International Parity Conditions: Purchasing Power Parity

- Parity Conditions in International Finance
- The Usefulness of Parity Conditions
- Foundations of Purchasing Power Parity
  - » Law of One Price
  - » Absolute PPP
  - » Relative PPP
- PPP and Real Exchange Rates
- Does PPP Really Work?
- Summary

The Usefulness of Parity Conditions
in International Financial Markets

- Parity conditions can be thought of as international financial "benchmarks" or "break-even values".
  - » They are the defining points where the decision-maker is indifferent between the two strategies summarized by the two halves of the parity relation.
- Why "use" a parity condition if it didn't "work?"
  - » Would you use Triangle Area = ½ x base x height if not true?
  - » What's different here in finance?
- Because parity conditions rely heavily on arbitrage, a violation of parity often implies that a profit opportunity or cost advantage is available to the decision-maker.

Parity Conditions in International Finance

- We begin our analysis of international parity conditions by assuming a perfect capital market (PCM) setting:
  - no transaction costs
  - no taxes
  - complete certainty
- Based on the PCM assumptions, there are four principle parity conditions in international finance, of which only three are independent.

Parity Conditions in International Finance

1a. ***Purchasing Power Parity***

Absolute Version

The price of a market basket of U.S. goods equals the price of a market basket of foreign goods when multiplied by the exchange rate.

$$P_{\text{US}} = P_{\text{UK}} \times \text{Spot}_{(\$/£)}$$

Driving force: Arbitrage in goods.

Parity Conditions in International Finance

1b. ***Purchasing Power Parity***

Relative Version

The percentage change in the exchange rate equals the percentage change in U.S. goods prices less the percentage change in foreign goods prices.

$$\Delta \text{Spot}_{(\$/£)} = \Delta P_{\text{US}} - \Delta P_{\text{UK}}$$

Driving force: Arbitrage in goods.

Parity Conditions in International Finance

2. ***Interest Rate Parity***

(a.k.a. Covered Interest Parity)

The forward exchange rate premium equals (approximately) the U.S. interest rate minus the foreign interest rate.

$$\left(F - S\right)/S = i_{\$} - i_{£}$$

Driving force: Arbitrage between the spot and forward exchange rates, and money market interest rates.

Parity Conditions in International Finance

3a. ***Fisher Parities***

Fisher Effect (Fisher Closed)

For a single economy, the nominal interest rate equals the real interest rate plus the expected rate of inflation.

$$i_{\$} = r_{\$} + E\left(\Delta \tilde{P}_{\text{US}}\right)$$

Driving force: Desire to insulate the real interest rate against expected inflation,
and arbitrage between real and nominal assets.

Parity Conditions in International Finance

3b. ***Fisher Parities***

International Fisher Effect (Fisher Open)
(a.k.a. Uncovered Interest Parity)

For two economies, the U.S. interest rate minus the foreign interest rate equals the expected percentage change in the exchange rate.

$$i_{\$} - i_{£} = E\left(\Delta \tilde{\text{S}}\text{pot}\right)$$

Driving force: Arbitrage between bonds denominated in two currencies, assuming no currency risk premium.

Parity Conditions in International Finance

*4. **Forward Rate Unbiased***

Today's forward premium (for delivery in *n* days) equals the expected percentage change in the spot rate (over the next *n* days).

$$\left(F_{t,n} - S_t\right) \Big/ S_t = \left(E\left(\tilde{S}_{t+n}\right) - S_t\right) \Big/ S_t$$

Driving force: Market players monitor the difference between today's forward rate (for delivery in *n* days) and their expectation of the future spot rate (*n* days from today), assuming no currency risk premium.

