**BURGERNOMICS:
THE ECONOMICS OF THE BIG MAC STANDARD**

by

Li Lian Ong

Department of Accounting & Finance
The University of Western Australia

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ABSTRACT

In the course of PPP research over the years, the debate has alternately boiled and simmered over the choice of appropriate ingredients for inclusion in the traditional "basket of goods and services". Amongst the items on the menu are a veritable smorgasbord of indices to whet the appetite of the PPP gourmet. The selection includes wholesale prices, consumer prices and gross domestic product price measures. However, researchers have made a meal of the argument over their accuracy for PPP purposes, given the different consistency in the mixture of goods and services which make up these indices, and the extent to which these items spice up the exchange rate. Thus, we consider the use of the Big Mac as the international monetary standard as being a more palatable alternative, since it is produced locally in 79 countries around the world, with only minor changes in recipe, and thus has the flavour of "the perfect universal commodity". The icing on the cake is that we are also able to incorporate the productivity bias concept into our research, since the Big Mac comprises both traded and non-traded goods. Our findings are indeed results to savour for connoisseurs of PPP as they appear to give this area of research its just desserts.

This paper is abstracted from my PhD thesis which is being jointly supervised by Professor H.Y. Izan of the Department of Accounting and Finance, The University of Western Australia, and Professor K.W. Clements of the Economic Research Centre, The University of Western Australia.

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"Suppose a man climbs five feet up a sea wall, then climbs down 12 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..."

The Economist, 29 August 1995, p.70

1. INTRODUCTION

The theory of purchasing power parity (PPP) states that the rate of exchange between two currencies is determined by the price levels in the two economies. In other words, the prices of a basket of similar goods and services in two countries *should be equal* when converted to a common currency. To the extent that the prices are *not* equalised, the exchange rate is said to be misaligned.

In the course of PPP research, there has been much argument over the choice of an *appropriate* "basket" for making PPP comparisons.¹ Amongst the possibilities that have been mooted are the wholesale price index (WPI), the consumer price index (CPI) and cost-of-living (COL) price measures. However, the different compositions of goods and services in these indices -- and the extent to which these items affect the exchange rates -- have resulted in arguments over their usefulness for PPP purposes (see, *e.g.*, Balassa, 1964, Froot and Rogoff, 1994, Keynes, 1930). Cassel (1922) suggests that ultimately, an index of the *general* price level is required for PPP. This is because only general index figures would encompass, as far as possible, the entire range of commodities available in an economy. He argues that the GDP deflator is appropriate since it reflects each country's pattern of production, which is ideal for weighting purposes in constructing a comprehensive price measure.

¹ For comprehensive reviews of the literature, see Froot and Rogoff (1994) and Officer (1982).

Given the prevailing index-number problem, we have decided to use the Big Mac as the international monetary standard in this test of PPP, in place of the traditional basket of goods and services. Our choice is based on the fact that the Big Mac is produced locally in 79 countries around the world, with only minor changes in recipe.² As well as being a "standard product", this means that its local prices are less likely to be distorted by international transport and distribution costs. Not surprisingly, it is considered "the perfect universal commodity". Furthermore, since the Big Mac comprises both traded and non-traded goods, we are able to incorporate the productivity bias concept into our research. In brief, the main objectives of this paper are to *test the validity of PPP using Big Mac hamburger prices*, and to *enhance PPP comparisons by decomposing the Big Mac into its traded and non-traded components*.

Our results indicate that the Big Mac Index performs just as well as, if not better than, most indices used in tests of PPP. Consistent with previous findings, we find that PPP holds over the long term, *i.e.*, the nine years of our sample period. Our results also demonstrate that even though individual currencies may deviate from parity on a country-by-country basis, the world currencies, in aggregate, are at parity for any one particular year. Furthermore, we show that PPP comparisons can be enhanced by excluding non-traded goods from the index.

This paper is organised as follows. Section 2 details the database, followed by an examination of currency valuation relative to the Big Mac PPP, in Section 3. Section 4 subsequently examines the role of geography in determining currency values. In Section 5, we carry out further tests on the data using regression analysis, and present a discussion on possible reasons for observed departures from PPP, in Section 6. In Sections 7 and 8, the Big Mac is decomposed into its traded and non-

traded components in order to enhance PPP comparisons. We conclude with a summary of our findings in Section 9.

2. THE DATA

The data used in this study consist of the prices of McDonald's Big Mac hamburgers in 34 countries, expressed in terms of the respective domestic currencies, and the corresponding exchange rates. These are published annually in The Economist magazine over the 1986 to 1994 period; an example of the data available is shown in Figure 2.1.

Looking at the first two columns of Figure 2.1, the cost of a Big Mac in Australia is A\$2.45 which is the equivalent of US\$1.76. This US dollar equivalent is calculated by converting the Australian price at the actual exchange rate of A\$1.39 = US\$1.00, which is given in the third column. The US dollar cost of the Australian Big Mac of US\$1.76 is to be compared with the cost of a Big Mac in the US of US\$2.28, given as the first entries in columns 1 and 2 of Figure 2.1. Consequently, hamburgers are relatively cheaper in Australia.

The implied PPP of the Australian dollar is derived by dividing the domestic currency price of A\$2.45 by the US Big Mac price of US\$2.28, $2.45 / 2.28 = 1.07$. This means that, on the basis of Big Mac prices, the exchange rate should be A\$1.07 per US dollar, as shown in the fourth column of Figure 2.1. Given the actual rate of A\$1.39 per US dollar (column 3), the Australian dollar is undervalued by 23 percent, as indicated in column 5.

² The Economist, 15 April 1995, p. 78.

The hamburger standard

	Big Mac prices		Actual	Implied	Local
	Prices in local currency*	Prices in dollars	exchange rate 13/4/93	PPP of the dollar	currency under (-)/over (+) valuation**, %
	(1)	(2)	(3)	(4)	(5)
UNITED STATES†	\$2.28	2.28	—	—	—
Argentina	Peso3.60	3.60	1.00	1.58	+58
Australia	A\$2.45	1.76	1.39	1.07	-23
Belgium	Bfr109	3.36	32.45	47.81	+47
Brazil	Cr77,000	2.80	27,521	33,772	+23
Britain	£1.79	2.79	1.56 **	1.27 **	+23
Canada	C\$2.76	2.19	1.26	1.21	-4
China	Yuan8.50	1.50	5.68	3.73	-34
Denmark	DKr25.75	4.25	6.06	11.29	+86
France	FFr18.50	3.46	5.34	8.11	+52
Germany	DM4.60	2.91	1.58	2.02	+28
Holland	Fl5.45	3.07	1.77	2.39	+35
Hong Kong	HK\$9.00	1.16	7.73	3.95	-49
Hungary	Forint157	1.78	88.18	68.86	-22
Ireland	Ir£1.48	2.29	1.54 **	1.54 **	0
Italy	Lire4,500	2.95	1,523	1,974	+30
Japan	¥391	3.45	113	171	+51
Malaysia	Ringgit3.35	1.30	2.58	1.47	-43
Mexico	Peso7 09	2.29	3.10	3.11	0
Russia	Rouble780	1.14	686 §	342	-50
S. Korea	Won2,300	2.89	796	1,009	+27
Spain	Ptas325	2.85	114	143	+25
Sweden	SKr25.50	3.43	7.43	11.18	+50
Switzerland	SwFr5.70	3.94	1.45	2.50	+72
Thailand	Baht48	1.91	25.16	21.05	-16

Source: McDonald's. * Prices may vary locally. † Purchasing-power parity, local price divided by price in United States.
 ** Against dollar. ‡ Average of New York, Chicago, San Francisco and Atlanta. § Dollars per pound. § Market rate.

Source: The Economist, 17 April 1993.

Figure 2.1

Table 2.1 summarises the implied and actual exchange rates of the 34 countries in the nine years that The Economist has undertaken the survey. These data form the basis of our study.

