380	3.700	4.040	4.050		4.790				
Italy		1342	1229	1382	1230	1239	1233	1523	1641	1702	1551	1683	1818	1799	2088	2195					
Jamaica																	47.40	56.70	60.00	61.25	
Japan	154.0		124.0	133.0	159.0	135.0	133.0	113.0	104.0	84.20	107.0	126.0	135.0	120.0	106.0	124.0	130.0	120.0	112.9	106.1	112.0
Jordan																			0.706	0.714	
Kuwait																	0.310	0.300	0.292		
Latvia																			0.551	0.571	0.550
Lebanon																		1512	1513	1511	
Lithuania																		3.150	2.872	2.789	2.690
Macau																	8.030	8.030	8.042	7.957	7.990
Macedonia																		55.80	51.25	50.00	
Malaysia								2.580	2.690	2.490	2.490	2.500	3.720	3.800	3.800	3.800	3.800	3.800	3.783	3.822	3.630
Mexico								3.100	3.360	6.370	7.370	7.900	8.540	9.540	9.410	9.290	9.280	10.53	11.50	10.89	11.30
Moldova																			11.84	12.53	13.20
Morocco																	11.53	9.820	9.111	9.011	8.710
New Zealand										1.510	1.470	1.450	1.820	1.870	2.010	2.470	2.240	1.780	1.630	1.394	1.620
Nicaragua																			15.87	16.38	
Norway																	8.560	7.160	6.816	6.414	6.100
Oman																	0.390				
Pakistan																			57.42	59.86	60.10
Paraguay																				6257	5505
Peru																	3.430	3.460	3.483	3.267	3.260
Philippines																50.30	51.00	52.50	55.35	54.38	52.60
Poland									22433	2.340	2.640	3.100	3.460	3.980	4.300	4.030	4.040	3.890	3.875	3.312	3.100
Portugal									174.0												
Qatar																	3.640		3.696	3.682	
Russia							98.95	686.0	1775	4985	4918	5739	5999	24.70	28.50	28.90	31.20	31.10	29.00	28.54	27.10

(continued on next page)

TABLE A2 (continued)

NOMINAL EXCHANGE RATES, 1986 TO 2006

Country	Year																				
	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Saudi Arabia																	3.750		3.773	3.769	3.750
Serbia & Montenegro																				67.35	
Singapore	2.150		2.000	1.960	1.880	1.770	1.650		1.570	1.400	1.410	1.440	1.620	1.730	1.700	1.810	1.820	1.780	1.727	1.662	1.590
Slovakia																	46.80		33.53	31.76	29.50
Slovenia																	253.0		200.0	194.0	189.0
South Africa											4.260	4.430	5.040	6.220	6.720	8.130	10.90	7.560	6.688	6.609	6.600
South Korea				666.0	707.0	721.0	778.0	796.0	810.0	769.0	779.0	894.0	1474	1218	1108	1325	1304	1220	1173	1009	952.0
Soviet Union					0.600	1.740															
Spain	133.0		111.0	117.0	106.0	103.0	102.0	114.0	138.0	124.0	126.0	144.0	156.0	155.0	179.0	189.0					
Sri Lanka																			98.57	100.4	103.0
Suriname																	2179				
Sweden	6.870		5.890	6.410	6.100	6.040	5.930	7.430	7.970	7.340	6.710	7.720	8.000	8.320	8.840	10.28	10.30	8.340	7.574	7.426	7.280
Switzerland								1.450	1.440	1.130	1.230	1.470	1.520	1.480	1.700	1.730	1.660	1.370	1.284	1.248	1.210
Taiwan									26.40	25.70	27.20	27.60	33.00	33.20	30.60	32.90	34.80	34.80	33.64	31.01	32.10
Thailand								25.16	25.30	24.60	25.30	26.10	40.00	37.60	38.00	45.50	43.30	42.70	40.60	40.83	38.40
Turkey																	1324500	1600500	1530415	1.379	1.540
Ukraine																	5.330		5.319	5.043	5.050
UAE																	3.670		3.652	3.675	3.670
Uruguay																	16.80		29.43	24.00	23.90
Venezuela							60.63										857.0	1598	2975	2614	2630
West Germany	2.020	1.887	1.660	1.890	1.680																
Yugoslavia			1400	9001	11.72	15.12											67.80				

Note: The nominal exchange rate is the domestic currency cost of one US dollar. An increase thus implies a depreciation of the domestic currency and vice versa.

