THE LONG-TERM BEHAVIOUR OF EXCHANGE RATES, PART III: THE EXPLOSION OF PURCHASING POWER PARITY

by

Yihui Lan

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DISCUSSION PAPER 03.07
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CHAPTER 3

THE EXPLOSION OF PURCHASING POWER PARITY

3.1. Introduction

The theory of purchasing power parity (PPP) is one of the fundamental principles in international finance. It states that prices across countries should be equal when converted to a common currency (absolute PPP), or less strictly, the change in the exchange rate should be equal to the difference between the changes in the domestic and foreign price indices (relative PPP). It is widely agreed that Gustav Cassel (20 October 1866 - 15 January 1945) is the father of the PPP doctrine, although this line of intellectual thought actually originated with Spanish scholars in the 16th century. Rigorous empirical examination of the theory did not appear until the 1960s, when evidence was found supporting PPP over long periods of time (see, for example, Friedman and Schwartz, 1963, and Gaillot 1970). The productivity-bias hypothesis proposed by Balassa (1964) and Samuelson (1964) obtained considerable empirical support, and continues to be highly influential. During the past three decades, there have been heated debates about the validity of PPP and professional confidence in the theory has experienced considerable ups and downs.

With the move to flexible exchange rates in the early 1970s, it was generally assumed that the exchange rate would quickly adjust to changes in relative price levels. However, the high volatility of exchange rates, in both nominal and real terms, rendered PPP theory almost untenable. Dornbusch (1976) proposed an overshooting model, temporarily mitigating some unease in the literature. He argued that stickiness of goods prices and continuously-clearing asset markets are the main reasons for deviations from PPP. Before the mid-1980s empirical tests were concerned with simple specifications of PPP that centred on coefficient restrictions, using the methods of ordinary and generalised least-squares. These tests tended to strongly reject PPP except
for hyperinflation countries. This line of research reached its high-water mark in the early 1980s with a paper published by Frenkel (1981) entitled “The Collapse of Purchasing Power Parities during the 1970s”. It is now widely agreed that such straightforward tests for PPP, which Froot and Rogoff (1995) termed the “Stage-One tests”, took no account of non-stationarity in exchange rates and relative prices, and thus produced possibly spurious results.

In the second half of the 1980s, with the advancement of time-series techniques, many PPP studies concentrated on testing the efficient-markets version of PPP (that is, the hypothesis of the random walk behaviour in real exchange rates), but could not reject the null of a random walk (see, e.g., Adler and Lehmann, 1983, Meese and Rogoff, 1988, and Mark, 1990). There was also a sizeable amount of work which failed to find cointegration between nominal exchange rates and relative prices (see, e.g., Corbae and Ouliaris, 1988, Enders, 1988, and Patel, 1990). The failure of PPP to pass empirical scrutiny further sapped confidence in the practical usefulness of the theory.

The late-1980s saw a rebirth of interest in PPP, mainly due to the advent of unit-root econometrics. As conventional unit-root tests have low power, researchers have circumvented the problem by using (i) longer periods of data; and (ii) cross-country-time-series analysis, known as ‘panel data’ techniques. Research from long-horizon data generally finds increasing evidence of convergence to PPP. Well-known examples of long-horizon studies include Frankel (1986), Edison (1987), Diebold et al. (1991) and Lothian and Taylor (1996). However, there still remains scepticism about inferences of real exchange rate behaviour based on data across exchange rate regimes (Frankel and Rose, 1996, and Lothian, 1998), or over long historical periods of peace and war (Johnson, 1993, and Grilli and Kaminsky, 1991). As data are available over long time spans only for industrial countries, the favourable results may be exaggerated by the problem of survivorship bias raised by Froot and Rogoff (1995). The large size bias of tests for PPP based on long-horizon data has been confirmed in several studies (see, for example, Engel and Kim, 1999, and Engel, 2000). By the late-1990s, there has been only
a few additional investigations of PPP using long time-series data (for example, Guimarães-Filho, 1999, Kuo and Mikkola, 1999, and Parkes and Savvides, 1999). It seems that this remedy for the problem of low test power has gradually lost favour.

The use of panel data has become increasingly popular among researchers to examine the behaviour of real exchange rates over relatively-short periods of time, such as during the post-Bretton Woods era. Hakkio (1984) and Abuaf and Jorion (1990) were early papers that applied panel data methods to tests for PPP. Evidence in favour of long-run PPP using cross-sectional datasets from industrial countries is reported in Wei and Parsley (1995), Frankel and Rose (1996), Oh (1996), Wu (1996), Papell (1997), Papell and Theodoridis (1998), and Higgins and Zakrajšek (1999). On the other hand, mixed results have been found for parity reversion for a limited number of panel analyses from developing countries. Phylaktis and Kassimatis (1994) support the validity of long-run PPP for eight Pacific Basin countries over the period of 1974 to 1987, while Wu and Chen (1999) find no evidence of PPP using data from the same eight Asia Pacific countries for the period of 1980 to 1996. Through unit-root tests from heterogeneous panels and variance ratio tests, Luintel (2000) finds support for PPP using data for eight Asian developing countries. There are a number of other methodologies used to test for PPP during the last decade, including the still-popular cointegration techniques, variance ratio tests, structural-break tests, non-linear approaches to mean reversion and so on.