3. THE VALUATION OF CURRENCIES

In this section, we investigate the valuation of currencies relative to their Big Mac PPP. Let P_{ct} be the domestic currency price of a Big Mac in country c in year t ; P_t^* be the price in US dollars of a Big Mac in the US; and S_{ct} be the spot exchange rate, defined as the domestic currency cost of US\$1. Accordingly, P_{ct} / P_t^* is the Big Mac PPP. Consider the ratio of this PPP to the actual exchange rate:

$$R_{ct} \equiv \frac{P_{ct} / P_t^*}{S_{ct}} \quad (3.1)$$

One way to determine whether or not the currency is over- or under- valued is to analyse the extent to which the ratio in (3.1) departs from unity: it is overvalued (undervalued) if it is greater (less) than 1, and at parity if it is equivalent to 1. However, it is more convenient to express the ratio (3.1) in logarithmic form:

$$r_{ct} \equiv \log \left(\frac{P_{ct} / P_t^*}{S_{ct}} \right) = \log \frac{P_{ct}}{P_t^*} - \log S_{ct} \quad (3.2)$$

Thus, a currency is said to be overvalued if r_{ct} is greater than 0, undervalued if r_{ct} is less than 0, and at parity if r_{ct} equals 0. Note that $r_{ct} \times 100$ is approximately the percentage deviation from parity.

Table 2.1
Actual and Implied Exchange Rates
(Domestic currency cost of US\$1)

Country	Currency	1986		1987		1988		1989		1990		1991		1992		1993		1994	
		Actual	Implied	Actual	Implied	Actual	Implied	Actual	Implied	Actual	Implied	Actual	Implied	Actual	Implied	Actual	Implied	Actual	Implied
1. Argentina	Peso	1.64	1.09	-	-	1.36	0.82	1.24	1.04	1.32	1.05	1.27	1.09	0.99	1.51	1.00	1.58	1.00	1.57
2. Australia	A\$	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.00	1.07
3. Austria	Sch	42.00	56.00	39.13	56.25	34.80	37.66	39.50	45.00	34.65	44.00	34.50	44.44	33.55	49.32	32.45	47.81	35.20	47.39
4. Belgium	Bfr	13.80	7.80	-	-	0.54	0.50	0.59	0.62	0.61	0.64	0.56	0.74	0.57	0.79	0.64	0.79	0.68	0.79
5. Brazil	Cr	0.67	0.69	0.68	-	1.24	0.86	1.19	1.06	1.16	1.00	1.15	1.04	1.19	1.26	1.26	1.21	1.39	1.24
6. Britain	£	1.39	1.18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.14	4.12
7. Canada	C\$	-	-	-	-	-	-	-	-	-	-	-	-	5.44	2.88	5.68	3.73	8.70	3.91
8. Chile	Yuan	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	29.70	21.70
9. China	Ckr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.69	11.20
10. Czech Republic	DKr	-	-	7.19	13.44	6.36	9.52	7.33	12.30	6.39	11.60	6.42	11.89	6.32	12.44	6.06	11.29	5.83	8.04
11. Denmark	FFr	6.65	10.30	6.30	10.88	5.63	7.24	6.37	8.76	5.63	8.05	5.65	8.00	5.55	8.26	5.34	8.11	5.83	8.04
12. France	DM	2.02	2.66	1.89	2.56	1.66	1.72	1.89	2.13	1.68	1.95	1.67	1.91	1.64	2.05	1.58	2.02	1.71	2.00
13. Germany	Dr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.51	2.70
14. Greece	Fl	2.28	2.72	2.13	2.81	1.86	2.03	2.13	2.52	1.88	2.39	1.88	2.33	1.84	2.44	1.77	2.39	1.91	2.37
15. Holland	HK\$	7.80	4.75	-	-	7.80	3.18	7.78	3.76	7.79	3.90	7.79	3.96	7.73	4.06	7.73	3.95	7.73	4.00
16. Hong Kong	Forint	-	-	-	-	0.62	0.51	0.71	0.64	0.63	0.59	0.62	0.62	0.61	0.66	0.65	0.65	103.00	73.48
17. Hungary	Lf	0.74	0.74	0.70	0.74	1229	1380	1382	1634	1230	1773	1239	1600	1233	1872	1523	1974	1641	1978
18. Ireland	Lira	-	-	1342	2063	124	155	133	183	159	168	135	169	133	174	113	171	104	170
19. Italy	¥	1.54	231	-	-	-	-	-	-	-	-	-	-	-	-	2.58	1.47	2.69	1.64
20. Japan	Ringgit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.10	3.46	3.36	3.52
21. Malaysia	Peso	-	-	-	-	-	-	-	-	-	-	-	-	-	-	29433	13478	174	191
22. Mexico	Zloty	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1775	1261
23. Portugal	Esc	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.57	1.30
24. Russia	Rouble	-	-	-	-	2.00	1.17	1.96	1.39	1.88	1.18	1.77	1.24	1.65	2.17	-	-	810	1000
25. Singapore	Won	2.15	1.75	-	-	-	-	666	1188	707	955	721	933	778	1050	796	1009	143	150
26. South Korea	Pias	-	-	-	-	111	119	117	139	106	134	103	155	102	144	114	143	138	150
27. Sweden	SKr	133	163	-	-	5.89	7.74	6.41	10.40	6.10	10.90	6.04	11.56	5.93	11.64	1.45	2.50	1.44	2.48
28. Switzerland	Sfr	6.87	10.30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	26.40	29.96
29. Taiwan	NT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	25.30	20.87
30. Thailand	Baht	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31. Thailand	Bs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
32. Venezuela	Dinar	-	-	-	-	1400	962	9001	3465	11.72	7.27	15.12	14.22	60.63	77.63	-	-	-	-
33. Yugoslavia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34. Yugoslavia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Sources: The Economist, 6 September 1986, p. 67; 17 January 1987, p. 60; 2 April 1988, p. 68; 15 April 1989, p. 82; 5 May 1990, p. 90; 13 April 1991, p. 86; 18 April 1992, p. 77; 17 April 1993, p. 83; 15 May 1993, p. 94; 9 April 1994, p. 92.

Table 3.1 gives r_{ct} for each country and year, as well as the row and column averages, $r_{c\cdot}$ and $r_{\cdot t}$. Looking at column 10 of the table, Chile appears closest to achieving parity, with an average undervaluation of only 0.5 percent. The Hong Kong dollar is undervalued against the US dollar by 68 percent, while the Danish krone is overvalued by 57 percent. The last row of Table 3.1 shows that these currencies are, on average, overvalued against the US dollar, with 1987 recording a high of 33 percent. In other words, the US dollar is undervalued on average. The years 1988 and 1994 are the exceptions, with average undervaluations of 9 percent and 0.4 percent respectively. Figure 3.1 shows $r_{c\cdot}$, the country averages of the over/under-valuations. We find that over the 1986 to 1994 period, 14 currencies are, on average, undervalued against the US dollar. The remaining currencies are above the grand average of 6.6 percent.

Next, we test whether or not the deviations from parity are significant. Table 3.2 provides the results of t -tests in the form of the inter-temporal averages for each country. As can be seen, the currencies of Brazil, Ireland, Mexico and Russia are insignificantly different from parity. All other currencies are either significantly over- or under-valued against the US dollar: the Yugoslavia dinar is significantly undervalued at the 10 percent level, while the currencies of Britain, Canada, China and Singapore are significantly different from parity at the 5 percent level. Malaysia, South Korea and Thailand are significantly different from parity at the 1 percent level, while the remaining currencies are significantly different at the 0.1 percent level.