TABLE A3

REAL EXCHANGE RATES, 1986 TO 2006

Country	Year																				
	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Argentina							42.01	45.68	44.80	25.70	24.00	3.25	-2.37	2.84	-0.40	-1.59	-113.70	-64.38	-67.33	-61.62	-30.39
Aruba																	-64.43	-16.82	-23.57	-10.54	-11.42
Australia	-40.51		-51.09	-17.63	-23.32	-15.39	-12.18	-25.74	-28.75	-24.56	-18.14	-22.21	-37.76	-37.71	-48.74	-51.66	-43.42	-37.46	-24.85	-19.85	-23.79
Austria									20.85	54.78		15.77	2.45								
Bahrain																	-10.72	-19.19			
Belarus																	-64.49	-80.30	-75.50		
Belgium	29.21	36.29	7.89	12.04	24.10	25.33	38.52	38.75	29.74	50.34	39.23	24.37	11.38								
Brazil	-217.84						-21.58	20.47	-37.51	14.76	23.32	14.65	6.04	-35.42	-42.07	-43.51	-48.15	-60.35	-52.76	-24.85	-10.80
Britain	2.58	3.90	-8.12	5.56	4.23	28.17	33.21	20.27	13.89	18.86	13.57	19.81	17.66	23.02	17.90	11.36	14.74	14.86	14.84	11.33	16.26
Bulgaria																		-48.16	-44.63	-49.43	-46.79
Canada	-16.27		-36.86	-11.16	-15.30	-9.63	5.74	-4.01	-11.14	-15.20	-11.53	-15.53	-26.46	-20.47	-25.82	-17.39	-16.04	-20.54	-22.31	-15.08	1.37
Chile									-0.44	3.60	-1.35	17.32	7.06	6.09	-2.36	-19.19	-15.27	-32.64	-28.77	-18.63	-5.18
China							-63.71	-42.11	-79.90	-78.91		-73.15	-76.13	-70.92	-74.16	-75.35	-67.48	-81.83	-84.40	-89.16	-86.32
Colombia																	1.24	-24.19	-21.07	-9.43	-17.75
Costa Rica																	0.12	6.69	-10.54	-24.85	-33.58
Croatia																	-32.60	-22.28	-18.63	-19.85	-16.73
Czech Republic									-31.20	-19.53	-24.47	-28.76	-48.91		-59.06	-57.04	-40.83	-32.53	-31.47	-28.77	-14.86
Denmark		62.55	40.32	51.38	59.55	61.62	67.74	62.25	51.49	75.30	62.33	48.98	28.09	38.80	20.41	14.13	17.07	41.23	43.18	40.55	43.05
Dominican Rep																	15.48	-3.81	-77.65	-37.11	-52.14
Egypt																		-69.58	-57.98	-67.33	-63.28
Estonia																	-43.03	-27.28	-24.85	-27.44	-25.66
Euro Area														11.33	-5.28	-11.61	-4.67	9.53	12.22	15.70	19.39
Fiji																			-21.07	-19.85	-14.27
France	43.27	54.56	25.13	31.89	35.70	34.78	39.82	41.84	32.18	50.76	36.84	22.75	10.25	-55.61	4.16	-2.13					
Georgia																		-49.52	-41.55	-41.55	-29.61
Germany						13.49	22.55	24.45	15.67	40.50	31.19	16.90	4.96	11.27	-5.95	-10.04					
Greece									7.14												
Guatemala																	-20.66	-28.74	-37.11	-32.85	-31.04
Holland	17.60	27.70	8.71	17.00	23.85	21.60	28.34	30.05	21.56	41.58	30.63	15.95	2.81	8.99							
Honduras																		-58.57	-38.57	-47.80	-48.84
Hong Kong	-49.60		-89.73	-72.65	-68.95	-67.77	-64.30	-67.21	-65.88	-63.54	-61.25	-63.89	-66.53	-61.32	-65.07	-61.60	-55.05	-60.87	-63.49	-69.31	-69.42

(continued on next page)

TABLE A3 (continued)