The revival of interest in PPP has been documented in a number of comprehensive and influential surveys -- see Breuer (1994), Froot and Rogoff (1995), MacDonald (1995) and Rogoff (1996). Chapter 2 focused on aspects of exchange-rate economics that revolve around PPP. In particular, it examined the interplay of monetary and non-monetary (or real) factors in influencing exchange rates in the short and the long run. This chapter aims to provide an up-to-date survey of the contemporary literature on PPP. It covers the literature that has appeared up until July 2000, with the major focus on the research from the last decade. The next section examines the research into and interest in PPP, while Section 3.3 gives a brief review of the geometric framework of PPP.
theory. Section 3.4 is devoted to issues related to deviations from parity, including two measures of PPP deviations. In Section 3.5 we summarise recent empirical evidence on PPP and the last section offers some concluding remarks. Material from this chapter has been published as Lan (2002); and related material can be found in Ong and Lan (2002).

3.2. How Much is Being Written on PPP?

The amount of research into PPP has exploded during the past three decades. The Big Mac Index (BMI), invented by The Economist magazine in 1986, has played a major role in popularising PPP and bringing its practical implications to the attention of financial markets. As a way of measuring the extent of professional interest in PPP, this section reports results of searching for (i) PPP in Econlit, a widely-used economic indexing database produced by the American Economic Association;¹ and (ii) the Big Mac Index in Google, a popular search engine on the world wide web.

To quantify the growth in the literature on PPP, we conducted a keyword search for the term “purchasing power parity” or “PPP” in EconLit. As we need to compare the amount published on PPP with something, we also searched for four additional broad economic terms -- inflation, unemployment, interest rate and exchange rate -- and another relatively narrow term, foreign direct investment (FDI).² We recorded the number of research articles on each topic in the 1970s, 1980s, 1990s and from January to July 2000.

Figure 3.1 plots, on the left-hand axis, the number of articles in each decade for the six topics. 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

¹ The source material of Econlit includes international economic journals, essays, research papers, books, dissertations, book reviews, and working papers. Years of coverage are from 1969 to the present with approximately 26,000 records added annually. Our search is done through the licensed Econlit website at The University of Western Australia.

² Foreign direct investment is chosen as a keyword due to its extraordinary growth over the past few decades.
seen that PPP has grown at an average annual rate of 18 percent p.a., second only to FDI. This growth rate clearly reflects that the research interest in PPP has been expanded very substantially over the last thirty years. Thus, rather than “collapsing”, PPP research can be described as “exploding”.

Since the introduction of the Big Mac Index (BMI) by The Economist in 1986, financial markets have become interested in PPP as a practical approach to valuing currencies and to making international price comparisons. Economic research on this index has evolved into an important strand of literature called “Burgernomics”.3 As a

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3 In the Burgernomics literature, Cumby (1996) is the first paper which uses the BMI to tests for PPP. Pakko and Pollard (1996) and Click (1996) examine the nature of deviations from PPP, while Annaert and Ceuster (1997) investigate the value of BMI from an investment perspective. Ong (1997) improves upon BMI and proposes the “No-Frills Index” to value currencies. Applications of Burgernomics include Ong (1998a) who analyses the Asian currency crisis, Ong (1998b) and Ong and Mitchell (2000) which examine the purchasing power of earnings around the world and real academic salaries.
way to measure the extent of such interest, we searched for the exact phase “Big Mac 
Index” in a web search engine -- Google.\textsuperscript{4} This resulted in 697 entries.\textsuperscript{5} We categorised 
these BMI web sites according to the language they use and their institutional domains 
and the results are presented in Table 3.1. The left panel shows that around 70 percent of 
the search results are written in the 17 frequently-used languages and the remaining 30 
percent are in the language not specifically identified by Google. English web sites are 
the most frequent, followed by European languages. Developing countries are also aware 
of this widely-quoted invention from The Economist. From the right panel of Table 3.1, 
it can be seen that BMI is used in all sectors. Only 20 percent of the BMI pages are 
related to educational activities (as represented by the ‘.edu’ domain), with the majority 
of web pages dedicated to the BMI created by non-educational parties. This suggests the 
widespread practical usefulness of the BMI, presumably because of the simple and timely 
nature of the metric.

\begin{table}[h]
\centering
\begin{tabular}{l|c|c}
\hline
Language of web page & Number & Institutional domain & Number \\
\hline
English & 405 & .com & 271 \\
Danish, French, German, Japanese, Swedish & 66 & .edu & 131 \\
Chinese, Dutch, Italian, Korea, Norwegian, Russian, Spanish & 27 & .org & 45 \\
Czech, Finnish, Hungarian, Portuguese & 7 & .net & 38 \\
Other & 192 & Other & 212 \\
Total & 697 & Total & 697 \\
\hline
\end{tabular}
\caption{Search Results of the Big Mac Index}
\end{table}


\textsuperscript{4} The address of the Google search engine is http://www.google.com.
\textsuperscript{5} Note that (1) to narrow down the search, we use an additional constraint “not computer”; (2) all the search 
results in Google refer to the returned entries excluding pages similar to those displayed; and (3) another 18 
entries from Google contain only the word “Burgernomics”, but not the phrase “Big Mac Index”.