Table 3.1
Over/Under-Valuation of the Domestic Currency Relative to the US Dollar
 $r(c, t) \times 100$

Country	1986 (1)	1987 (2)	1988 (3)	1989 (4)	1990 (5)	1991 (6)	1992 (7)	1993 (8)	1994 (9)	Average (10)
1. Argentina	-	-	-	-	-	-	42.22	45.74	45.11	44.36
2. Australia	-40.85	-	-50.59	-17.59	-22.88	-15.28	-12.16	-26.16	-28.30	-26.73
3. Austria	-	-	-	-	-	-	-	-	20.97	20.97
4. Belgium	28.77	36.29	7.90	13.04	23.89	25.32	38.53	38.75	29.74	26.91
5. Brazil	-57.05	-	-	-	-	-	-21.59	20.47	-37.54	-23.93
6. Britain	2.94	4.32	-7.70	4.96	4.80	27.87	32.64	21.06	13.94	11.65
7. Canada	-16.38	-	-36.59	-11.57	-14.84	-10.05	5.72	-4.05	-11.42	-12.40
8. Chile	-	-	-	-	-	-	-	-	-0.48	-0.48
9. China	-	-	-	-	-	-	-63.60	-42.05	-79.98	-61.88
10. Czech Republic	-	-	-	-	-	-	-	-	-31.38	-31.38
11. Denmark	-	62.55	40.34	51.76	59.63	61.63	67.72	62.22	51.53	57.17
12. France	43.75	54.64	25.15	31.86	35.76	34.78	39.76	41.79	32.14	37.74
13. Germany	27.52	30.34	3.55	11.95	14.90	13.43	22.31	24.57	15.67	18.25
14. Greece	-	-	-	-	-	-	-	-	7.30	7.30
15. Holland	17.65	27.71	8.75	16.81	24.00	21.46	28.22	30.03	21.58	21.80
16. Hong Kong	-49.60	-	-89.72	-72.71	-69.19	-67.66	-64.39	-67.14	-65.88	-68.29
17. Hungary	-	-	-	-	-	-38.51	-27.18	-24.73	-33.77	-13.05
18. Ireland	0.00	5.49	-19.53	-10.38	-6.56	0.00	7.88	0.00	-	-2.89
19. Italy	-	43.01	11.59	16.75	36.57	25.57	41.76	25.94	18.68	27.48
20. Japan	40.55	-	22.31	31.91	5.51	22.46	26.87	41.43	49.14	30.02
21. Malaysia	-	-	-	-	-	-	-	-56.25	-49.48	-52.87
22. Mexico	-	-	-	-	-	-	-	10.99	4.65	7.82
23. Poland	-	-	-	-	-	-	-	-	-50.95	-50.95
24. Portugal	-	-	-	-	-	-	-	-	9.32	9.32
25. Russia	-	-	-	-	104.15	93.68	-131.82	-69.61	-34.19	-7.56
26. Singapore	-20.59	-	-53.61	-34.36	-46.58	-35.59	27.40	-	-18.87	-26.03
27. South Korea	-	-	-	57.87	30.07	25.78	29.98	23.71	21.07	31.41
28. Spain	20.34	-	6.96	17.23	23.44	40.87	34.48	22.66	8.34	21.79
29. Sweden	40.50	-	27.31	48.39	58.05	64.91	67.44	40.86	33.13	47.57
30. Switzerland	-	-	-	-	-	-	-	54.47	54.36	54.42
31. Taiwan	-	-	-	-	-	-	-	-	12.65	12.65
32. Thailand	-	-	-	-	-	-	-	-17.84	-19.25	-18.54
33. Venezuela	-	-	-	-	-	-	24.72	-	-	24.72
34. Yugoslavia	-	-	-37.52	-95.46	-47.75	-6.14	-	-	-	-46.72
Average	2.68	33.04	-8.84	3.56	11.83	14.97	9.86	8.20	-0.39	6.63

Notes: The currency is overvalued if $r(c, t) > 0$; undervalued if $r(c, t) < 0$; and at parity if $r(c, t) = 0$.
The grand average of 6.63 percent overvaluation against the US dollar is derived by dividing the sum of the individual observations by the total number of observations in the sample. This figure does not equal the average of either the cross-sectional or inter-temporal averages as the number of observations for each year and country are irregular over the entire sample.

Figure 3.1
Over/Under-Valuation of Currencies: 1986-1994 Averages

Table 3.2
Tests of Over/Under -Valuation of the Domestic Currency Relative to the US Dollar:
1986-1994 Averages

Country	Average $r(c, *) \times 100$	Standard error of mean $\times 100$	t-statistic	Level of significance (%)
1. Argentina	44.36	1.09	40.87	0.1
2. Australia	-26.73	4.65	-5.74	0.1
3. Austria	20.97	-	-	N/A
4. Belgium	26.91	3.61	7.45	0.1
5. Brazil	-23.93	16.48	-1.45	-
6. Britain	11.65	4.40	2.65	5
7. Canada	-12.40	4.25	-2.92	5
8. Chile	-0.48	-	-	N/A
9. China	-61.88	10.98	-5.63	5
10. Czech Republic	-31.38	-	-	N/A
11. Denmark	57.17	3.09	18.48	0.1
12. France	37.74	2.84	13.30	0.1
13. Germany	18.25	2.85	6.40	0.1
14. Greece	7.30	-	-	N/A
15. Holland	21.80	2.24	9.73	0.1
16. Hong Kong	-68.29	3.90	-17.51	0.1
17. Hungary	-31.05	3.14	-9.90	0.1
18. Ireland	-2.89	3.16	-0.92	-
19. Italy	27.48	4.18	6.57	0.1
20. Japan	30.02	4.89	6.14	0.1
21. Malaysia	-52.87	3.38	-15.62	1
22. Mexico	7.82	3.17	2.47	-
23. Poland	-50.95	-	-	N/A
24. Portugal	9.32	-	-	N/A
25. Russia	-7.56	46.22	-0.16	-
26. Singapore	-26.03	10.09	-2.58	5
27. South Korea	31.41	5.48	5.73	1
28. Spain	21.79	4.12	5.28	0.1
29. Sweden	47.57	5.21	9.13	0.1
30. Switzerland	54.42	0.06	978.96	0.1
31. Taiwan	12.65	-	-	N/A
32. Thailand	-18.54	0.71	-26.23	1
33. Venezuela	24.72	-	-	N/A
34. Yugoslavia	-46.72	18.50	-2.52	10
All countries: $r(*, *) \times 100$	6.63	3.00	2.21	5

Note: The t-statistic for each country is derived by dividing the average over / (under) -valuation of the domestic currency, in the first column, by its standard error, in the second column. The level of significance in the last column shows the probability of incorrectly rejecting the null hypothesis of a zero average. Where "-" is indicated, the null hypothesis cannot be rejected at any level less than 10 percent.

The results for Brazil and Russia, especially, provide a strong case for using averages. Although these currencies are two of the most volatile (with standard errors of the mean of 16 percent and 46 percent respectively) their alternating positions against the US dollar, from one year to the next, tend to cancel out over time the deviations from parity. Finally, the *t*-statistic for the entire sample indicates that the currencies, averaged over time and countries, deviate significantly from parity at the 5 percent level.

Figure 3.2 plots for each year the cross-country averages, r_{-t} , from the last row of Table 3.1. As can be seen, in 1988 and 1994, the US dollar is overvalued, although not by much in the latter year. The dollar is undervalued in all other years. Results of the *t*-tests in Table 3.3 seem to imply that the over- or under- valuation of each currency, with respect to the US dollar, tend to offset one another on an annual basis. With the exception of 1987, when the US dollar is significantly overvalued (at the 1 percent level), it appears that the US dollar is more or less at parity in each year.

4. GEOGRAPHIC EFFECTS

In Figure 4.1, the countries are classified according to regional groupings, namely the Americas, Western and Central Europe, Eastern Europe, East Asia and ASEAN-Oceania. Broadly speaking, it appears that the high growth, developing economies in the ASEAN-Oceania and Eastern Europe regions are generally undervalued against the US, while the currencies of developed countries in Western and Central Europe, along with those of the highly industrialised East Asian countries of Taiwan, Japan and South Korea, are overvalued.