REAL EXCHANGE RATES, 1986 TO 2006

Country	Year																				
	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Hungary						-38.51	-27.18	-24.73	-33.77	-38.51		-46.34	-74.45	-65.55	-72.55	-65.69	-38.90	-21.42	-13.93	-16.25	-13.13
Iceland																	50.92	75.95	72.75	77.93	72.10
Indonesia										-28.30			-78.75	-37.99	-31.87	-62.89	-38.36	-38.60	-49.43	-69.31	-68.31
Ireland	-0.34	5.49	-19.44	-9.82	-6.41	0.36	8.20	-0.04													
Israel										26.27	23.89	34.07	27.74	34.78	35.51		0.61				
Italy		43.01	11.64	16.73	36.55	25.57	41.76	25.92	18.69	13.07	20.65	12.17	-3.37	2.90	-15.24	-25.97					
Jamaica																	1.66	-30.70	-43.08	-12.78	
Japan	40.65		22.19	32.01	5.61	22.40	26.59	41.71	49.14	69.39	13.15	-3.65	-21.05	0.82	9.99	-6.89	-21.15	-21.61	-22.31	-26.14	-32.84
Jordan																			23.11	17.40	
Kuwait																	-17.19	-22.38	92.82		
Latvia																			-37.11	-46.20	-23.35
Lebanon																		4.85	-2.02	-7.26	
Lithuania																		-27.25	-24.85	-27.44	-24.91
Macau																	-57.96	-66.42	-73.40	-77.65	-80.26
Macedonia																		-46.48	-44.63	-47.80	
Malaysia								-56.30	-49.54	-42.94	-44.65	-44.68	-79.51	-71.44	-74.68	-75.87	-62.99	-71.45	-77.65	-79.85	-71.59
Mexico								0.31	4.70	-30.44	-15.47	-24.93	-20.00	-15.27	-12.23	-7.46	-5.37	-21.57	-32.85	-17.44	-18.89
Moldova																			-40.05	-51.08	-57.61
Morocco																	-22.17	-14.59	-240.79	-11.65	-9.72
New Zealand										-17.19	-16.21	-7.67	-30.05	-29.01	-39.46	-55.54	-34.50	-19.98	-8.34	3.92	-12.09
Nicaragua																			-28.77	-37.11	
Norway																	49.60	71.08	58.22	68.31	82.15
Oman																	-7.60				
Pakistan																			-41.55	-34.25	-35.99
Paraguay																				-75.50	-63.98
Peru																	-0.48	-17.14	-11.65	-10.54	-6.18
Philippines																-77.26	-66.97	-78.34	-84.40	-73.40	-65.15
Poland									-50.95	-46.79	-49.44	-55.66	-51.36	-56.44	-67.41	-55.10	-53.36	-51.48	-57.98	-44.63	-39.10
Portugal									9.48												
Qatar																	-0.70		-146.97	-151.41	
Russia							-131.81	-69.58	-34.20	-35.61	-20.03	-23.32	-24.67	-58.31	-59.39	-74.07	-68.91	-72.06	-69.31	-73.40	-55.97

(continued on next page)

TABLE A3 (continued)

REAL EXCHANGE RATES, 1986 TO 2006

Country	Year																				
	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Saudi Arabia																	-3.68		-151.41	-24.85	-25.59
Serbia & Montenegro																				-38.57	
Singapore	-20.59		-53.48	-34.64	-46.42	-35.23	27.35		-19.21	-9.62	-8.71	-14.98	-32.38	-27.29	-28.78	-33.16	-31.72	-37.96	-41.55	-34.25	-31.42
Slovakia																	-61.50		-38.57	-38.57	-45.53
Slovenia																	-38.19		-18.63	-17.44	-11.93
South Africa											-36.20	-31.80	-47.80	-56.39	-62.81	-75.56	-102.89	-38.43	-44.63	-37.11	-38.30
South Korea				57.88	30.02	25.81	30.00	23.69	21.07	25.40	22.40	6.12	-37.25	1.35	7.58	-11.50	-4.63	-0.19	-6.19	-21.07	-16.59
Soviet Union					104.41	93.78															
Spain	20.03		7.17	16.95	23.51	41.23	34.37	22.35	8.34	21.03	20.50	7.33	-6.29	-0.44	-18.07	-19.50					
Sri Lanka																			-71.33	-56.21	-51.91
Suriname																	10.06				
Sweden	40.62		27.32	48.36	58.13	64.88	67.48	40.90	33.01	42.32	49.58	33.05	15.86	17.15	7.85	-8.43	1.37	28.32	30.75	30.75	38.00
Switzerland								54.47	54.29	81.12	70.93	50.59	41.62	49.50	32.40	36.03	42.14	52.88	52.47	50.08	51.85
Taiwan									2.09	8.63	1.25	1.79	-21.70	-14.19	-9.28	-17.71	-21.34	-29.81	-26.14	-23.57	-26.95
Thailand								-17.82	-19.25	-17.31	-21.83	-30.20	-67.76	-56.37	-55.05	-74.25	-67.31	-67.36	-69.31	-73.40	-68.51
Turkey																	19.30	-14.55	-11.65	-5.13	-12.81
Ukraine																	-38.84		-184.57	-53.95	-55.36
UAE																	-3.89		-37.90	-43.87	-29.15
Uruguay																	-40.15		-104.98	-51.08	-56.05
Venezuela							24.71										15.83	-15.74	-67.33	-35.67	-35.77
West Germany	27.38	30.61	3.29	11.89	15.14																
Yugoslavia			-37.49	-95.45	-47.72	-6.12											-68.62				