102
3.3. The Geometry of PPP: A Brief Review

This section presents a brief review of the geometric framework of PPP theory by recapitulating the two perspectives on traditional PPP we examined in Chapter 2: (1) The exchange-rate/relative-price relationship; and (2) the relationship among exchange rates, money and prices.

Recall from Section 2.2 that there are three versions of PPP: absolute PPP, relative PPP and stochastic deviations from relative PPP. These are illustrated in Figure 3.2, where \( s \) is the logarithmic nominal exchange rate and \( r \) is the logarithmic ratio of home to foreign prices, i.e., \( s = \log s \) and \( r = \log (P/p^*) = p - p^* \). (This figure reproduces Figure 2.1 with less detail.) Panel A presents the absolute version of PPP:

(3.1) \( s = p - p^* \),

i.e., \( s = r \), which passes through the origin. A change in the relative price leads to a proportional change in the nominal exchange rate. Thus here the real exchange rate \( q = p - s - p^* = 0 \), and is constant. Relative PPP allows for a constant gap in absolute PPP and is shown in Panel B. In non-log form, relative PPP is \( S = P/KP^* \), where \( K \) is a constant. Thus geometrically, the relationship between \( s \) and \( r \) is a straight line of the form \( s = r - k \), which has a unit slope and intercept \( -k \), where \( k \equiv \log K \). It is to be noted that here the changes in the exchange rate and in the relative price are still proportional. The real exchange rate in this case, \( q = k \), is also constant. Panel C gives the case of stochastic deviations from relative PPP. If we denote the stochastic deviation by \( e \) with \( \mathbb{E}(e) = 0 \), the real exchange rate is then

(3.2) \( q = k - e \),
FIGURE 3.2
THREE VERSIONS OF PPP

A. Absolute PPP

B. Relative PPP

C. Stochastic deviations from relative PPP
which is not a constant. Suppose that the shock $e$ varies continuously within the range $[e_1, e_2]$ and the relative price changes within $[r_1, r_2]$. Then the exchange-rate/relative-price point lies somewhere in the shaded parallelogram. It can be seen that in the short run $s = r - k + e$ and due to the random shocks $e$, the exchange rate and prices are not proportionate. However in the long run, as $E(e) = 0$ and thus $s = r - k$, relative PPP holds and the real exchange rate $q = k$ is again constant. Here $k$ is the long-run, or equilibrium value of the real exchange rate.

Next, we provide a brief review of the analytical framework employed in Chapter 2 pertaining to the relationship among the exchange rate, money and relative prices. The right-hand side of Panel A of Figure 3.3 contains two curves, (i) the absolute price schedule, $AA$, along which the overall price level is held constant; and (ii) the relative price schedule $OR$, along which the price of traded in terms of nontraded goods, $P_T/P_N$, is held constant at $\alpha_0$. For monetary equilibrium, the economy must lie on $AA$, while the real economy equilibrates along $OR$; these two curves intersect at the point $E_0$, which represents the initial overall equilibrium. We apply PPP to traded goods, so that $S = P_T/P_T^*$, and the left-hand side of Panel A shows that given the prices of traded goods at home and abroad, $P_{T0}$ and $P_{T0}^*$, the exchange rate is the slope of the ray from the origin to the point $(P_{T0}, P_{T0}^*)$, that is $S_0$.

Panel B of Figure 3.3 illustrates the effects of a monetary expansion. This raises the price level, shifts the absolute price schedule up and to the right to $AA'$ and the overall equilibrium moves from the point $E_0$ to $E_1$. Subsequently, the domestic price of traded goods rises to $P_{T1}$ and the exchange rate depreciates to $S_1 > S_0$. Section 2.4 showed that in this case the real exchange rate remains unchanged.

Finally, Panel C of Figure 3.3 shows the effect of a real disturbance, which increases the relative price of traded goods to $\alpha_1 > \alpha_0$. This leads to a depreciation of
FIGURE 3.3
THE EXCHANGE RATE, MONEY AND RELATIVE PRICES

A. The initial equilibrium

B. A monetary expansion

C. Changing relative prices
the nominal exchange rate to \( S_2 > S_0 \). The figure in Panel C is associated with the “productivity-bias hypothesis” we examined in Sections 2.5 and 2.6, according to which the currencies of poor countries tend to be undervalued, whereas those of rich countries are overvalued. This is due to the fact that the prices of traded goods are relatively more expensive in poor countries than in rich countries. Section 2.5 showed that productivity enhancement in the traded goods sector leads to the appreciation of the real exchange rate, which is equi-proportional to the appreciation of the nominal rate.

As noted in Chapter 2, there are many other factors that may influence the real exchange rate. However, PPP postulates that the equilibrium value of the real exchange rate is a constant; see Section 6.1 for justifications. The next section examines temporary deviations of the real exchange rate from its constant equilibrium value.