Figure 3.2

Over/Under-Valuation of Currencies: Annual Cross-Country Averages

Table 3.3

Tests of Over/Under-Valuation of the World Currencies Relative to the US Dollar by Year:
Annual Cross-Country Averages

Statistic	Year				
	1986	1987	1988	1989	1990
Average $r(*, t) \times 100$	2.68	33.04	-8.84	3.56	11.83
Standard error of mean $\times 100$	9.23	7.40	8.96	10.06	10.03
t-statistic	0.29	4.46	-0.99	0.35	1.18
Level of significance (%)	-	1	-	-	-

Statistic	Year				All years $r(*, t) \times 100$
	1991	1992	1993	1994	
Average $r(*, t) \times 100$	14.97	9.86	8.20	-0.39	6.63
Standard error of mean $\times 100$	8.88	10.10	7.86	6.37	3.00
t-statistic	1.69	0.98	1.04	-0.06	2.21
Level of significance (%)	-	-	-	-	5

Note: The level of significance in the last row shows the probability of incorrectly rejecting the null hypothesis of a zero average. Where "-" is indicated, the null hypothesis cannot be rejected at any level less than 10 percent.

Figure 4.1
Over/Under-Valuation of Currencies: Regional Groups, 1986-1994 Averages

Table 4.1 tests for parity by region. The figures indicate that except for Western and Central Europe, all other regions are, on average, undervalued against the US. The Western and Central European currencies are significantly overvalued at the 0.1 percent level. East European currencies are the most volatile, with a standard error of mean of approximately 16 percent for the region, followed by East Asia, where the standard error of mean is 10 percent. The currencies of ASEAN-Oceania and Eastern Europe are undervalued by about 28 percent, and the deviations for both regions are significant. The null hypothesis of PPP does hold, however, for the Americas and East Asia.

Test statistics within the regional groupings indicate that the majority of the Western and Central European currencies deviate significantly from parity at the 0.1 percent level. Only Ireland is at parity with the US. In the Americas group, parity with the US is achieved by Mexico and Brazil, while Canada, surprisingly, deviates from its North American neighbour at the 5 percent level. All the ASEAN-Oceania currencies are significantly undervalued.

The above findings could perhaps be explained to some extent by Frankel and Wei's (1993) research into the existence of currency blocs, in which they suggest that currency movements are influenced by dominant economies within the selected trade blocs. For instance, the Deutsche mark appears to dominate the determination of currency values in Europe, while the US dollar is most influential in the Americas. However, except for the Singapore dollar, they find that changes in currency values in the Asian region are not really influenced by the Japanese yen; the US dollar appears to be the dominant currency in this region.

Table 4.1
Tests of Over/Under-Valuation of the Domestic Currency Relative to the US Dollar by Region:
1986 - 1994 Averages

Region / Country	Average r(c, *) x 100	Standard error of mean x 100	t-statistic	Level of significance (%)
Americas				
1. Argentina	44.36	1.09	40.87	0.1
2. Brazil	-23.93	16.48	-1.45	-
3. Canada	-12.40	4.25	-2.92	5
4. Venezuela	24.72	-	-	N/A
5. Chile	-0.48	-	-	N/A
6. Mexico	7.82	3.17	2.47	-
Region	-1.16	6.50	-0.18	-
Western and Central Europe				
1. Austria	20.97	-	-	N/A
2. Belgium	26.91	3.61	7.45	0.1
3. Britain	11.65	4.40	2.65	5
4. Denmark	57.17	3.09	18.48	0.1
5. Germany	18.25	2.85	6.40	0.1
6. Greece	7.30	-	-	N/A
7. France	37.74	2.84	13.30	0.1
8. Holland	21.80	2.24	9.73	0.1
9. Ireland	-2.89	3.16	-0.92	-
10. Italy	27.48	4.18	6.57	0.1
11. Portugal	9.32	-	-	N/A
12. Spain	21.79	4.12	5.28	0.1
13. Sweden	47.57	5.21	9.13	0.1
14. Switzerland	54.42	0.06	978.96	0.1
Region	26.70	2.02	13.20	0.1
Eastern Europe				
1. Czech Republic	-31.38	-	-	N/A
2. Hungary	-31.05	3.14	-9.90	0.1
3. Poland	-50.95	-	-	N/A
4. Russia	-7.56	46.22	-0.16	-
5. Yugoslavia	-46.72	18.50	-2.52	10
Region	-28.75	15.59	-1.84	10
East Asia				
1. China	-61.88	10.98	-5.63	5
2. Hong Kong	-68.29	3.90	-17.51	0.1
3. Japan	30.02	4.89	6.14	0.10
4. South Korea	31.41	5.48	5.73	1
5. Taiwan	12.65	-	-	N/A
Region	-11.18	9.82	-1.14	-
ASEAN-Oceania				
1. Australia	-26.73	4.65	-5.74	0.1
2. Malaysia	-52.87	3.38	-15.62	1
3. Singapore	-26.03	10.09	-2.58	5
4. Thailand	-18.54	0.71	-26.23	1
Region	-28.36	4.51	-6.28	0.1

Notes: The figures in the "Region" rows are calculated by pooling the individual observations from each country within the region in question. The level of significance in the last column shows the probability of incorrectly rejecting the null hypothesis of a zero average. Where "-" is indicated, the null hypothesis cannot be rejected at any level less than 10 percent.

5. FURTHER TESTS OF PARITY

In the previous section, we used t -tests to investigate whether departures from PPP are significant, and find that the parity condition generally holds across countries and over time. We now conduct regression-based tests to corroborate our results. Both time-series and average data are used to test for the relationship between actual and implied exchange rates.

Consider the following relationship between the actual exchange rate in country c and year t (S_{ct}) and the corresponding price ratio $p_{ct} = P_{ct} / P_t^*$:

$$S_{ct} = \alpha + \beta \cdot p_{ct} \quad (5.1)$$

The PPP hypothesis implies a zero intercept term and a unit slope coefficient ($\alpha = 0$, $\beta = 1$). The results are given in Table 5.1. The first two hypotheses are tested using the t -statistic, while the third uses the F -test. Initially, we estimate model (5.1) for each year, using the cross-country data. Additionally, we also estimate a logarithmic version:

$$\log S_{ct} = \alpha' + \beta' \cdot \log p_{ct} \quad (5.2)$$

The results are given in the first part of Table 5.1.

Looking at the adjusted R^2 figures of the linear model (5.1), there seems to be a significant relationship between the implied and actual exchange rates on a year-by-year basis. Apart from 1989 and 1992, R^2 is well over 90 percent for each year of the sample period. Furthermore, with the exception of 1994, all the intercept terms are not significantly different from zero. However, the majority of the slope coefficients are statistically different from 1 at the 0.1 percent level, except for 1988

Table 5.1
Regression Results for Purchasing Power Parity
(Standard errors in parentheses)