Notes: 1. The real exchange rate for country c in year t is defined as $q_{ct} = \log\left(P_{ct}/S_{ct}P_t^*\right)$, where P_{ct} is the price of a Big Mac hamburger in country c during t, P_t^* is the corresponding price in the US and S_{ct} is the nominal exchange rate, defined as the domestic currency cost of $US1. A positive value of $q_{c,t}$ implies that the domestic currency is overvalued in real terms and vice versa.

2. All entries are to be divided by 100.

TABLE A4

PREDICTIVE REGRESSIONS WITH TIME DUMMIES, CHANGES IN NOMINAL EXCHANGE RATES, 24 COUNTRIES,1994-2006

$$-(s_{c,t+h}-s_{c,t})=\Sigma_\tau \alpha_{s,\tau,\tau+h} D_{s,\tau,t}+\phi_s^h d_{c,t}+u_{s,ct}^h$$

(Standard errors in parentheses)

Horizon	Year dummies $\alpha_{s,\tau,\tau+h}$ (×100)												$\eta_s^h = \left(1/N^h\right)\Sigma_\tau \alpha_{s,\tau,\tau+h}$ (×100)	Slope ϕ_s^h	No of Obs.	R^2
h	94, 94+h	95, 95+h	96, 96+h	97, 97+h	98, 98+h	99, 99+h	00, 00+h	01, 01+h	02, 02+h	03, 03+h	04, 04+h	05, 05+h				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
							A. With overlapping observations									
1	70.13 (15.73)	1.13 (16.30)	-1.64 (16.05)	-9.58 (15.63)	18.18 (15.42)	-4.18 (15.36)	-9.77 (15.49)	-7.56 (15.76)	3.09 (15.70)	2.30 (15.52)	4.05 (15.50)	0.94 (15.41)	5.59 (4.43)	-0.304 (0.301)	288	0.073
2	65.81 (18.00)	-5.10 (18.71)	-14.03 (18.40)	10.24 (17.87)	14.48 (17.61)	-11.83 (17.53)	-13.77 (17.70)	-1.24 (18.04)	7.60 (17.96)	8.45 (17.73)	6.30 (17.70)	-	6.08 (5.28)	-0.314 (0.360)	264	0.062
3	59.31 (20.40)	-17.78 (21.29)	5.58 (20.90)	6.52 (20.23)	6.89 (19.92)	-15.74 (19.81)	-7.28 (20.03)	3.45 (20.45)	13.90 (20.35)	10.82 (20.06)	-	-	6.57 (6.28)	-0.307 (0.428)	240	0.046
4	48.60 (23.11)	4.85 (24.21)	4.42 (23.73)	0.44 (22.90)	2.16 (22.50)	-9.59 (22.37)	-3.79 (22.64)	7.78 (23.16)	14.48 (23.04)	-	-	-	7.70 (7.52)	-0.466 (0.508)	216	0.024
5	69.62 (24.92)	3.25 (26.39)	-1.45 (25.75)	-2.39 (24.63)	8.02 (24.10)	-5.17 (23.92)	1.64 (24.28)	8.76 (24.99)	-	-	-	-	10.28 (8.74)	-0.578 (0.613)	192	0.042
6	66.37 (26.65)	-3.74 (28.39)	-4.83 (27.64)	4.39 (26.31)	12.45 (25.68)	0.99 (25.47)	3.71 (25.90)	-	-	-	-	-	11.33 (10.44)	-0.613 (0.690)	168	0.040