3.4. Deviations from Parity and the Speed of Adjustment

As Rogoff (1996) points out, every reasonable theoretical exchange-rate model suggests that there should be at least some temporary component to PPP deviations. This section first explores the notion of deviations from PPP from both the traditional and the efficient-markets perspectives of PPP. Then we discuss the concept of the half-life as a measure of the speed of adjustment to long-run PPP. Finally, a summary of estimates of the half-life of PPP deviations from a variety of studies is presented.

Recall from equation (3.2) that the real exchange rate (with a time subscript added to the error term) is \( k - e_t \). The nature of the error term \( e_t \) determines the validity of PPP. Following Maeso-Fernández (1998), we write \( e_t \) as a moving average of a white-noise process, \( \{e_t\} : e_t = a(L)\varepsilon_t \), where \( a(L) \) is a polynomial in the lag operator \( L \) and \( a(L) = \sum_{l=0}^{\infty} a_l L^l \). There are three possibilities for the PPP deviations \( e_t \):
(i) If the polynomial \( a(L) \) is of zero degree (i.e., \( N = 0 \), so that \( a(L) = a_0 \)), PPP deviations \( e_t \) are serially-uncorrelated white noise. In such a case, shocks to PPP only have a transitory effect.

(ii) If \( a(L) \) is of greater-than-zero degree \( (N > 0) \) and its roots are outside the unit circle, a real shock has permanent effects on the current level of the real exchange rate, but the effects gradually die out. In this case, PPP deviations are persistent, but relative PPP holds in the long run. The real exchange rate thus displays mean reversion.

(iii) If \( a(L) \) has greater-than-zero degree and its roots are inside the unit circle, all previous real shocks have permanent effects on the current exchange rate level. In this case, \( e_t \) is a nonstationary process, implying that relative PPP does not hold in the long run.

The above analysis examines the traditional view of PPP, i.e., PPP as a relationship between the exchange rate and relative prices. Next, we examine deviations from PPP from the perspective of the efficient-markets view of PPP and review two alternative measures of the speed of adjustment. The traditional and the efficient-markets views are closely related to each other and test for PPP from different angles, although they seem to be contradictory with opposite economic implications.\(^6\)

The efficient-markets view, initiated by Magee (1978), Roll (1979) and Darby (1980), examines the stochastic behaviour of real exchange rates. It states that if expectations are rational, changes in the real exchange rate should be serially uncorrelated. Thus the real exchange rate should follow a random walk process. One of the implications of this random walk hypothesis is that changes in the real exchange rate cannot be predicted using past information. The base-line test for the efficient-markets view of PPP is equivalent to testing for a unit root in the real exchange rate against the stationarity alternative. Consider the following simple data-generating process:

\[
H_0 : q_t = \alpha + \beta q_{t-1} + u_t, \quad \beta = 1, \\
H_1 : q_t = \alpha + \beta q_{t-1} + u_t, \quad 0 < \beta < 1, 
\]

\(^6\) See, e.g., MacDonald and Marsh (1999) and Maeso-Fernández (1998), for discussions of the two views of PPP.
where \( q_t \) is the real exchange rate defined as \( q_t = p_t - s_t - p_t^* \); \( \alpha \) and \( \beta \) are the intercept and the speed-of-adjustment parameters respectively, and \( u_t \) is a disturbance term.\(^7\) Equation (3.2) shows that \( q_t = k - e_t \), so that the real exchange rate represents deviations from PPP. The stationarity of the real exchange rate implies that deviations from PPP are transitory and eventually die out.

Consider again the above data-generating process,

\[
q_t = \alpha + \beta q_{t-1} + u_t,
\]

(4.1)

averaging over \( t = 2, ..., T \), we have

\[
\overline{q}_t = \alpha + \beta \overline{q}_{t-1} + \overline{u}_t,
\]

(4.2)

where the bars denote means. For a process lasting for a sufficiently long period of time, \( \overline{q}_t = \overline{q}_{t-1} = \overline{q} \). Subtracting equation (4.2) from equation (4.1) and ignoring the disturbance terms (which represent the deviations from the deterministic relationship), we obtain through successive substitution

\[
d_t = d_0 \beta^t,
\]

(4.3)

where \( d_t = q_t - \overline{q} \) is the value of the current deviation and \( d_0 \) is the value of the initial deviation. Under stationarity, the speed-of-adjustment parameter \( \beta \) in equation (4.1) is less than one, thus \( \beta^t \to 0 \) and the deviation in equation (4.3) \( d_t \to 0 \) when \( t \to \infty \). A value of \( \beta \) of .97, for example, means that 3 percent of the PPP deviation vanishes per period.