Foundations of Purchasing Power Parity

- *Purchasing power parity (PPP)* is built on the notion of arbitrage across goods markets and the Law of One Price.
- The *Law of One Price* is the principle that in a PCM setting, homogeneous goods will sell for the same price in two markets, taking into account the exchange rate.

$$P_{\text{US,wheat}} = P_{\text{UK,wheat}} \times S_{\$/£}$$

L.O.O.P. and McDonalds

A feast of burgernomics

The Big Mac index

	Big Mac prices		Implied PPP* of the dollar	Actual dollar exchange rate Jan 31st	Under (-)/over (+) valuation against the dollar, %
	In local currency	in dollars			
United States†	$3.22	3.22			
Argentina	Peso 8.25	2.65	2.56	3.11	-18
Australia	A$3.45	2.67	1.07	1.29	-17
Brazil	Real 6.4	3.01	1.99	2.13	-6
Britain	£1.99	3.90	1.62‡	1.96‡	+21
Canada	C$3.63	3.08	1.13	1.18	-4
Chile	Peso 1,670	3.07	519	544	-5
China	Yuan 11.0	1.41	3.42	7.77	-56
Colombia	Peso 6,900	3.06	2,143	2,254	-5
Costa Rica	Colones 1,130	2.18	351	519	-32
Czech Republic	Koruna 52.1	2.41	16.2	21.6	-25
Denmark	DKr27.75	4.84	8.62	5.74	+50
Egypt	Pound 9.09	1.60	2.82	5.70	-50
Estonia	Kroon 30	2.49	9.32	12.0	-23
Euro area§	€2.94	3.82	1.10**	1.30**	+19
Hong Kong	HK$12.0	1.54	3.73	7.81	-52
Hungary	Forint 590	3.00	183	197	-7
Iceland	Kronur 509	7.44	158	68.4	+131
Indonesia	Rupiah 15,900	1.75	4,938	9,100	-46
Japan	¥280	2.31	87.0	121	-28
Latvia	Lats 1.35	2.52	0.42	0.54	-22
Lithuania	Litas 6.50	2.45	2.02	2.66	-24
Malaysia	Ringgit 5.50	1.57	1.71	3.50	-51
Mexico	Peso 29.0	2.66	9.01	10.9	-17
New Zealand	NZ$4.60	3.16	1.43	1.45	-2
Norway	Kroner 41.5	6.63	12.9	6.26	+106
Pakistan	Rupee 140	2.31	43.5	60.7	-28
Paraguay	Guarani 10,000	1.90	3,106	5,250	-41
Peru	New Sol 9.50	2.97	2.95	3.20	-8
Philippines	Peso 85.0	1.74	26.4	48.9	-46
Poland	Zloty 6.90	2.29	2.14	3.01	-29
Russia	Rouble 49.0	1.85	15.2	26.5	-43
Saudi Arabia	Riyal 9.00	2.40	2.80	3.75	-25
Singapore	S$ 3.60	2.34	1.12	1.54	-27
Slovakia	Crown 57.98	2.13	18.0	27.2	-34
South Africa	Rand 15.5	2.14	4.81	7.25	-34
South Korea	Won 2,900	3.08	901	942	-4
Sri Lanka	Rupee 190	1.75	59.0	109	-46
Sweden	SKr32.0	4.59	9.94	6.97	+43
Switzerland	SFr6.30	5.05	1.96	1.25	+57
Taiwan	NT$75.0	2.28	23.3	32.9	-29
Thailand	Baht 62.0	1.78	19.3	34.7	-45
Turkey	Lire 4.55	3.22	1.41	1.41	nil
UAE	Dirhams 10.0	2.72	3.11	3.67	-15
Ukraine	Hryvnia 9.00	1.71	2.80	5.27	-47
Uruguay	Peso 55.0	2.17	17.1	25.3	-33
Venezuela	Bolivar 6,800	1.58	2,112	4,307	-51

Sources: McDonald's; *The Economist*

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

• *The Economist*'s Big Mac index is based on the theory of purchasing-power parity, under which exchange rates should adjust to equalize the cost of a basket of goods and services, wherever it is bought around the world. Our basket is the Big Mac. At end-January 2007, the most overvalued currency is the Icelandic krona: the exchange rate that would equalise the price of an Icelandic Big Mac with an American one is 158 kronur per USD; the actual rate is 68.4, making the krona 131% too dear. The most undervalued currency is the Chinese yuan, at 56% below its PPP rate; several other Asian currencies also appear to be 40-50% undervalued.