7	58.66 (28.92)	-7.80 (31.01)	1.49 (30.10)	8.92 (28.51)	18.71 (27.74)	3.32 (27.48)	-	-	-	-	-	-	13.88 (12.89)	-0.606 (0.789)	144	0.033
8	56.17 (31.69)	0.91 (34.12)	8.05 (33.07)	16.36 (31.21)	20.39 (30.32)	-	-	-	-	-	-	-	20.38 (16.11)	-0.730 (0.891)	120	0.027
9	69.39 (33.12)	16.27 (36.19)	23.49 (34.87)	24.41 (32.51)	-	-	-	-	-	-	-	-	33.39 (20.98)	-1.319 (1.027)	96	0.042
10	79.69 (35.36)	31.52 (39.06)	33.54 (37.48)	-	-	-	-	-	-	-	-	-	48.25 (25.90)	-1.813 (1.170)	72	0.061
11	94.53 (40.42)	47.50 (45.56)	-	-	-	-	-	-	-	-	-	-	71.02 (34.04)	-2.560 (1.481)	48	0.091
12	119.20 (55.33)	-	-	-	-	-	-	-	-	-	-	-	119.20 (55.33)	-4.498 (2.674)	24	0.114
							B. Without overlapping observations									
1	70.13 (15.73)	1.13 (16.30)	-1.64 (16.05)	-9.58 (15.63)	18.18 (15.42)	-4.18 (15.36)	-9.77 (15.49)	-7.56 (15.76)	3.09 (15.70)	2.30 (15.52)	4.05 (15.50)	0.94 (15.41)	5.59 (4.43)	-0.304 (0.301)	288	0.073
2	68.69 (22.42)	-	-10.12 (23.19)	-	13.21 (21.67)	-	-15.53 (21.84)	-	4.86 (22.33)	-	4.52 (21.85)	-	10.94 (8.78)	-0.564 (0.557)	144	0.067
3	72.12 (28.20)	-	-	17.35 (27.60)	-	-	-15.11 (26.87)	-	-	2.39 (27.00)	-	-	19.19 (13.12)	-1.418 (0.937)	96	0.057
4	52.87 (32.45)	-	-	-	0.27 (30.78)	-	-	-	10.42 (32.25)	-	-	-	21.19 (17.59)	-0.837 (0.992)	72	0.022
5	99.45 (38.59)	-	-	-	-	-9.70 (33.25)	-	-	-	-	-	-	44.87 (24.88)	-3.165 (1.718)	48	0.108
6	91.99 (37.63)	-	-	-	-	-	-11.94 (34.81)	-	-	-	-	-	40.02 (23.61)	-2.835 (1.565)	48	0.091
7	90.57 (56.80)	-	-	-	-	-	-	-	-	-	-	-	90.57 (56.80)	-3.373 (2.745)	24	0.064
8	96.85 (55.73)	-	-	-	-	-	-	-	-	-	-	-	96.85 (55.73)	-4.258 (2.694)	24	0.102
9	102.99 (54.60)	-	-	-	-	-	-	-	-	-	-	-	102.99 (54.60)	-4.233 (2.639)	24	0.105
10	108.26 (54.28)	-	-	-	-	-	-	-	-	-	-	-	108.26 (54.28)	-4.290 (2.624)	24	0.108
11	115.90 (54.98)	-	-	-	-	-	-	-	-	-	-	-	115.90 (54.98)	-4.413 (2.657)	24	0.111
12	119.20 (55.33)	-	-	-	-	-	-	-	-	-	-	-	119.20 (55.33)	-4.498 (2.674)	24	0.114

TABLE A5

PREDICTIVE REGRESSIONS WITH TIME DUMMIES, INFLATION DIFFERENTIALS, 24 COUNTRIES,1994-2006

$$r_{c,t+h} - r_{c,t} = \Sigma_\tau \alpha_{r,\tau,\tau+h} D_{r,\tau,t} + \phi_r^h d_{c,t} + u_{r,ct}^h$$