\(^7\) In testing for the efficient-markets view of PPP, in practice a more extended time-series model is typically used. The most common data-generating process used is the Augmented Dickey-Fuller framework:

\[
\Delta q_t = \alpha + \beta q_{t-1} + \sum_{i=1}^{\lambda} \lambda_i \Delta q_{t-i} + \eta_t,
\]

where the lagged real exchange rate changes are added to control for serial correlation. Under the null, \( \alpha = \rho = 0 \). Under the alternative, \( \rho < 0 \).
More generally, let the real exchange rate be generated by a more complex process:

\[(4.4)\quad q_t = \alpha + \sum_{j=1}^{m} \beta_j q_{t-j} + u_t.\]

When the lag length \(m\) is much smaller than the sample size, we have in equilibrium 
\(E(q_t) = E(q_{t-j})\) for \(j = 1, ..., m\), so that the speed of adjustment is the sum of the coefficients of all the lags, i.e., \(\sum_{j=1}^{m} \beta_j\). Accordingly, stationarity of \(\{q_t\}\) requires \(0 < \sum_{j=1}^{m} \beta_j < 1\).

An alternative measure of the speed of adjustment is the “half-life” of a process, a concept originally from physics. It measures the decay of a substance comprising of a large number of identical particles. The half-life is the time taken by a given amount of substance to decay to half its mass. Figure 3.4 plots the remaining amount of particles as a function of time. Here, \(H\) is the half-life of the process. After a second half-life, one half of the remaining particles will have decayed, leaving 1/4 of the original amount. After three half-life intervals, 1/8 of the original amount remains and so on. Thus the decay process can be expressed as:

\[(4.5)\quad d_t = d_0 e^{-\frac{t}{H}},\]

\[\text{FIGURE 3.4}\]
\[\text{THE TIME PATH OF A MEAN REVERSION PROCESS}\]
where $T$ is the time required for the total amount to decay, usually called the “life-time”. According to the definition of the half life, $e^{-H/T} = d_H / d_0 = 1/2$, so that

$$H = T \log 2.$$  

(4.6)

This relationship shows that the half-life is an alternative measure of the total time required for mean reversion, $T$. It indicates how long it takes for the impact of a unit shock to dissipate by half. Comparing expressions (4.3) and (4.5), we obtain the relationship between the life-time $T$ and the adjustment speed $\beta$: $T = -1 / (\log \beta)$. Substituting this into (4.6), we obtain:

$$H = - \log 2 / (\log \beta).$$  

(4.7)

Empirically, the half-life of PPP can be estimated not only from an autoregressive data-generating process of the real exchange rate, but also from variance ratios. The simplest variance ratio for a time series $\{ y_t \}$, proposed by Cochrane (1988), is $R(k) = \text{var}(y_{t+k} - y_t) / \text{var}(y_{t+1} - y_t)$, where $k = 2, \ldots$. This expression is the variance of the $k^{th}$ difference divided by that of the first difference. When the value of $k$ is sufficiently large, it can be shown that $R(k)$ is approximately the variance of the unit-root component of the real exchange rate. The time required for $R(k)$ to diminish to half of its size is an alternative estimator of the half-life of real exchange rate innovations.

Table 3.2 summarises estimates of half-lives from various studies in the PPP literature; these estimates are presented in descending order in Figure 3.5. It can be seen that most of the estimates lie between 3 and 5 years. The median and mean of half-lives are 4 and 4.1 years, respectively. These figures are in broad agreement with the length of the long run insofar as PPP is concerned that is reported in the survey paper by Froot and

---

8 If the data-generating process is in the form of equation (4.4) and $\beta_1$ is the first-order coefficient, the expression $H = - \log 2 / \log |\beta_1|$ is an approximate measure of the half-life. I would like to thank Associate Professor Jeff Sheen of the University of Sydney for clarification of this point.
<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Half life (Years)</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frankel (1990)</td>
<td>4.6</td>
<td>Dollar-pound</td>
</tr>
<tr>
<td>Abuaf and Jorion (1990)</td>
<td>3.3</td>
<td>Ten industrial countries</td>
</tr>
<tr>
<td>Manzur (1990, 1993)</td>
<td>5</td>
<td>Seven industrial countries</td>
</tr>
<tr>
<td>Fung and Lo (1992)</td>
<td>6.5</td>
<td>Six industrial countries</td>
</tr>
<tr>
<td>Wei and Parsley (1995)</td>
<td>a 4.25</td>
<td>EMS (European Monetary System)</td>
</tr>
<tr>
<td></td>
<td>b 4.75</td>
<td>Non-EMS</td>
</tr>
<tr>
<td>Frankel and Rose (1996)</td>
<td>4</td>
<td>150 countries</td>
</tr>
<tr>
<td>Cumby (1996)</td>
<td>1</td>
<td>Big Mac currencies</td>
</tr>
<tr>
<td>Lothian and Taylor (1996)</td>
<td>a 2.8</td>
<td>Franc-pound</td>
</tr>
<tr>
<td></td>
<td>b 5.9</td>
<td>Dollar-pound</td>
</tr>
<tr>
<td>Papell (1997)</td>
<td>a 1.9</td>
<td>EC (The European Community)</td>
</tr>
<tr>
<td></td>
<td>b 2.8</td>
<td>EMS</td>
</tr>
<tr>
<td>Higgins and Zakrajšek (1999)</td>
<td>a 5</td>
<td>Europe, CPI</td>
</tr>
<tr>
<td></td>
<td>b 3</td>
<td>Europe, WPI</td>
</tr>
<tr>
<td></td>
<td>c 2.5</td>
<td>OECD, WPI</td>
</tr>
<tr>
<td></td>
<td>d 11.5</td>
<td>Open economies, CPI</td>
</tr>
<tr>
<td>Cheung and Lai (2000)</td>
<td>a (2-5)</td>
<td>Industrial countries</td>
</tr>
<tr>
<td></td>
<td>b (under 3)</td>
<td>Developing countries</td>
</tr>
<tr>
<td>Median</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>4.1</td>
<td></td>
</tr>
<tr>
<td>Standard error of mean</td>
<td>2.3</td>
<td></td>
</tr>
</tbody>
</table>