Retail Prices Around the World

Titleist Pro VI golf balls, box of 12

Prices, including taxes, as provided by retailers in each city, averaged and converted into US$

Source: *Wall Street Journal*, April 10, 2007

City	Currency	US$
New York		$48.77
Seoul	61,000 won	65.45
Tokyo	6,300 yen	52.81
Kuala Lampur	255 ringgit	73.92
Singapore	S$110	72.61
Manila	3,100 pesos	64.54
Sydney	A$92.33	75.33
Hong Kong	HK$432	55.26
Brussels	€49.00	65.53
Paris	€52	69.55
Rome	€52	69.55
Frankfurt	€57	76.23
London	£35.49	69.72
Taipei	NT$1,600	48.37

Retail Prices Around the World

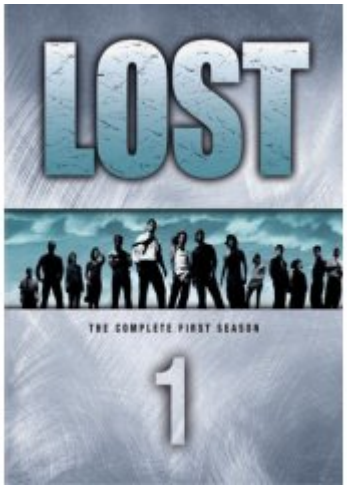
iPod Shuffle 1GB

Prices, including taxes, as provided by retailers in each city, averaged and converted into US$

Source: *Wall Street Journal*, Jan. 31, 2007

City	Currency	US$
New York		$ 85.00
Tokyo	9,800 yen	80.00
Hong Kong	HK$4,695	83.00
Rome	€79	102.00
Frankfurt	€79	102.00
Brussels	€89	115.00
Paris	€89	115.00
London	£55	115.00

Retail Prices Around the World



The price of a boxed DVD of "Lost" (first season, containing 7 DVDs, coded for respective regions)

City	Currency	US$
New York		$ 65.00
Frankfurt	€33	44.00
Hong Kong	HK$444	57.00
Brussels	€46	46.00
Paris	€49	65.00
Rome	€50	66.00
London	£34	67.00
Tokyo	21,000 yen	179.00

Prices, including taxes, as provided by retailers in each city, averaged and converted into US$

Source: *Wall Street Journal*, March 22, 2007

Absolute Purchasing Power Parity

- Let P_{US} and P_{UK} represent the weighted average price level for goods in the U.S. and U.K. market baskets respectively.
- *Absolute PPP* predicts that these two price measures will be equal after adjusting for the exchange rate:

$$P_{US} = S_{\$/£} \times P_{UK}$$

- Absolute PPP requires that the consumption baskets are identical across the two countries.

Relative Purchasing Power Parity

Suppose absolute PPP is violated. Introduce K so that:

$$P_{\text{US},\,t+1} = K \times S_{\$/£,\,t+1} \times P_{\text{UK},\,t+1} \qquad (a)$$

$$P_{\text{US},\,t} = K \times S_{\$/£,\,t} \times P_{\text{UK},\,t} \qquad (b)$$

$$\Rightarrow \quad \boldsymbol{p_{\text{US}} = s + p_{\text{UK}} + s \times p_{\text{UK}}}$$

where $s = \dfrac{S_{\$/£,\,t+1} - S_{\$/£,\,t}}{S_{\$/£,\,t}}$, $p_{\text{US}} = \dfrac{P_{\text{US},\,t+1} - P_{\text{US},\,t}}{P_{\text{US},\,t}}$, $p_{\text{UK}} = \dfrac{P_{\text{UK},\,t+1} - P_{\text{UK},\,t}}{P_{\text{UK},\,t}}$

For small % changes, or when continuous rates are used, the cross- product term $s \times p_{\text{UK}}$ can be ignored.

$$\%\Delta \text{exchange rate} = \%\Delta \text{U.S.prices} - \%\Delta \text{U.K.prices}$$