Data / Year / Model	Number of Observations	Intercept (t)	t-statistic t = 0	Level of Significance (%)	Slope (S)	t-statistic t = 1	Level of Significance (%)	Adjusted R ²	SE	F-statistic F = 1	Level of Significance (%)
I. Cross-Country											
1986 Linear	14	1.8148 (1.8435)	0.9844	-	0.7077 (0.0239)	-12.235	0.1	0.9854	6.1346	88.284	0.1
1986 Logarithmic	14	0.1241 (0.1182)	1.0503	-	0.9153 (0.0461)	-1.8350	10	0.9679	0.3175	1.7336	-
1987 Linear	8	0.1621 (0.4794)	0.3382	-	0.6504 (0.0007)	-532.06	0.1	1.0000	1.2605	163692	0.1
1987 Logarithmic	8	-0.2255 (0.0874)	-2.5802	5	0.9533 (0.0262)	-1.7839	-	0.9947	0.1828	14.665	5
1988 Linear	16	3.7669 (32.601)	0.1155	-	1.0686 (0.0770)	0.8915	-	0.9274	119.70	0.5281	-
1988 Logarithmic	16	0.1804 (0.1162)	1.5328	-	0.9575 (0.0349)	-1.2165	-	0.9804	0.3527	1.2422	-
1989 Linear	17	-200.35 (216.91)	-0.9236	-	2.2067 (0.2226)	5.4211	0.1	0.8588	817.97	15.656	0.1
1989 Logarithmic	17	-0.0104 (0.1446)	-0.0722	-	0.9907 (0.0371)	-0.2495	-	0.9780	0.4274	0.0900	-
1990 Linear	18	4.8642 (3.4806)	1.3975	-	0.7026 (0.0073)	-40.799	0.1	0.9982	13.756	936.41	0.1
1990 Logarithmic	18	-0.0136 (0.1350)	-0.1006	-	0.9525 (0.0414)	-1.1467	-	0.9689	0.4215	1.3663	-
1991 Linear	19	1.5500 (2.3902)	0.6485	-	0.7726 (0.0056)	-40.765	0.1	0.9991	9.6773	951.93	0.1
1991 Logarithmic	19	-0.0626 (0.1284)	-0.4876	-	0.9638 (0.0385)	-0.9421	-	0.9721	0.3884	1.8558	-
1992 Linear	22	-0.1785 (40.005)	-0.0045	-	0.9000 (0.0677)	-1.4768	-	0.8932	171.72	1.3052	-
1992 Logarithmic	22	-0.0726 (0.1538)	-0.4716	-	0.9904 (0.0419)	-0.2285	-	0.9637	0.4848	0.4810	-
1993 Linear	24	13.379 (18.516)	0.7225	-	0.8144 (0.0027)	-69.248	0.1	0.9998	88.346	2515.9	0.1
1993 Logarithmic	24	-0.0475 (0.1125)	-0.4225	-	0.9874 (0.0288)	-0.4366	-	0.9808	0.3920	0.6206	-
1994 Linear	31	-121.52 (61.863)	-1.9644	10	1.6514 (0.0251)	25.996	0.1	0.9931	332.98	350.08	0.1
1994 Logarithmic	31	-0.0284 (0.1027)	-0.2769	-	1.0101 (0.0248)	0.4056	-	0.9822	0.3597	0.0841	-
II. Cross-Country / Time-Series											
Linear	169	55.240 (73.511)	0.7515	-	0.9404 (0.0258)	-2.3111	5	0.8878	942.09	2.7386	10
Logarithmic	162	-0.0174 (0.0424)	-0.4105	-	0.9810 (0.0117)	-1.6202	-	0.9765	0.3881	3.7765	5
III. Average over time											
Linear	34	-96.766 (201.62)	-0.4799	-	1.4143 (0.0716)	5.7835	0.1	0.9218	1123.1	17.553	0.1
Logarithmic	34	-0.0179 (0.0943)	-0.1901	-	1.0009 (0.0238)	0.0373	-	0.9817	0.3471	0.0333	-

and 1992. The respective F -statistics indicate a rejection of the joint hypothesis of a zero intercept and unit slope, at the 0.1 percent level of significance, for all years other than 1988 and 1992. On the basis of these results with the linear model, it appears that short-term PPP is achieved only in 1988 and 1992.

When the logarithmic model is used, all three hypotheses cannot be rejected for any one year, except for 1986 and 1987. We find the slope coefficient for 1986 to be significantly different from unity at the 10 percent level. The intercept term for 1987 is different from zero at the 5 percent level of significance, while the joint hypothesis is also rejected at the 5 percent level of significance for that year. Overall, the logarithmic model appears to model short-term PPP very well, with the year-by-year regression results in the first part of Table 5.1 showing strong support for its existence.

Next, we pool the data over time and countries, and the results are presented in the second part of Table 5.1. Consistent with the majority of the year-by-year results for the linear model, the intercept term is not significantly different from zero, whilst the slope coefficient differs significantly from unity at the 5 percent level. However, the joint hypothesis, in this instance, cannot be rejected at any level of significance. As with the individual-year results, the pooled results for the logarithmic model also show a marked improvement relative to the linear model, with the adjusted R^2 increasing to 98 percent from 89 percent. In this case, both the null hypotheses of a zero intercept and unity in the slope coefficient, when taken separately, cannot be rejected. However, the joint hypothesis is rejected at the 5 percent level of significance.

Subsequently, let $S_{c\bullet} = \frac{1}{T} \cdot \sum_{t=1}^T S_{ct}$ and $p_{c\bullet} = \frac{1}{T} \cdot \sum_{t=1}^T p_{ct}$ be the average exchange rate and relative price for country c . We now use these averages in the cross-country regressions:

$$S_{c\bullet} = \alpha + \beta \cdot p_{c\bullet} \quad (5.3)$$

and

$$\log S_{c\bullet} = \alpha' + \beta' \cdot \log p_{c\bullet} \quad (5.4)$$

where the logarithmic averages are analogously defined as $\log S_{c\bullet} = \frac{1}{T} \cdot \sum_{t=1}^T \log S_{ct}$ and $\log p_{c\bullet} = \frac{1}{T} \cdot \sum_{t=1}^T \log p_{ct}$. The estimates of these equations are given in the third part of Table 5.1. We see that the results for the linear model show an improvement in the adjusted R^2 of 92 percent relative to the "pooled data" figure of 89 percent, obtained from the (5.1) model. However, the null hypothesis for the slope coefficient is still rejected, this time at the 0.1 percent level. Furthermore, the F -statistic shows that the joint hypothesis is rejected at the 0.1 percent level of significance. Using the logarithmic model (5.4), the adjusted R^2 further improves to 98 percent. The intercept and slope coefficient are not significantly different from zero and unity, respectively, while the joint hypothesis for the slope and intercept also cannot be rejected. Figure 5.1 gives scatterplots of the "averaged" data.

In conclusion, it appears that PPP holds in logarithmic form as a long-run proposition, *i.e.*, when the data are averaged over time. This result is intuitively appealing in that logarithmic transformations reduce the relative magnitude of outliers in the data, while the averaging process decreases the effects of short-run volatility of exchange rate fluctuations. Also, note that this long-run result agrees with prior findings (see, *e.g.*, Manzur, 1990).

Figure 5.1
Exchange Rates and Prices:
Country Averages, 1986-1994

6. POSSIBLE CAUSES OF DEPARTURES FROM PARITY

Our earlier tests indicate that PPP generally holds for our sample countries, both on a year-by-year basis, and averaged over nine years. However, our results are not without exception. In several instances, the exchange rates have been found to deviate significantly from parity. We will now explore the different possibilities as to how these deviations would occur in the context of our research.

Firstly, the theory of PPP assumes that there are no barriers to trade. It has been long recognised that such barriers prevent arbitrage from taking place and lead to departures from parity. For instance, Harrod (1936, p. 71) argues that the costs of transportation of commodities across borders, and the effects of tariffs on those commodities, would result in the divergence of purchasing power between two economies within the limits imposed by these costs. In our case, these market imperfections would be further augmented by cost differentials as a result of comparative advantage between countries within the Big Mac production chain. Although the Big Macs are made locally, the same may not be true for each individual ingredient required to make it, *e.g.*, meat and wheat are produced cheaply in Australia and the US, but labour in these countries costs more than, say, the developing countries such as Malaysia and Thailand.

Big Mac prices could also be distorted by high taxes in countries such as Denmark and Sweden, and inflated property costs in Hong Kong, Japan and Singapore, which could exaggerate the degree of departure from parity for these currencies. Then there is the "status symbol" argument that in certain countries, fast-food chains in general, and the McDonald's franchise in particular, are rarities and are thus able to command a monopoly premium over other commodities. This is not the case in the US where intense competition from other fast-food chains would serve to keep margins slim.

The deviations from parity could partly be due to the exchange rates themselves. Institutional intervention in foreign exchange rate markets by central banks results in a "dirty" float whereby rates can be artificially held away from their underlying economic fundamental values.

Another important reason for deviations from PPP is the existence of productivity differences between countries. For example, if international productivity differences are greater in the production of traded goods than non-traded goods, then the currency of rich countries, which have higher overall productivity levels, will appear overvalued in PPP terms (Balassa, 1964). This *productivity bias hypothesis*, as it is commonly known, will be investigated in the next two sections.