Notes: 1. Where a study contains more than one estimate of half-life, we use a, b, c, etc. to distinguish different estimates, with additional information provided in the final column of the corresponding row.

2. Where a study does not report the half-life directly, we compute it from the speed-of-adjustment estimate (on an annual basis) using equation (4.7) for an AR(1) process. For higher-order systems, we use the approximate half-life set out in footnote 8 on the previous page.

3. In those cases where the underlying data are not annual and the parameter estimated is $\beta$, we compute the speed of adjustment per annum as $\beta^n$, where $n$ is the number of periods per year.

4. Cheung and Lai (2000) report the range of half-life estimates for two groups of countries. To compute the mean and its standard error in the last two rows of this table, we use 3.5 and 2 years as the respective point estimates.

Rogoff (1995) -- four to five years.\(^9\) This increasing consensus boosts professional confidence in the long-run PPP despite the fact that PPP deviations are quite persistent.

\(^9\) This consensus on the value of the half-life has been questioned by Taylor (2001), who shows that the estimates of PPP half-lives may be biased upwards due to temporal aggregation problems.
3.5. Recent Empirical Findings

This section gives an overview of the most recent empirical evidence regarding PPP that has emerged during the course of the theory’s resurrection over the 1990s. Table 3.3 gives a list of the most recent work on PPP.\(^\text{10}\) To review the empirical evidence using a variety of techniques, we classify these papers into three kinds of samples: (1) Industrial countries; (2) mixed samples of both developed and developing countries; and (3) purely developing countries.

\(^{10}\)Note that this review of the recent empirical evidence was completed in July 2000.
Panel A of Table 3.3 shows that recent evidence from industrial countries is generally supportive of long-run PPP, and interestingly, such favourable results are obtained through a diverse variety of econometric techniques. Bayoumi and MacDonald (1999), Chaudhuri and Sheen (2001), Flôres et al. (1999), Koedijk et al. (1998), and Papell and Theodoridis (1998) are some examples in favour of PPP using panel frameworks. Maeso-Fernández (1998) find evidence of mean reversion of real exchange rates using variance ratio tests. Edison et al. (1997) employ cointegration techniques. Michael et al. (1997) apply a non-linear approach to mean reversion. Parkes and Savvides (1999) use a sequential model to search for endogenous breaks and find that the real sterling rate reverts to a shifting mean. Sjaastad (1998) uses a commodity currency approach to model exchange rates and commodity prices.

Negative results for PPP from industrial countries are reported in Baum et al. (1999), Engel (2000), Li (1999) and O’Connell (1998). It is to be noted that most studies examine real exchange rates against the US dollar, and there are only a limited number of studies using the German mark as the base currency (e.g., Anker, 1999, Engel et al., 1997, Flôres et al., 1999, Koedijk et al., 1998, and Papell, 1997). The common finding is that PPP holds more strongly for the German mark than the US dollar exchange rates. Lothian (1998) argues that this is caused by the large depreciation of the dollar during the early and mid-1980s and the strong appreciation afterwards.

Mixed evidence is found in studies whose samples include both industrial and developing countries; see Panel B of Table 3.3. Wu and Chen (1999) fail to find evidence for PPP using two panel unit-root tests. Lee (1999) tests for PPP for 13 Asia Pacific countries using a generalised error correction model and finds support for PPP for a majority of countries. Favourable empirical results from mixed samples are reported in Higgins and Zakrajšek (1999) who include eight developing countries in their

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11 Some earlier examples using the German mark as the base currency are Edison and Fisher (1991), Fisher and Park (1991), and Mark (1990).
### TABLE 3.3
RECENT EMPIRICAL EVIDENCE ON PPP