Calculating the PPP Spot Rate

- Often, we are interested in the *level* of the exchange rate that satisfies PPP.
- The *PPP spot rate* reestablishes PPP relative to a base period. It is the exchange rate that would just offset the relative inflation between a pair of countries since the base period.

$$\frac{(a)}{(b)} \Rightarrow \quad S_{PPP,t+1} = S_{\$/£,t} \frac{P_{\text{US},t+1} / P_{\text{US},t}}{P_{\text{UK},t+1} / P_{\text{UK},t}}$$

Calculating the PPP Spot Rate

Example

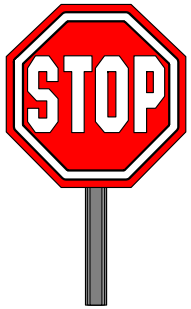
Base period nominal exchange rate = \$1.50/£
Prices of U.S. goods had risen by 8%
Prices of U.K. goods had risen by 4%

PPP spot rate = \$1.50/£ $\times$ 1.08/1.04 = \$1.5577/£

- A nominal exchange rate of \$1.5577/£ would reestablish PPP in comparison to the base period.

- Nominal exchange rates greater than \$1.5577/£ represent £ "overvaluation" (\$ undervaluation), while rates less than \$1.5577/£ represent \$ "overvaluation" (£ undervaluation).

Interpreting Purchasing Power Parity



PPP conditions do not imply anything about causal linkages between prices and exchange rates or vice versa.

- Both prices and exchange rates are jointly determined by other variables in the economy.
- PPP is an equilibrium condition that must be satisfied when the economy is at its long-term equilibrium.

PPP and "Real" FX Rates

- *Real* magnitudes are constructed from nominal magnitudes by adjusting for the appropriate price levels or inflation rates.

Example

Nominal income in 2007 (base year) = $55,000/year

$$\text{Real income} = \frac{\$55{,}000/\text{year}}{\$250/\text{market basket}} = 220 \text{ market baskets/year}$$

Nominal income in 2008 = $60,500/year

$$\text{Real income} = \frac{\$60{,}500/\text{year}}{\$270/\text{market basket}} = 224.07 \text{ market baskets/year}$$

Index (2008) = 224.07/220 = 1.0185

PPP and "Real" FX Rates

- The real exchange rate is calculated by correcting the nominal exchange rate for the price levels in the two countries.
- When absolute PPP holds:

$$\$1.50/£ = \frac{\$1{,}500/\text{US good}}{£\,1{,}000/\text{British good}}$$

$$\frac{\text{LHS}}{\text{RHS}} = 1 \text{ US good / British good}$$

- When PPP holds, the real exchange rate is constant.

PPP and "Real" FX Rates

- An index of the real exchange rate is defined as:

$$\text{Spot (Real, } t\text{)} = \frac{\text{Spot (Nominal, } t\text{)}}{\text{Spot (}PPP\text{, } t\text{)}}$$

Example

Today's spot exchange rate is \$1.80/£
PPP spot rate is \$1.50/£
Real exchange rate index = 1.80/1.50 = 1.20

- At 1.20, the £ is "overvalued" on a PPP basis.
  - » 1.0 British good can be exchanged for 1.2 U.S. goods. So, sellers of British goods have "lost competitiveness" on international markets.

Relaxing the Perfect Capital Market Assumptions

- Transaction Costs
  - » Transport and menu costs lead to a neutral band around the PPP line, within which it is not profitable to execute arbitrage transactions.
- Taxes
  - » Tariffs have an effect similar to transaction costs.
- Uncertainty
  - » Arbitrageurs will seek a greater profit to compensate for risks, thus leading to a wider band around the PPP line before arbitrage becomes profitable.

Does PPP Work?