7. IS THE BIG MAC ALL TRADEABLE?

According to Harrod (1939, p. 71), "the rate at which currencies exchange against each other should normally be that rate which causes each when converted into the other to purchase the same quantity of goods in the land of the currency into which it has converted as it purchases at home." He sees this definition as holding true for traded goods (hereafter T) only, as the prices of these goods are purely the effect of exchange rate movements. Accordingly, these prices should not vary outside the limits set by transportation costs and tariffs. Harrod argues that PPP no longer holds once non-traded goods (hereafter N) are taken into account, since they are not expected to have the same prices in different countries except under special circumstances. Balassa (1964) formalises Harrod's exposition by looking at deviations from PPP in the context of productivity biases. He finds that marked productivity differentials in T between "rich" and "poor" countries, along with wage

equalisation within each economy, cause the prices of N in terms of T to be higher in the richer economies. We will use this approach as a basis for slicing the Big Mac into its T and N components.

Clements and Frenkel (1980) take the price level to be a linear homogeneous (Cobb-Douglas) function of the prices of non-traded goods, P_N , and traded goods, P_T , with weight α given to N:

$$P = P_N^\alpha \cdot P_T^{1-\alpha}, \quad (7.1)$$

where $0 < \alpha < 1$. As this implies that $P = P_T \left(\frac{P_N}{P_T} \right)^\alpha$, it follows that

$$P_T = P \left(\frac{P_T}{P_N} \right)^\alpha. \quad (7.2)$$

Similarly, for the foreign country (denoted by an asterisk),

$$P_T^* = P^* \left(\frac{P_T^*}{P_N^*} \right)^{\alpha^*}. \quad (7.3)$$

If PPP applies to T only, then $S = P_T / P_T^*$, and it follows that

$$P_T = S \cdot P_T^*. \quad (7.4)$$

Substituting (7.2) and (7.3) into (7.4), we obtain

$$P \left(\frac{P_T}{P_N} \right)^\alpha = S \cdot P^* \left(\frac{P_T^*}{P_N^*} \right)^{\alpha^*}.$$

so that

$$S = \frac{(P_T / P_N)^\alpha}{(P_T^* / P_N^*)^{\alpha^*}} \cdot \frac{P}{P^*} \quad (7.5)$$

Consider a two-country world, where one country is rich and the other poor. Let the rich country be more productive in the production of both T and N. Although this country has an absolute advantage in both goods, it is plausible to postulate that it is *relatively* more productive in T. The reason lies in the nature of N which have large service components and are labour-intensive. Thus, productivity improvements are more difficult in these areas. Consequently, the relatively higher productivity of T in the rich country means that their relative price will be cheaper in the rich country (in terms of N). This is Balassa's argument.

Since N enters into the calculation of PPP, via the overall price level, but do not directly affect exchange rates, the currency of the richer country will appear to be "overvalued". Looking at equation (7.5), we can see that the $(P_T / P_N)^\alpha$ term becomes smaller, on the basis of a simple PPP calculation, as T becomes relatively cheaper to N in the rich country. As the numerator decreases relative to the denominator in the term $(P_T / P_N)^\alpha / (P_T^* / P_N^*)^{\alpha^*}$, this term falls. The result is a greater "gap" between PPP (as represented by P / P^*) and the equilibrium exchange rate, S. Thus, the currency of the country with higher productivity levels appears overvalued in PPP terms if the PPP value of the exchange rate is defined merely as P / P^* .

Clements and Semudram (1983) analyse this relationship between the relative prices of T and N, and GDP per capita by estimating the following equation:

$$\log \left(\frac{P_T}{P_N} \right) = \lambda + \phi \log \text{GDP} \quad (7.6)$$

They use the price of haircuts in 24 countries to measure the price of N. They find a strong association between the price of a haircut and the GDP, and estimate ϕ in (7.6) as being equal to -0.256 , with standard error 0.061 . Accordingly, the income elasticity of the relative price of T is about -0.26 . Furthermore, their analysis of the relationship between the relative price and per capita GDP within nine selected countries through time shows that the income elasticity of P_T / P_N are all negative and significant. Their finding that N become relatively more expensive with increasing income supports the above argument.

We rewrite (7.6) for the foreign economy as

$$\log \left(\frac{P_T^*}{P_N^*} \right) = \lambda^* + \phi^* \log \text{GDP}^* \quad (7.7)$$

and express (7.5) in logarithmic form:

$$\log S = \alpha \log \left(\frac{P_T}{P_N} \right) - \alpha^* \log \left(\frac{P_T^*}{P_N^*} \right) + \log \left(\frac{P}{P^*} \right) \quad (7.8)$$

If we substitute (7.6) and (7.7) for $\log (P_T / P_N)$ and $\log (P_T^* / P_N^*)$, respectively, in equation (7.8), we then obtain

$$\log S = \gamma + \beta \log \text{GDP} - \beta^* \log \text{GDP}^* + \log \left(\frac{P}{P^*} \right) \quad (7.9)$$

where $\gamma = \alpha\lambda - \alpha^*\lambda^*$, $\beta = \alpha\phi$ and $\beta^* = \alpha^*\phi^*$. Assuming for expository purposes that $\alpha = \alpha^*$ and $\phi = \phi^*$, β would then be equal to β^* , so that (7.9) becomes

$$\log S = \gamma + \beta \log \left(\frac{GDP}{GDP^*} \right) + \log \left(\frac{P}{P^*} \right) \quad (7.10)$$

As in Section 3, we define the over/under-valuation of the currency as:

$$r \equiv \log \frac{P}{P^*} - \log S,$$

so that $r > 0$ (< 0) implies that the currency is over (under)-valued. (The negative of r is the conventional definition of the real exchange rate.) We can thus take the term $\log (P/P^*)$ to the left-hand side of equation (7.10) and to rewrite it as:

$$r = \gamma' + \beta' \log \left(\frac{GDP}{GDP^*} \right), \quad (7.11)$$

where $\gamma' = -\gamma$ and $\beta' = -\beta$. As the coefficient $\beta = \alpha\phi$, with $0 < \alpha < 1$ and $\phi < 0$, we expect $\beta < 0$ and $\beta' > 0$. Consequently, as the country becomes poorer, the ratio GDP/GDP^* falls towards zero and $\log (GDP/GDP^*)$ becomes more negative; the term $\beta' \log (GDP/GDP^*)$ also becomes more negative, so that r falls and the currency of the country becomes more undervalued.

To estimate (7.11), we use the data on r given in Table 3.1 and derive the relative GDP data (with the US as the base) from the raw GDP figures in Table 7.1; we omit those observations for which GDP is missing. The estimates of equation (7.11) are given in Table 7.2.

Table 7.1
Real Gross Domestic Product per Capita
(In US Dollars)

Country	1986	1987	1988	1989	1990	1991	1992	Average
US	17,269	17,637	18,162	18,460	18,413	18,003	18,216	18,023
1. Argentina	-	-	-	-	-	-	5,399	5,399
2. Australia	9,278	-	12,867	14,876	13,926	13,853	13,355	13,026
3. Austria	-	-	-	-	-	-	-	-
4. Belgium	12,048	13,066	15,076	13,852	16,053	-	-	14,019
5. Brazil	1,871	-	-	-	-	-	4,127	2,999
6. Britain	9,855	19,494	13,891	13,269	13,096	14,230	14,091	13,989
7. Canada	13,973	-	17,129	18,099	18,050	17,384	16,432	16,845
8. Chile	-	-	-	-	-	-	-	-
9. China	-	-	-	-	-	-	-	-
10. Czechoslovakia	-	-	-	-	-	-	-	-
11. Denmark	-	17,901	20,380	17,741	20,374	20,195	20,523	19,519
12. France	13,401	14,365	16,557	14,973	16,974	16,772	17,145	15,741
13. Germany	15,212	16,264	18,672	16,509	18,967	19,550	-	17,529
14. Greece	-	-	-	-	-	-	-	-
15. Holland	12,571	13,311	15,132	13,325	15,308	15,374	15,832	14,408
16. Hong Kong	-	-	-	-	-	-	-	-
17. Hungary	-	-	-	-	-	2,379	2,657	2,518
18. Ireland	7,015	7,721	9,057	8,514	9,827	9,907	10,616	8,951
19. Italy	-	12,066	14,047	13,051	15,417	16,172	16,806	14,593
20. Japan	17,414	-	22,189	21,039	18,011	21,592	21,941	20,364
21. Malaysia	-	-	-	-	-	-	-	-
22. Mexico	-	-	-	-	-	-	-	-
23. Poland	-	-	-	-	-	-	-	-
24. Portugal	-	-	-	-	-	-	-	-
25. Russia	-	-	-	-	-	-	-	-
26. Singapore	6,761	-	8,568	9,410	10,376	11,392	12,579	9,848
27. South Korea	-	-	-	4,406	4,749	5,347	5,326	4,957
28. Spain	6,131	-	8,468	8,605	10,104	10,921	11,491	9,287
29. Sweden	16,012	-	20,363	19,695	21,703	22,134	21,787	20,282
30. Switzerland	-	-	-	-	-	-	-	-
31. Taiwan	-	-	-	-	-	-	-	-
32. Thailand	-	-	-	-	-	-	-	-
33. Venezuela	-	-	-	-	-	-	2,658	2,658
34. Yugoslavia	-	-	423	1151	-	-	-	787

Source: IMF International Financial Statistics Yearbook, 1993; International Financial Statistics, March 1994.

