CHAPTER 4
INTERNATIONAL PARITY CONDITIONS: PURCHASING POWER PARITY

Chapter Overview

This chapter begins with an overview of the importance of the parity conditions: purchasing power parity, interest rate parity, the Fisher parities, and the unbiased forward rate condition. The parity conditions can be considered as international financial “benchmarks” or “break-even values” – defining points where decision-makers in private enterprises are indifferent between the two strategies summarized by the two halves of the parity relation. A summary of the international parity conditions is presented in the chapter. The focus of this chapter is an analysis of purchasing power parity (PPP) both in the context of the perfect capital market (PCM) assumptions and in the context in which PCM assumptions are relaxed. While PPP is built upon the Law of One Price, the chapter stresses the relative version of PPP, which may be valid even if the absolute version of PPP is violated. PPP is closely linked to the concept of real exchange rate, which is an important measure of international prices competitiveness. This chapter also provides and reviews empirical evidence on PPP. In the final two sections of the chapter, the role of PPP in policy decisions for both private enterprises and public policymakers is discussed.

Chapter Outline

The Usefulness of Parity Conditions in International Financial Markets
   An Overview of International Parity Conditions in a Perfect Capital Market
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   The Law of One Price
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   Relative Purchasing Power Parity
   The Real Exchange Rate and Purchasing Power Parity
Relaxing the Perfect Capital Market Assumption
   Transaction Costs
   Taxes
   Uncertainty
Empirical Evidence on Prices and Exchange Rates
   Empirical Methods, or How to test a Parity Condition
   Evidence on the Law of One Price
   Relative PPP: Evidence from Recent Quarterly Data
   Relative PPP: Evidence from Hyperinflationary Economies
   Relative PPP: Evidence from Long-Run Data
   Empirical Tests of PPP: The Final Word
Policy Matters - Private Enterprises
   The Role of Parity Conditions for Management Decisions
   Purchasing Power Parity and Managerial Decisions
Purchasing Power Parity and Product Pricing Decisions
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How do we compare prices across countries?

For the same automobile, it costs DM20,000 in Germany, but only $10,000 in the U.S. Is it cheaper in the U.S or in Germany? If you have to buy one of these vehicles, where would you like to buy it (ignore transportation and transaction costs)?

If the exchange rate is $.40/DM, where would you buy it? Does this present a profit opportunity for you?

If the exchange rate is $.60/DM, where would you buy it? Does this present a profit opportunity for you?

At what exchange rate will the prices be equal in both countries?

The law of one price:

The argument that international differences in prices for the same commodity should be arbitraged away by trade. (Ingram and Dunn, 1993).

Grabbe (1991, p. 191) puts it in this way:

The simplest concept of PPP is the so-called law of one price, which says that bananas will cost the same whether purchased directly with red chips or whether the red chips are first converted to blue chips at the going rate of exchange and the blue chips then used to purchase bananas.

Example: Gold standard (1876-1913)

\[
S_{dc, t} = \frac{P_{dc, t}}{P_{fc, t}} = \frac{\$20.67}{\£4.2474} = \frac{\$4.86656}{\£}
\]

Example:

According to a survey ("Big MacCurrencies," The Economist, April 17th 1993), in 1993, the average price of a Big Mac in the U.S. was $2.28. In Japan, Big Mac fans had to fork out ¥391 for this feast. What was the PPP implied exchange rate between the $ and the ¥?
A related question to be addressed later: In the currency markets on April 13th, yen-holders could buy a dollar for ¥113. Was the ¥ overvalued or undervalued against the $? By how much?

PPP Implied exchange rate

\[ \frac{¥391}{\text{Big Mac}} / \frac{2.28}{\text{Big Mac}} = ¥171/\$ \]

\[ \Rightarrow \text{\$ undervalued (¥ overvalued)} \]

**Purchasing power parity: absolute version**

\[ S_{\text{de/FC},t} = \frac{P_{\text{de},t}}{P_{\text{FC},t}} \] (2)

**Purchasing power parity: relative version**

We are more interested in the changes in exchange rates.

\[ \frac{S_{\text{de/FC},T}}{S_{\text{de/FC},t}} = \frac{P_{\text{de},T}}{P_{\text{FC},T}} / \frac{P_{\text{de},t}}{P_{\text{FC},t}} = \frac{1 + \pi_{\text{de,t},T}}{1 + \pi_{\text{FC,t},T}} \] (3)

Or

\[ S_{\text{de/FC},t} = S_{\text{de/FC},T} \frac{1 + \pi_{\text{de,t},T}}{1 + \pi_{\text{FC,t},T}} \] (4)

The superscript e denotes expectation.