(Standard errors in parentheses)

Horizon h	Year dummies $\alpha_{r,\tau,\tau+h}$ $(\times 100)$ 94, 94+h	95, 95+h	96, 96+h	97, 97+h	98, 98+h	99, 99+h	00, 00+h	01, 01+h	02, 02+h	03, 03+h	04, 04+h	05, 05+h	$\eta_r^h = \left(1/N^h\right) \Sigma_\tau \alpha_{r,\tau,\tau+h}$ $(\times 100)$	Slope ϕ_r^h	No of Obs.	R^2
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
							A. With overlapping observations									
1	-58.56 (15.57)	3.91 (16.13)	2.28 (15.88)	-1.17 (15.46)	-16.97 (15.26)	-1.85 (15.19)	1.93 (15.33)	3.55 (15.59)	-4.31 (15.53)	-5.01 (15.35)	-4.43 (15.33)	2.46 (15.24)	-6.51 (4.38)	-0.114 (0.297)	288	0.052
2	-53.28 (17.78)	9.87 (18.48)	4.68 (18.17)	-14.65 (17.64)	-20.14 (17.39)	0.37 (17.31)	4.73 (17.48)	-3.09 (17.81)	-11.74 (17.73)	-10.90 (17.51)	-3.59 (17.48)	-	-8.88 (5.22)	-0.413 (0.355)	264	0.047
3	-49.59 (20.22)	12.66 (21.10)	-7.36 (20.72)	-13.59 (20.05)	-18.82 (19.74)	4.79 (19.63)	-0.29 (19.85)	-10.55 (20.26)	-18.39 (20.16)	-10.03 (19.88)	-	-	-11.12 (6.22)	-0.691 (0.425)	240	0.044
4	-51.33 (22.74)	-2.87 (23.82)	-8.27 (23.35)	-10.39 (22.53)	-14.15 (22.14)	1.64 (22.02)	-4.77 (22.28)	-14.73 (22.79)	-15.94 (22.67)	-	-	-	-13.42 (7.40)	-0.738 (0.500)	216	0.037
5	-67.78 (24.96)	-4.60 (26.43)	-5.61 (25.79)	-5.53 (24.67)	-17.19 (24.14)	-2.50 (23.96)	-8.35 (24.32)	-11.70 (25.03)	-	-	-	-	-15.41 (8.76)	-0.733 (0.614)	192	0.045
6	-68.73 (26.85)	-0.76 (28.60)	0.25 (27.85)	-8.01 (26.51)	-21.64 (25.87)	-6.22 (25.66)	-5.80 (26.09)	-	-	-	-	-	-15.84 (10.52)	-0.794 (0.695)	168	0.045
7	-66.05 (29.10)	4.05 (31.20)	-2.90 (30.29)	-12.20 (28.69)	-25.23 (27.91)	-3.24 (27.66)	-	-	-	-	-	-	-17.60 (12.97)	-0.788 (0.794)	144	0.038
8	-61.94 (31.98)	-0.27 (34.43)	-8.12 (33.37)	-16.49 (31.50)	-21.91 (30.60)	-	-	-	-	-	-	-	-21.74 (16.26)	-0.720 (0.899)	120	0.026
9	-72.45 (33.68)	-16.23 (36.79)	-21.86 (35.45)	-19.82 (33.06)	-	-	-	-	-	-	-	-	-32.59 (21.34)	-0.073 (1.044)	96	0.023
10	-81.81 (36.11)	-28.11 (39.89)	-25.97 (38.27)	-	-	-	-	-	-	-	-	-	-45.30 (26.45)	0.379 (1.195)	72	0.029
11	-93.12 (40.80)	-37.32 (45.98)	-	-	-	-	-	-	-	-	-	-	-65.22 (34.35)	1.046 (1.495)	48	0.041
12	-112.79 (55.25)	-	-	-	-	-	-	-	-	-	-	-	-112.79 (55.25)	3.009 (2.671)	24	0.055
							B. Without overlapping observations									
1	-58.56 (15.57)	3.91 (16.13)	2.28 (15.88)	-1.17 (15.46)	-16.97 (15.26)	-1.85 (15.19)	1.93 (15.33)	3.55 (15.59)	-4.31 (15.53)	-5.01 (15.35)	-4.43 (15.33)	2.46 (15.24)	-6.51 (4.38)	-0.114 (0.297)	288	0.052
2	-56.20 (22.11)	-	0.72 (22.87)	-	-18.86 (21.37)	-	6.51 (21.54)	-	-8.97 (22.02)	-	-1.78 (21.54)	-	-13.10 (8.65)	-0.160 (0.549)	144	0.044
3	-62.48 (27.96)	-	-	-24.49 (27.37)	-	-	7.59 (26.65)	-	-	-1.55 (26.77)	-	-	-20.23 (13.01)	0.427 (0.929)	96	0.038
4	-56.80 (31.86)	-	-	-	-11.74 (30.22)	-	-	-	-10.74 (31.67)	-	-	-	-26.43 (17.28)	-0.264 (0.974)	72	0.029
5	-100.70 (38.79)	-	-	-	-	2.51 (33.42)	-	-	-	-	-	-	-49.10 (25.01)	2.121 (1.727)	48	0.083
6	-98.86 (38.04)	-	-	-	-	-	12.61 (35.19)	-	-	-	-	-	-43.12 (23.87)	1.819 (1.582)	48	0.082
7	-105.82 (56.56)	-	-	-	-	-	-	-	-	-	-	-	-105.82 (56.56)	2.660 (2.734)	24	0.041
8	-99.62 (56.78)	-	-	-	-	-	-	-	-	-	-	-	-99.62 (56.78)	2.548 (2.744)	24	0.038
9	-106.22 (55.87)	-	-	-	-	-	-	-	-	-	-	-	-106.22 (55.87)	2.855 (2.700)	24	0.048
10	-109.63 (55.68)	-	-	-	-	-	-	-	-	-	-	-	-109.63 (55.68)	2.791 (2.691)	24	0.047
11	-112.91 (55.57)	-	-	-	-	-	-	-	-	-	-	-	-112.91 (55.57)	2.762 (2.686)	24	0.046
12	-112.79 (55.25)	-	-	-	-	-	-	-	-	-	-	-	-112.79 (55.25)	3.009 (2.671)	24	0.055