Table 7.2
Regression Results: Currency Valuation and GDP
Cross-Country / Time-Series, 1986 - 1992
(Standard errors in parentheses)

$$r_{ct} = \gamma' + \beta' \log \left(\frac{GDP_{ct}}{GDP_t^*} \right)$$

Intercept coefficient γ'	0.237	(0.033)
Coefficient of relative GDP β'	0.238	(0.042)
Adjusted R ²	0.241	
Standard error of estimate	0.274	

To interpret these estimates, suppose that the GDP per capita of country c is US\$1,000, and that of the foreign economy (in this case the US) is US\$18,000, so that:

$$\frac{GDP}{GDP^*} = \frac{1}{18} = 0.056, \quad \log \left(\frac{GDP}{GDP^*} \right) = -2.890.$$

Thus country c is approximately 95 percent less affluent than the US. We use the Table 7.2 estimates of $\hat{\gamma}' = 0.237$ and $\hat{\beta}' = 0.238$ to calculate the estimated value of currency c :

$$\begin{aligned} \hat{r}_c &= 0.237 + 0.238 \cdot (-2.890) \\ &= -0.451, \end{aligned}$$

that is, the currency of country c is undervalued by approximately 45 percent.

Recall that one of the basic (or structural) parameters of this model is α , the share of non-tradeables in total costs. As the coefficient $\beta' = -\alpha\phi$, we can obtain an estimate of α given estimates of β' and ϕ , the income elasticity of the relative price of tradeables. We use Clements and Semudram's (1983) estimate $\hat{\phi} = -0.256$ to derive α :

$$\hat{\alpha} \equiv \frac{-\hat{\beta}'}{\hat{\phi}} = \frac{-0.238}{-0.256} = 0.930.$$

Thus, the non-traded component in the cost of a Big Mac accounts for approximately 93 percent. This figure appears reasonable given the prominence of wages, rent, other overheads, etc., in the cost of a Big Mac.

8. IMPROVING THE BIG MAC INDEX: THE NO-FRILLS INDEX

As previously discussed, PPP theory needs to be extended to take account of non-traded goods. Our calculations in the previous section indicate that, on average, non-tradeables account for approximately 93 percent of the hamburger prices. Since these goods play only a very small part in determining exchange rates, they should be excluded in a more sophisticated PPP calculation. We pursue this idea in this section by introducing the the No-Frills Index (NFI) in which the non-tradeables are excluded from the Big Mac Index (BMI).

Equation (7.4) is the PPP condition applied to traded goods. We write this in logarithmic form:

$$\begin{aligned}
\log S &= \log P_T - \log P_T^* \\
&= f(\log P, \log GDP) - f^*(\log P^*, \log GDP^*) \\
&= g\left(\log \frac{P}{P^*}, \log \frac{GDP}{GDP^*}\right). \quad (8.1)
\end{aligned}$$

In the above, the second line reflects equations (7.1) and (7.6) and their foreign-country counterparts. The third line invokes (i) a homogeneity assumption that prices at home *relative* to those abroad affect the exchange rate; and (ii) an assumption that the relevant parameter values are identical in the two countries ($\alpha = \alpha^*$ and $\phi = \phi^*$, in the notation of Section 7).

Once we have an estimate of the parameters of the function $g(\cdot, \cdot)$ in (8.1), we can estimate the NFI:

$$\log \hat{S} = \hat{g}\left(\log \frac{P}{P^*}, \log \frac{GDP}{GDP^*}\right).$$

It can be shown that this index can be computed as:

$$\log \hat{S} \equiv \log S - \hat{\varepsilon},$$

where S is the actual exchange rate and $\hat{\varepsilon}$ is the residual from the productivity bias equation (7.11). Another way of visualising the NFI is that it incorporates the systematic relation between departures from parity according to the BMI and GDP; this relationship is the productivity bias equation (7.11).

Table 8.1 presents the NFI. We see from column 6 of the table that the NFI is not significantly different from the actual exchange rate, as expected. This is in contrast with the results in columns 5 and 7, which respectively show the actual

exchange rates and the NFI to be significantly different from the BMI at the 0.1 percent level.

The last entry of column 7 of Table 8.1 reveals that the mean of the excess of the BMI over its No-Frills counterpart is about 13 percent. In other words, the BMI undervalues currencies by 13 percent, on average. Consequently, if The Economist magazine wishes to make some rough adjustments to its BMI to allow for the productivity bias, a simple approach would be to add 13 percent to its estimates of currency values, especially for the poorest countries.

9. SUMMARY AND CONCLUSIONS

The Economist magazine is considered the most influential and prestigious financial newspaper in the world. In view of its well-known breezy style which has been described as "simplify and then exaggerate", one suspects that when the Editor first introduced the Big Mac Index in 1986, it was a somewhat tongue-in-cheek contribution to what is perhaps the most widely-researched and debated doctrine in international finance. Nine years later, the Big Mac Index is still going strong, and is now widely cited and used by academics and practitioners alike. Given the competitive nature of publishing, one would assume that the survival of the index is based on some intrinsic merit and usefulness of the measure in judging the long-term value of currencies.

Our test results demonstrate that the Big Mac Index is surprisingly accurate in tracking exchange rates over the longer term. The regression tests indicate that purchasing power parity holds with the Big Mac Index over a nine-year horizon, which is consistent with previous findings (see Frenkel, 1981, Manzur, 1990, Officer, 1976). However, that is not to say that the currencies of all individual

countries for all years are at parity. Geographic influences appear to play a part in those instances where deviations from parity occur. For example, the currencies of developing Asian and East European countries are consistently undervalued, while the currencies of the industrialised economies are overvalued on average.

The versatility of the Big Mac Index notwithstanding, we were still able to further improve on it by taking into account the existence of productivity bias between countries. According to the productivity bias hypothesis, services are relatively cheaper in poorer countries, and because these goods have little, if any, role in determining exchange rates, standard PPP calculations which include services seem to imply that the currencies of these countries are systematically undervalued. In other words, these deviations from parity are related to GDP. We confirmed the existence of productivity bias in the Big Mac Index, and subsequently introduced the No-Frills Index to solve this problem.

The new index excludes the non-traded component of Big Mac hamburgers in computing parity. Interestingly, we estimated that this component accounts for as much as 93 percent of the cost of a Big Mac. Our new results indicate that the No-Frills Index performs even better than the Big Mac in tracking exchange rates over the long term, and could be of use to practitioners and policy-makers.

Other issues investigated in the thesis (which are not discussed in this paper) include:

- tests of relative parity;
- examination of the future predictive ability of the Big Mac Index; and
- explorations on the effects of qualitative factors, such as political affiliation, quality of life and cost of living, in exchange-rate valuations.