Example: Given the following

<table>
<thead>
<tr>
<th>Year</th>
<th>CPI (US)</th>
<th>CPI (Japan)</th>
<th>Exchange rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1973</td>
<td>40.3</td>
<td>44.0</td>
<td>$.003762/¥</td>
</tr>
<tr>
<td>1989</td>
<td>117.2</td>
<td>104.6</td>
<td>$.006971/¥</td>
</tr>
</tbody>
</table>

Questions:

According to PPP, should the ¥ appreciate or depreciate against the $ in 1989? What was the PPP implied exchange rate between the ¥ and the $ in 1989? Was the ¥ overvalued or undervalued against the $? By how much?
\[ S_{yen, 1989} = S_{yen, 1973} \frac{1 + \pi_{1973-1989}}{1 + \pi_{yen, 1973-1989}} \]  

(5a)

\[ S_{yen, 1989} = S_{yen, 1989} \frac{117.2 / 40.3}{104.6 / 44.0} \]

(5b)

\[ = S_{yen, 1989} \times \frac{44.0}{104.6} = 0.4208 \]  

So the yen is overvalued (\$ undervalued).

### Real exchange rate

\[ R_{def/c} = \frac{\text{actual exchange rate}}{\text{PPP implied exchange rate}} = \frac{S_{def/c}}{S_{ppp, def/c}} \]  

(6)

Questions:

What does the real exchange rate measure?

How do we determine whether a currency is overvalued or undervalued?

Go back to the two previous examples and calculate the real exchange rates. What are the implications of the results?

In the Big Mac case,

\[ R_{def/c} = \frac{\text{actual exchange rate}}{\text{PPP implied exchange rate}} \]

(7)

\[ \frac{1 / 113\text{yen}}{1 / 171\text{yen}} = \frac{171}{113} = 1.51 \]

The yen is 51% overvalued against the dollar.

\[ R_{fc/def} = \frac{\text{actual exchange rate}}{\text{PPP implied exchange rate}} \]

(8)

\[ \frac{113\text{yen}}{171\text{yen}} = \frac{113}{171} = 0.6608 \]

The dollar is 33.92% (1-.6608) undervalued against the yen.
In the CPI case,

\[ R_{\text{def}, t} = \frac{\text{actual exchange rate}}{\text{PPP implied exchange rate}} \]

\[ = \frac{0.006971}{0.004602} = 1.5148 \]  

The yen is 51.48% overvalued against the dollar.

\[ R_{\text{fc/ide}, t} = \frac{\text{actual exchange rate}}{\text{PPP implied exchange rate}} \]

\[ = \frac{1}{0.006971} = 0.6602 \]

The dollar is about 34% undervalued against the yen.

**Effective exchange rate**

The effective exchange rate is an index of the weighted-average foreign exchange value of a currency against a basket of other currencies. This index summarizes in one number the value of the currency against a number of other currencies. The weights are usually based on a country's trade against its trading partners.

Example:

Suppose the U.S. only trades with Japan and Germany:

<table>
<thead>
<tr>
<th>Year</th>
<th>Yen</th>
<th>Index</th>
<th>DM1.50/$</th>
<th>Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100</td>
<td>100</td>
<td>1.50</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>105</td>
<td>105</td>
<td>1.65</td>
<td>110</td>
</tr>
<tr>
<td>3</td>
<td>110</td>
<td>110</td>
<td>1.65</td>
<td>110</td>
</tr>
</tbody>
</table>

Total U.S. trade (X+M)= $1000 billion
- with Japan $600 billion (weight: 60%)
- with Germany $400 billion (weight: 40%)
Effective exchange rate for the $:
year 1: 100
year 2: 107
year 3: 110

Effective exchange rate for the $:
year 1: 100
year 2: 107
year 3: 110
Answers to end-of-chapter questions

1. Define the necessary conditions for a perfect capital market. Why do these assumptions make the analysis of international parity conditions easier?

The assumptions necessary for a perfect capital market are no transactions costs, no taxes, and complete certainty. These assumptions make the analysis of international parity conditions easier because various market frictions and barriers that limit arbitrage are assumed away. By assuming a world of certainty, our analysis can focus on expected values of outcomes without considering risk.