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Nature of data</th>
<th>Countries in sample</th>
<th>Sample period</th>
<th>Price index used</th>
<th>Approach</th>
<th>Does PPP hold?</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Industrial countries</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anker (1999)</td>
<td>Panel</td>
<td>18 (14) industrial countries</td>
<td>1974-1997 (Q)</td>
<td>CPI (WPI)</td>
<td>Panel unit-root test (GLS)</td>
<td>Yes</td>
</tr>
<tr>
<td>Baum et al. (1999)</td>
<td>Time-series</td>
<td>17 countries, 12 countries</td>
<td>1973-95 (M)</td>
<td>CPI and WPI</td>
<td>Fractional cointegration and structural break tests</td>
<td>No</td>
</tr>
<tr>
<td>Chaudhuri and Sheen (2001)</td>
<td>Panel</td>
<td>7 cities and 8 goods/services in Australia</td>
<td>1972-99 (Q)</td>
<td>CPI and disaggregated CPI</td>
<td>Panel unit-root tests</td>
<td>Yes</td>
</tr>
<tr>
<td>Edison et al. (1997)</td>
<td>Time-series</td>
<td>13 countries</td>
<td>1974-92 (Q)</td>
<td>CPI</td>
<td>Cointegration</td>
<td>Yes</td>
</tr>
<tr>
<td>Engel (2000)</td>
<td>Time-series</td>
<td>US/UK</td>
<td>1970-95 (Q)</td>
<td>GDP deflator</td>
<td>Unit-root and cointegration tests</td>
<td>No</td>
</tr>
<tr>
<td>Engel et al. (1997)</td>
<td>Panel</td>
<td>4 pairs of cities in the US and Europe</td>
<td>1978-94 (M)</td>
<td>CPI</td>
<td>GLS applied to a system of error-correction models</td>
<td>No</td>
</tr>
<tr>
<td>Flóres et al. (1999)</td>
<td>Panel</td>
<td>10 industrial countries</td>
<td>1973-94 (M)</td>
<td>CPI</td>
<td>Panel unit-root test (SUR-GLS)</td>
<td>Yes</td>
</tr>
<tr>
<td>Koedijk et al. (1998)</td>
<td>Panel</td>
<td>17 industrial countries</td>
<td>1972-96 (Q)</td>
<td>CPI</td>
<td>A numeraire-invariant panel methodology</td>
<td>Yes</td>
</tr>
<tr>
<td>Li (1999)</td>
<td>Time-series</td>
<td>29, 26 and 25 OECD countries</td>
<td>1974-96 (A)</td>
<td>CPI</td>
<td>Hierarchical model</td>
<td>No</td>
</tr>
<tr>
<td>Maeso-Fernández (1998)</td>
<td>Time-series</td>
<td>19 developed countries</td>
<td>1974-92 (M, A)</td>
<td>CPI and WPI</td>
<td>Variance ratio</td>
<td>Yes</td>
</tr>
<tr>
<td>Michael et al. (1997)</td>
<td>Time-series</td>
<td>US, UK, France, Germany</td>
<td>1921-25 (M), 1800-1992 (A)</td>
<td>WPI</td>
<td>Nonlinear adjustment (STAR model)</td>
<td>Yes</td>
</tr>
<tr>
<td>O’Connell (1998)</td>
<td>Panel</td>
<td>64 countries</td>
<td>1973-95 (Q)</td>
<td>CPI</td>
<td>Panel unit-root test (GLS)</td>
<td>No</td>
</tr>
<tr>
<td>Papell and Theodoridis (1998)</td>
<td>Panel</td>
<td>20 industrial countries</td>
<td>1973-96 (Q)</td>
<td>CPI</td>
<td>Panel unit-root test (GLS)</td>
<td>Yes</td>
</tr>
<tr>
<td>Parkes and Savvides (1999)</td>
<td>Panel</td>
<td>G7 countries</td>
<td>1917-94 (A)</td>
<td>CPI and WPI</td>
<td>SUR and sequential test for structural breaks</td>
<td>Yes</td>
</tr>
<tr>
<td>Sjaastad (1998)</td>
<td>Time-series</td>
<td>Switzerland</td>
<td>1974-91 (Q)</td>
<td>GDP deflator, CPI and PPI</td>
<td>Commodity currency</td>
<td>Yes</td>
</tr>
</tbody>
</table>

(continued on next page)
### TABLE 3.3 (continued)