TABLE A6

SEEMINGLY UNRELATED REGRESSIONS WITH TIME DUMMIES, 24 COUNTRIES, 1994-2006

$$-(s_{c,t+h} - s_{c,t}) = \Sigma_\tau\, \alpha_{s,\tau,\tau+h} D_{s,\tau,t} + \phi_s^h d_{c,t} + u_{s,ct}^h \text{ and } r_{c,t+h} - r_{c,t} = \Sigma_\tau\, \alpha_{r,\tau,\tau+h} D_{r,\tau,t} + \phi_r^h d_{c,t} + u_{r,ct}^h$$

(Standard errors in parentheses)

Horizon h	Year dummies $\alpha_{s,\tau,\tau+h}$ $(\times 100)$ 94, 94+h	95, 95+h	96, 96+h	97, 97+h	98, 98+h	99, 99+h	00, 00+h	01, 01+h	02, 02+h	03, 03+h	04, 04+h	05, 05+h	$\eta_s^h = (1/N^h)\Sigma_\tau\, \alpha_{s,\tau,\tau+h}$ $(\times 100)$	Slope ϕ_s^h	No of Obs.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
							A. With overlapping observations								
1	62.16 (15.23)	-2.34 (15.78)	-2.08 (15.54)	-2.17 (15.12)	17.35 (14.93)	-0.03 (14.86)	-4.37 (15.00)	-4.80 (15.26)	3.93 (15.19)	4.17 (15.02)	4.31 (15.00)	-1.40 (14.91)	6.23 (4.29)	-0.705 (0.291)	288
2	55.49 (17.38)	-9.03 (18.07)	-6.33 (17.77)	13.87 (17.25)	19.14 (17.01)	-2.39 (16.93)	-6.32 (17.09)	2.33 (17.42)	11.01 (17.34)	10.47 (17.12)	4.06 (17.10)	-	8.39 (5.10)	-0.539 (0.347)	264
3	51.41 (19.76)	-13.62 (20.61)	7.02 (20.24)	12.26 (19.59)	16.58 (19.29)	-6.84 (19.18)	-1.13 (19.39)	9.22 (19.80)	17.55 (19.70)	10.18 (19.43)	-	-	10.26 (6.08)	-0.309 (0.415)	240
4	51.85 (22.21)	2.50 (23.27)	9.00 (22.81)	12.29 (22.01)	16.43 (21.63)	-0.13 (21.51)	6.39 (21.76)	16.05 (22.27)	16.21 (22.14)	-	-	-	14.51 (7.23)	-0.223 (0.489)	216
5	68.85 (24.30)	3.82 (25.74)	1.51 (25.12)	0.93 (24.02)	11.86 (23.50)	-1.96 (23.33)	4.45 (23.68)	9.99 (24.37)	-	-	-	-	12.43 (8.53)	-0.448 (0.598)	192
6	66.64 (26.03)	-3.23 (27.73)	-4.31 (26.99)	4.80 (25.70)	13.49 (25.08)	1.58 (24.87)	3.95 (25.29)	-	-	-	-	-	11.85 (10.20)	-0.567 (0.674)	168