2. Define and contrast absolute and relative Purchasing Power Parity. Provide an example of each one.

Absolute purchasing power parity is the case where an identical basket of goods sells at the same price in two different countries once the basket prices are expressed in the same unit of account. To satisfy absolute PPP, a market basket in Germany valued at DM 1,000 should cost $500 in the United States when the spot rate is $0.50/DM. Relative purchasing power parity is the case where the percentage rate of change in the prices of market baskets in two countries differs by an amount equal to the percentage rate of change in the exchange rate. To satisfy relative PPP, if the German market basket price rose by 2% (from DM 1,000 to DM 1020.20) and the US market basket price rose by 4% (from $500 to $520.41), the US$ would have to depreciate by 2% from its original value.

3. When does a change in nominal level of prices in two countries not imply any change in real exchange rates?

When the nominal exchange rate change exactly equals the difference in the inflation rates between two countries, the real exchange rate does not change. In other words, when relative PPP holds, the real exchange rate does not change.

4. Define the real spot exchange rate between two currencies. What are the "units" of the real exchange rate?

The real exchange rate is defined by the ratio of the nominal exchange rate ($S_t$) relative to the PPP exchange rate ($S_{ppp,t}$). The units of the real exchange rate are goods of one country per unit of goods in the second country.

5. "When Purchasing Power Parity holds, the real exchange rate is constant." Discuss.

When relative PPP holds the nominal exchange rate change equals the difference in national inflation rates. The nominal exchange rate thus changes by the same amount as the PPP exchange rate. Therefore the real exchange rate is constant.
6. Describe several alternative methods for testing Purchasing Power Parity. What is the most appropriate method?

PPP could be tested using regression methods and regressing the exchange rate change against the inflation differential. Alternatively, PPP could be tested by measuring the average deviation from PPP and its standard deviation, and testing whether the average deviation from PPP is different than zero. Finally, PPP could be tested by estimating whether there is a tendency for exchange rates to revert back to a central value associated with the PPP rate. Tests that rely on regression and use monthly quarterly data are too demanding to capture what appears to be a weak but steady tendency for PPP to reassert itself in the longer run. Other methods are more appropriate for testing PPP.

7. What empirical evidence tends to show that PPP holds in the long-term?

Empirical tests of PPP based on long sample periods or a wide cross section of data from many countries show the most favorable evidence toward PPP as a long-run relationship. The tests show that when PPP deviations arise, 50% of the deviation is eliminated within 3-5 years.

8. "When PPP holds, managers can choose their production location solely on the basis of comparative advantage." Is this statement true or false? Why?

This statement is generally true if the production decision is made at a time when the current spot rate equals its PPP value. Both exchange rates and inflation may occur over the productive life of an investment, but when PPP holds the price competitiveness of any location is not affected. However, if the deviations from PPP are especially large or prolonged, some production sites may be selected on the theory that they will be competitive at some point in the PPP cycle.

9. Empirical evidence shows that there are often deviations from Purchasing Power Parity. Do these deviations always represent profit opportunities for business managers?

Deviations from PPP that are measured using available data reflect many factors including transport costs, taxes and customs duties, products sold with financing included or after-sales service contracts, quality differences, price indices with different mixtures of traded and non-traded goods, etc. Measured deviations from PPP are not necessarily indicative of profit opportunities through arbitrage.

10. Empirical evidence shows frequent deviations from Purchasing Power Parity. What kind of threats and opportunities does this open up for financial managers?

Deviations from PPP indicate a change in the price competitiveness of goods originating in one country versus others. Managers prefer, other things equal, to source production in countries gaining price competitiveness (through depreciation in the real exchange rate), and
they prefer to earn revenues in countries losing price competitiveness (through appreciation in the real exchange rate). The ability of managers to pursue a flexible strategy with respect to exchange rates is tempered by the fact that production and investment decisions take time to be realized, and once in place, it is very costly for firms to move either their production locations or target markets.

**Answers to end-of-chapter exercises**

1. Suppose a Big Mac at a McDonald's in New York costs $2.50 and FFr 15 in Paris.

   a. What spot exchange rate establishes the Law of One Price for these two commodities?

   b. If the current spot exchange rate is FFr 5/$, what is the real exchange rate? What are the units of the calculation?

   c. According to your calculation, is the dollar over- or under-valued? How about the French franc?

   **SOLUTIONS:**

   a. \( S = \frac{FF \ 15}{$2.50}; \ S = \frac{FF6}{\$} \) or \( \$\ 0.16667/FF\)

   b. \( S (FF/$) / [(FF/Paris \ Big \ Mac) / ($/NY \ Big \ Mac)] = 5 \ FF/$ / (15 \ FF/$2.50) = 0.83333 \ Paris \ Big \ Macs/NY \ Big \ Macs\)

   c. \( S_t/S_{PPP} = $0.20 / $0.16667 = 1.20\). The dollar is undervalued by 20%. The FF is over-valued. We can only get 83.3% of a Parisian Big Mac versus one NY Big Mac.