**RECENT EMPIRICAL EVIDENCE ON PPP**

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Nature of data</th>
<th>Countries in sample</th>
<th>Sample period</th>
<th>Price index used</th>
<th>Approach</th>
<th>Does PPP hold?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>B. Industrial and developing countries</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higgins and Zakrajšek (1999)</td>
<td>Panel</td>
<td>11 European countries, 12 OECD countries and 17 open economies</td>
<td>1973 (or 76 or 79)-97 (Q)</td>
<td>CPI and WPI</td>
<td>Four panel unit-root tests</td>
<td>Yes</td>
</tr>
<tr>
<td>Lee (1999)</td>
<td>Time-series</td>
<td>13 Asia Pacific countries</td>
<td>1957-94 (Q)</td>
<td>CPI and WPI</td>
<td>Generalised error correction</td>
<td>Yes</td>
</tr>
<tr>
<td>Wu and Chen (1999)</td>
<td>Panel</td>
<td>8 Pacific Basin countries</td>
<td>1980-96 (M)</td>
<td>CPI and WPI</td>
<td>Two panel unit-root tests</td>
<td>No</td>
</tr>
<tr>
<td><strong>C. Developing countries</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bahmani-Oskooee (1998)</td>
<td>Time-series</td>
<td>11 Middle Eastern countries</td>
<td>1971-94 (Q)</td>
<td>CPI</td>
<td>Stationarity and ADF tests</td>
<td>Yes</td>
</tr>
<tr>
<td>Boyd and Smith (1999)</td>
<td>Panel</td>
<td>31 developing countries</td>
<td>1966-90 (Q)</td>
<td>CPI</td>
<td>Panel unit-root and cointegration tests</td>
<td>Yes</td>
</tr>
<tr>
<td>Doğanlar (1999)</td>
<td>Time-series</td>
<td>India, Indonesia, Pakistan, Turkey and Philippines</td>
<td>1980-95 (Q)</td>
<td>CPI</td>
<td>Cointegration</td>
<td>No</td>
</tr>
<tr>
<td>Guimarães-Filho (1999)</td>
<td>Time-series</td>
<td>Brazil</td>
<td>1855-1990 (Q)</td>
<td>Unknown</td>
<td>Robust rank test</td>
<td>No</td>
</tr>
<tr>
<td>Luintel (2000)</td>
<td>Panel</td>
<td>8 Asian developing countries</td>
<td>1958-89 (M)</td>
<td>CPI</td>
<td>Panel unit-root and variance ratio tests</td>
<td>Yes</td>
</tr>
<tr>
<td>Sarno (2000)</td>
<td>Time-series</td>
<td>11 Middle Eastern countries</td>
<td>1973-94 (Q)</td>
<td>CPI</td>
<td>Multivariate nonlinear models</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**Note:** In the column headed “Sample period”, M denotes monthly data, Q quarterly and A annual.
open-economy panel, and Cheung and Lai (2000) who find evidence of PPP mean-reversion through a country-by-country unit-root testing approach.

Due to limited data availability and quality, there are only a handful of studies which examine the validity of long-run PPP for developing economies. Panel C of Table 3.3 lists such papers. Empirical results from the developing world are in disagreement. Using cointegration techniques, Doğanlar (1999) finds evidence in favour of PPP for only one among five Asian developing countries. Salehizadeh and Taylor (1999) examine 27 emerging economies in Europe, the Americas, Asia and Africa. Their results obtained from cointegration support PPP for more than half of the countries and strongly reject the symmetry and proportionality conditions. In Boyd and Smith (1999), who focus on 31 developing countries, PPP is strongly supported using panel unit-root tests, but only weakly supported using cointegration tests. The panel cointegration analysis of Nagayasu (1998) reveals that the behaviour of parallel market exchange rates of 16 African countries is consistent with long-run PPP.

There are a number of studies for developing countries using tests other than cointegration. Luintel (2000) confirms the stationarity of black-market real exchange rates for eight Asian developing countries using both panel unit-root and variance ratio tests. Using the robust rank test, Guimarães-Filho (1999) cannot reject the existence of a unit root in the Brazilian real exchange rate for more than a century. Evidence of PPP from Middle-Eastern countries is provided in Bahmani-Oskooee (1998) and Sarno (2000); the former uses conventional univariate tests and finds mixed results, and the latter strongly supports PPP using multivariate nonlinear models.

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12 Recall from Section 3.2 that the absolute PPP is expressed in equation (3.1) (with time subscripts added) as $s_t = p_t - p_t^*$. Expressing this in regression form, we have $s_t = \alpha_1 p_t - \alpha_2 p_t^* + u_t$. Symmetry requires $\alpha_1 = \alpha_2$ and proportionality requires $\alpha_1 = \alpha_2 = 1$.
3.6. Concluding Remarks

In a nutshell, research on PPP has been exploding in the past three decades, especially during the last ten years. With the use of increasingly-powerful test techniques, the conclusions concerning the validity of PPP are becoming more and more reliable. The increasing evidence favouring PPP has strengthened confidence in PPP. As Taylor and Sarno (1998) put it, “..... it seems that the profession’s confidence in long-run PPP, having been low for a number of years, may itself be mean reverting” (p. 308).

The implications of PPP holding in the long run are no less than profound. For example, PPP means that nominal devaluations are just inflationary in the long run and have no impact on a country’s competitiveness. A further implication of PPP holding in the long run is that it can be used as a convenient way to define equilibrium exchange rates. Chapters 4 to 6 use the Big Mac Index published by The Economist magazine to test for PPP and estimate equilibrium exchange rates for 16 countries. It is found that real exchange rates are stationary using this single-good index, and the estimated equilibrium exchange rates are quite similar to those derived from more complex methodologies. The attractions of this approach are its modest data requirement (exchange rates and Big Mac prices), the minimal economic structure placed on the problem and, above all, its simplicity.

Concerning the future direction of the research on PPP, there are at least two important issues to be resolved. First, the purchasing power parity puzzle summarised by Rogoff (1996): How can one reconcile the excessively high volatility of real exchange rates in the short term with seemingly “long” half-life of deviations from PPP, i.e., four to five years? Second, the economic underpinnings of deviations from PPP, as pointed out by Higgins and Zakrajšek (1999): Economists should move beyond the purely statistical issue of whether the real exchange rate contains a unit root, to focus on the economic sources of deviations from PPP, which may comprise persistent and/or transitory components.