Table 8.1
Actual Exchange Rates, the Big Mac and No-Frills Indices

Country	Logarithmic			Logarithmic differences x 100		
	Actual exchange rate	Big Mac Index	No-Frills Index	Actual ER - BMI	Actual ER - NFI	BMI - NFI
(1)	(2)	(3)	(4)	(5) = (2) - (3)	(6) = (2) - (4)	(7) = (3) - (4)
1986						
Australia	0.49	0.09	0.00	40.85	49.76	8.91
Belgium	3.74	4.03	3.87	-28.77	-13.63	15.13
Brazil	2.62	2.05	2.35	57.05	27.82	-29.23
Britain	-0.40	-0.37	-0.47	-2.94	7.41	10.35
Canada	0.33	0.17	-0.02	16.38	35.05	18.67
France	1.89	2.33	2.16	-43.75	-26.08	17.67
Germany	0.70	0.98	0.77	-27.52	-6.83	20.69
Holland	0.82	1.00	0.84	-17.65	-1.50	16.15
Ireland	-0.30	-0.30	-0.32	0.00	2.25	2.25
Japan	5.04	5.44	5.20	-40.55	-16.63	23.91
Singapore	0.77	0.56	0.55	20.59	21.96	1.37
Spain	4.89	5.09	5.10	-20.34	-21.30	-0.96
Sweden	1.93	2.33	2.11	-40.50	-18.59	21.91
1987						
Belgium	3.67	4.03	3.86	-36.29	-19.73	16.57
Britain	-0.39	-0.34	-0.60	-4.32	21.78	26.10
Denmark	1.97	2.60	2.36	-62.55	-38.49	24.07
France	1.84	2.39	2.20	-54.64	-35.81	18.82
Germany	0.64	0.94	0.72	-30.34	-8.56	21.78
Holland	0.76	1.03	0.86	-27.71	-10.70	17.01
Ireland	-0.36	-0.30	-0.34	-5.49	-1.46	4.03
Italy	7.20	7.63	7.48	-43.01	-28.35	14.67
1988						
Australia	0.31	-0.20	-0.35	50.59	66.09	15.50
Belgium	3.55	3.63	3.44	-7.90	11.38	19.28
Britain	-0.62	-0.69	-0.87	7.70	25.02	17.33
Canada	0.22	-0.15	-0.37	36.59	58.91	22.32
Denmark	1.85	2.25	1.99	-40.34	-13.88	26.46
France	1.73	1.98	1.76	-25.15	-3.64	21.51
Germany	0.51	0.54	0.30	-3.55	20.82	24.37
Holland	0.62	0.71	0.51	-8.75	10.62	19.36
Ireland	-0.48	-0.67	-0.74	19.53	26.67	7.13
Italy	7.11	7.23	7.05	-11.59	6.00	17.59
Japan	4.82	5.04	4.76	-22.31	6.17	28.48
Singapore	0.69	0.16	0.10	53.61	59.43	5.81
Spain	4.71	4.78	4.72	-6.96	-1.43	5.53
Sweden	1.77	2.05	1.78	-27.31	-0.88	26.44
Yugoslavia	7.24	6.87	7.53	37.52	-28.34	-65.86
1989						
Australia	0.22	0.04	-0.15	17.59	36.16	18.57
Belgium	3.68	3.81	3.64	-13.04	3.83	16.87
Britain	-0.53	-0.48	-0.64	-4.96	10.89	15.85
Canada	0.17	0.06	-0.17	11.57	34.81	23.24
Denmark	1.99	2.51	2.28	-51.76	-29.00	22.77
France	1.85	2.17	1.98	-31.86	-13.14	18.72
Germany	0.64	0.76	0.55	-11.95	9.10	21.05
Holland	0.76	0.92	0.76	-16.81	-0.87	15.95
Ireland	-0.34	-0.45	-0.50	10.38	15.65	5.27
Italy	7.23	7.40	7.24	-16.75	-1.30	15.45
Japan	4.89	5.21	4.94	-31.91	-5.09	26.83
Singapore	0.67	0.33	0.25	34.36	42.02	7.66
South Korea	6.50	7.08	7.18	-57.87	-68.30	-10.42
Spain	4.76	4.93	4.88	-17.23	-11.70	5.53
Sweden	1.86	2.34	2.09	-48.39	-23.14	25.26
Yugoslavia	9.11	8.15	8.57	95.46	53.06	-42.40

Table 8.1 (cont'd)
Actual Exchange Rates, the Big Mac and No-Frills Indices

Country	Logarithmic			Logarithmic differences x 100		
	Actual exchange rate	Big Mac Index	No-Frills Index	Actual ER - BMI	Actual ER - NFI	BMI - NFI
(1)	(2)	(3)	(4)	(5) = (2) - (3)	(6) = (2) - (4)	(7) = (3) - (4)
1990						
Australia	0.28	0.05	-0.12	22.88	39.94	17.06
Belgium	3.55	3.78	3.58	-23.89	-3.45	20.44
Britain	-0.49	-0.45	-0.60	-4.80	10.79	15.59
Canada	0.15	0.00	-0.23	14.84	38.08	23.24
Denmark	1.85	2.45	2.19	-59.63	-33.50	26.12
France	1.73	2.09	1.87	-35.76	-13.98	21.77
Germany	0.52	0.67	0.42	-14.90	9.52	24.42
Holland	0.63	0.87	0.68	-24.00	-4.69	19.31
Ireland	-0.46	-0.53	-0.62	6.56	15.31	8.75
Italy	7.11	7.48	7.29	-36.57	-17.08	19.48
Japan	5.07	5.12	4.89	-5.51	17.68	23.19
Singapore	0.63	0.17	0.07	46.58	56.62	10.05
South Korea	6.56	6.86	6.95	-30.07	-38.64	-8.57
Spain	4.66	4.90	4.80	-23.44	-14.03	9.41
Sweden	1.81	2.39	2.11	-58.05	-30.42	27.63
1991						
Australia	0.24	0.09	-0.09	15.28	32.75	17.47
Britain	-0.58	-0.30	-0.48	-27.87	-9.76	18.11
Canada	0.14	0.04	-0.19	10.05	32.93	22.88
Denmark	1.86	2.48	2.21	-61.63	-35.18	26.45
France	1.73	2.08	1.86	-34.78	-12.75	22.02
Germany	0.51	0.65	0.39	-13.43	12.25	25.68
Holland	0.63	0.85	0.65	-21.46	-1.51	19.95
Hungary	4.32	3.93	4.18	38.51	14.00	-24.51
Ireland	-0.48	-0.48	-0.57	0.00	9.48	9.48
Italy	7.12	7.38	7.17	-25.57	-4.41	21.16
Japan	4.91	5.13	4.85	-22.46	5.58	28.04
Singapore	0.57	0.22	0.09	35.59	48.40	12.81
South Korea	6.58	6.84	6.89	-25.78	-30.99	-5.21
Spain	4.63	5.04	4.93	-40.87	-29.07	11.80
Sweden	1.80	2.45	2.16	-64.91	-36.28	28.63
1992						
Argentina	-0.01	0.41	0.46	-42.22	-47.48	-5.26
Australia	0.27	0.15	-0.01	12.16	28.48	16.32
Brazil	7.67	7.46	7.58	21.59	9.93	-11.66
Britain	-0.56	-0.24	-0.41	-32.64	-15.04	17.60
Canada	0.17	0.23	0.02	-5.72	15.54	21.26
Denmark	1.84	2.52	2.26	-67.72	-41.17	26.55
France	1.71	2.11	1.89	-39.76	-17.49	22.27
Holland	0.61	0.89	0.69	-28.22	-7.85	20.37
Hungary	4.38	4.11	4.33	27.18	5.04	-22.15
Ireland	-0.49	-0.42	-0.52	-7.88	2.97	10.85
Italy	7.12	7.53	7.32	-41.76	-19.96	21.79
Japan	4.89	5.16	4.88	-26.87	1.28	28.15
Singapore	0.50	0.77	0.63	-27.40	-12.50	14.89
South Korea	6.66	6.96	7.01	-29.98	-35.57	-5.59
Spain	4.62	4.97	4.84	-34.48	-21.75	12.74
Sweden	1.78	2.45	2.17	-67.44	-39.46	27.98
Venezuela	4.10	4.35	4.57	-24.72	-46.86	-22.14
Mean				-13.27	0.00	13.27
Standard error of mean				3.16	2.74	1.57
t-statistic				-4.20	0.00	8.43

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