2. A bottle of champagne costs FF 150 in a Paris wine store. The same bottle of champagne costs DM 45 in a Frankfurt wine store.

   a. What spot exchange rate establishes the Law of One Price for these two commodities?

   b. If the current spot exchange rate is 3.55 FF/$, what is the real exchange rate? What are the units of the calculation?

   c. According to your calculation, is the DM over- or under-valued?

   **SOLUTIONS:**

   a. \( S = FF150/DM45 \implies S = FF3.33/DM\)
b. $S_{real} = S_r/S_{PPP} \implies 3.55/3.33 = 1.065$ Paris wine/Frankfurt wine

c. The DM is over-valued by 6.5%.

3. Data on price index and exchange rates in 1973 and 1993 for 22 OECD countries are included on the data diskette accompanying the instructor’s manual for this text. Estimate a regression of the form: $Y_i = a + bX_i$ where $Y$ is the exchange rate change over the 20-year period and $X$ is the total inflation over 20-year period for $i = 1, \ldots, 22$ countries. Do your results come close to the results computed by Obstfeld (1995) and reported in this chapter?

**SOLUTIONS:**

<table>
<thead>
<tr>
<th>Spot Exchange Rate (Foreign Currency per US$)</th>
<th>Consumer Prices</th>
<th>Spot Rate Change 20 years</th>
<th>Relative Price Change Foreign vs. U.S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>19.5800</td>
<td>11.6322</td>
<td>46.10</td>
</tr>
<tr>
<td>Belgium</td>
<td>38.9765</td>
<td>34.5965</td>
<td>37.08</td>
</tr>
<tr>
<td>Denmark</td>
<td>6.0495</td>
<td>6.4839</td>
<td>27.19</td>
</tr>
<tr>
<td>France</td>
<td>4.4528</td>
<td>5.6632</td>
<td>26.08</td>
</tr>
<tr>
<td>Germany</td>
<td>2.6726</td>
<td>1.6533</td>
<td>55.93</td>
</tr>
<tr>
<td>Italy</td>
<td>582.9958</td>
<td>1573.6659</td>
<td>13.10</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>38.9765</td>
<td>34.5965</td>
<td>39.93</td>
</tr>
<tr>
<td>Norway</td>
<td>5.7658</td>
<td>7.0941</td>
<td>26.23</td>
</tr>
<tr>
<td>Sweden</td>
<td>4.3673</td>
<td>7.7834</td>
<td>24.21</td>
</tr>
<tr>
<td>Switzerland</td>
<td>3.1648</td>
<td>1.1500</td>
<td>54.48</td>
</tr>
<tr>
<td>Canada</td>
<td>1.0001</td>
<td>1.2901</td>
<td>30.09</td>
</tr>
<tr>
<td>Greece</td>
<td>29.6250</td>
<td>229.2498</td>
<td>5.74</td>
</tr>
<tr>
<td>Iceland</td>
<td>0.9013</td>
<td>67.6032</td>
<td>0.45</td>
</tr>
<tr>
<td>Ireland</td>
<td>0.4082</td>
<td>0.6772</td>
<td>17.45</td>
</tr>
<tr>
<td>Portugal</td>
<td>24.5152</td>
<td>160.8002</td>
<td>5.02</td>
</tr>
<tr>
<td>Spain</td>
<td>58.2601</td>
<td>127.2604</td>
<td>12.94</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>0.4082</td>
<td>0.6668</td>
<td>18.82</td>
</tr>
<tr>
<td>Netherlands</td>
<td>2.7956</td>
<td>1.8573</td>
<td>48.50</td>
</tr>
<tr>
<td>Japan</td>
<td>271.7017</td>
<td>111.1978</td>
<td>43.04</td>
</tr>
<tr>
<td>Finland</td>
<td>3.8212</td>
<td>5.7123</td>
<td>22.76</td>
</tr>
<tr>
<td>Australia</td>
<td>0.7035</td>
<td>1.4706</td>
<td>20.94</td>
</tr>
<tr>
<td>New Zealand</td>
<td>0.7368</td>
<td>1.8505</td>
<td>14.28</td>
</tr>
<tr>
<td>United States</td>
<td>1.0000</td>
<td>1.0000</td>
<td>34.00</td>
</tr>
</tbody>
</table>
### SUMMARY OUTPUT