7	59.69 (28.22)	-7.28 (30.26)	1.68 (29.38)	9.38 (27.82)	19.62 (27.07)	3.31 (26.82)	-	-	-	-	-	-	14.40 (12.58)	-0.551 (0.770)	144
8	55.50 (30.91)	0.98 (33.27)	8.04 (32.25)	16.35 (30.44)	20.22 (29.57)	-	-	-	-	-	-	-	20.22 (15.71)	-0.783 (0.868)	120
9	66.33 (32.08)	16.32 (35.05)	25.11 (33.77)	28.99 (31.49)	-	-	-	-	-	-	-	-	34.19 (20.32)	-1.709 (0.995)	96
10	76.21 (33.91)	37.13 (37.46)	45.97 (35.94)	-	-	-	-	-	-	-	-	-	53.10 (24.84)	-2.525 (1.122)	72
11	95.64 (39.07)	55.42 (44.03)	-	-	-	-	-	-	-	-	-	-	75.53 (32.90)	-2.960 (1.432)	48
12	113.89 (52.91)	-	-	-	-	-	-	-	-	-	-	-	113.89 (52.91)	-4.093 (2.557)	24
							B. Without overlapping observations								
1	62.16 (15.23)	-2.34 (15.78)	-2.08 (15.54)	-2.17 (15.12)	17.35 (14.93)	-0.03 (14.86)	-4.37 (15.00)	-4.80 (15.26)	3.93 (15.19)	4.17 (15.02)	4.31 (15.00)	-1.40 (14.91)	6.23 (4.29)	-0.705 (0.291)	288
2	56.60 (21.59)	-	-1.02 (22.33)	-	18.67 (20.87)	-	-6.80 (21.03)	-	8.83 (21.51)	-	1.87 (21.04)	-	13.03 (8.45)	-0.831 (0.536)	144
3	61.61 (27.23)	-	-	25.13 (26.66)	-	-	-6.91 (25.95)	-	-	1.47 (26.08)	-	-	20.33 (12.67)	-1.428 (0.905)	96
4	59.37 (30.87)	-	-	-	19.26 (29.28)	-	-	-	10.95 (30.68)	-	-	-	29.86 (16.74)	-0.671 (0.944)	72
5	99.21 (37.37)	-	-	-	-	-11.09 (32.20)	-	-	-	-	-	-	44.06 (24.09)	-3.174 (1.664)	48
6	85.78 (36.32)	-	-	-	-	-	-11.34 (33.60)	-	-	-	-	-	37.22 (22.79)	-2.849 (1.511)	48
7	108.59 (54.17)	-	-	-	-	-	-	-	-	-	-	-	108.59 (54.17)	-3.712 (2.618)	24
8	93.59 (52.98)	-	-	-	-	-	-	-	-	-	-	-	93.59 (52.98)	-5.090 (2.561)	24
9	91.38 (50.32)	-	-	-	-	-	-	-	-	-	-	-	91.38 (50.32)	-5.593 (2.432)	24
10	103.33 (49.80)	-	-	-	-	-	-	-	-	-	-	-	103.33 (49.80)	-6.085 (2.407)	24
11	120.15 (52.36)	-	-	-	-	-	-	-	-	-	-	-	120.15 (52.36)	-5.338 (2.531)	24
12	113.89 (52.91)	-	-	-	-	-	-	-	-	-	-	-	113.89 (52.91)	-4.093 (2.557)	24