#### Regression Statistics
- Multiple R: 0.983068
- R Square: 0.966422
- Adjusted R Square: 0.964743
- Standard Error: 0.215514
- Observations: 22

#### ANOVA

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>Significance F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>1</td>
<td>26.735903</td>
<td>26.7359</td>
<td>575.6318</td>
<td>3.26E-16</td>
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<tr>
<td>Residual</td>
<td>20</td>
<td>0.9289237</td>
<td>0.046446</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>21</td>
<td>27.664827</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Coefficients

<table>
<thead>
<tr>
<th>Coefficients</th>
<th>Standard Error</th>
<th>t Stat</th>
<th>P-value</th>
<th>Lower 95%</th>
<th>Upper 95%</th>
<th>Lower 95.0%</th>
<th>Upper 95.0%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-0.08649</td>
<td>-1.66536</td>
<td>0.111429</td>
<td>-0.19481</td>
<td>0.021843</td>
<td>-0.19481</td>
<td>0.021843</td>
</tr>
<tr>
<td>Relative Price Change: Foreign vs. U.S.</td>
<td>1.019955</td>
<td>23.99233</td>
<td>3.26E-16</td>
<td>0.931277</td>
<td>1.108632</td>
<td>0.931277</td>
<td>1.108632</td>
</tr>
</tbody>
</table>
4. Suppose the expected annual inflation rate in the UK is 4.5% and that in the US 3%. According to PPP, will the dollar appreciate or depreciate? By which percentage?

**SOLUTIONS:**

The expected currency depreciation is the differential of inflation rates between the two countries: $ s_{S/E} = p_S - p_E$ measures the US$ depreciation. $3\% - 4.5\% = -1.5\%$; US$ appreciation of 1.5% or UK£ depreciation of 1.5%

5. Suppose the current spot rate is $1.55/£$ on the first of January. By year's end, the US CPI is expected to climb from 144 to 150 and the UK CPI is expected to climb from 120 to 130. According to PPP, what is the expected spot rate on December 31?

**SOLUTIONS:**

$$S_{PPP,t+1} = S_{t,$$/£} \times \frac{CPI_{t+1,US}}{CPI_{t+1,UK}} \times \frac{CPI_{t,US}}{CPI_{t,UK}};$$

$$S_{PPP,Dec} = $1.55/£ \times \frac{150}{144} \times \frac{120}{130} = $ 1.4904/£$$

6. Consider the following data for the U.S. and Surlandia for the years 1975 - 1980.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pengo/$</td>
<td>8.5</td>
<td>17.4</td>
<td>28.0</td>
<td>34.0</td>
<td>39.0</td>
<td>39.0</td>
</tr>
<tr>
<td>Surlandia CPI</td>
<td>100</td>
<td>312</td>
<td>599</td>
<td>838</td>
<td>1118</td>
<td>1511</td>
</tr>
<tr>
<td>U.S. CPI</td>
<td>161.2</td>
<td>170.5</td>
<td>181.5</td>
<td>195.4</td>
<td>217.4</td>
<td>246.8</td>
</tr>
</tbody>
</table>

a. According to the Purchasing Power Parity Theory, by how much is the Pengo over- or under-valued at the end of 1980?

b. On what basis could someone refute your calculation?

**SOLUTIONS:**
7. In the above table of numbers for Surlandia and the US, the nominal bi-lateral exchange rate at the end of 1980 was reported as 39.0 Pengos/$. What was the real bi-lateral exchange rate?

SOLUTIONS:

8. Try your hand at testing the Law of One Price by checking the purchase price of a book at Amazon.com from their sites in the United States (www.amazon.com), Germany (www.amazon.de), and Britain (www.amazon.co.uk). Try several different books—perhaps *Galileo’s Daughter*, by Dava Sobel (the book we presented data on in this chapter), or use another book. How similar are the three prices? Would it be cheaper to buy from one of the foreign sites than a domestic site after taking transactions costs into account?

SOLUTIONS:


1£ = (1/0.71)$
1DM = (1/2.32)$

*Galileo’s Daughter* (Paperback - October 2000), by Dava Sobel is selling at www.amazon.com for $8.40; at www.amazon.de for DM 22.90 (=9.87 as of 23/11/00); at www.amazon.co.uk for £3.99 (=5.62). Please note that they all paperback but it is on sale in England Amazon web site.

*Galileo’s Daughter* (Hardbound - October 2000), by Dava Sobel is selling at www.amazon.com for $21.60; at www.amazon.de for DM 25.00 (=8 as of 23/11/00); at www.amazon.co.uk for £13.59 (=£).