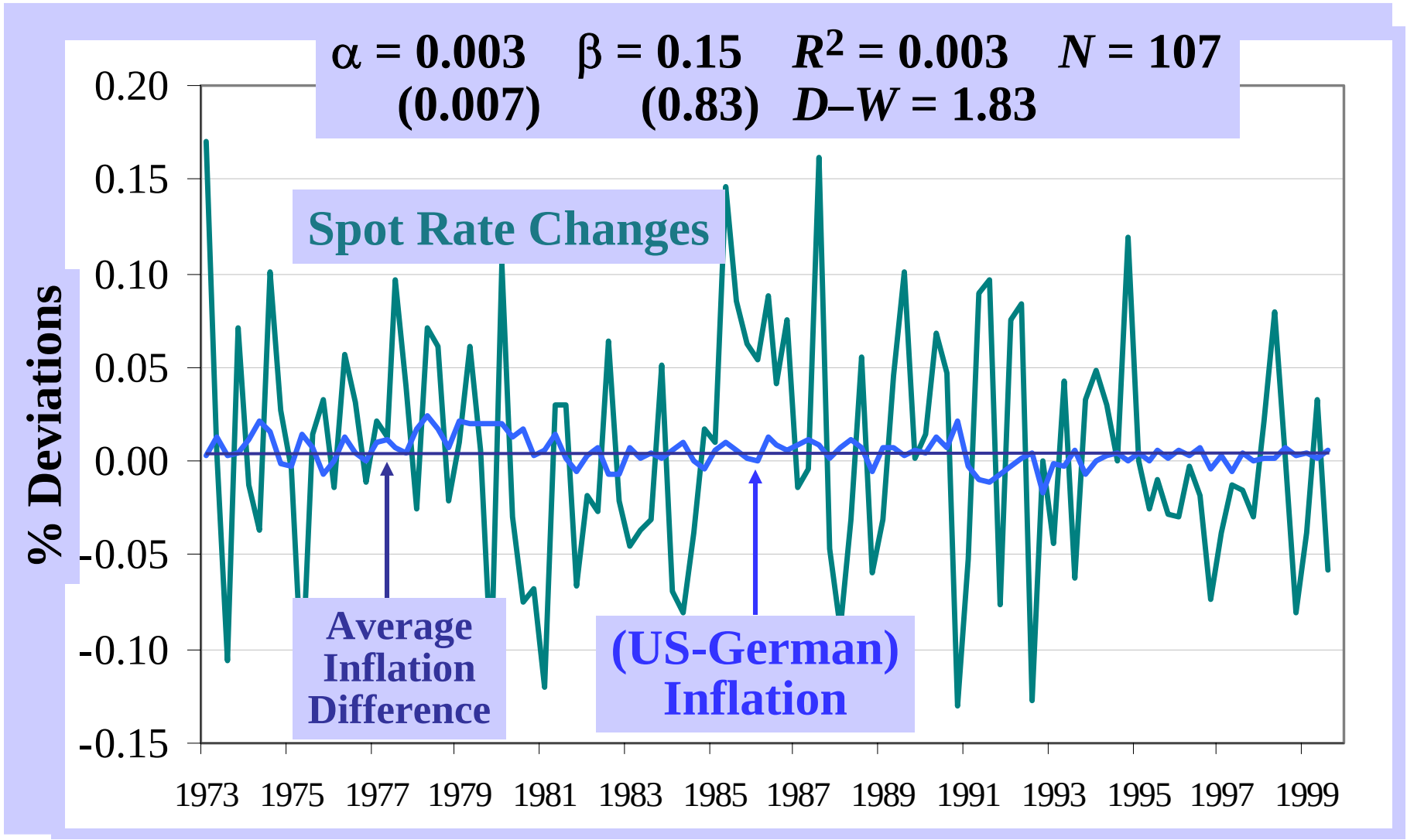
- To examine the relative PPP condition, we can compare the exchange rate change to the contemporaneous inflation differential:

$$s_t = \alpha + \beta (p_{\$} - p_{DM})_t + \varepsilon_t$$

  - » Null hypotheses: α=0, β=1, and R^2 is high
- Evidence suggests that PPP is a poor explanation of exchange-rate changes on a period-by-period basis.
- However, there is a tendency for PPP to reassert itself as time passes (*mean reversion*).
- Adjustment path to PPP could be non-linear
  - » Faster for large deviations
  - » Slower or not at all for small deviations

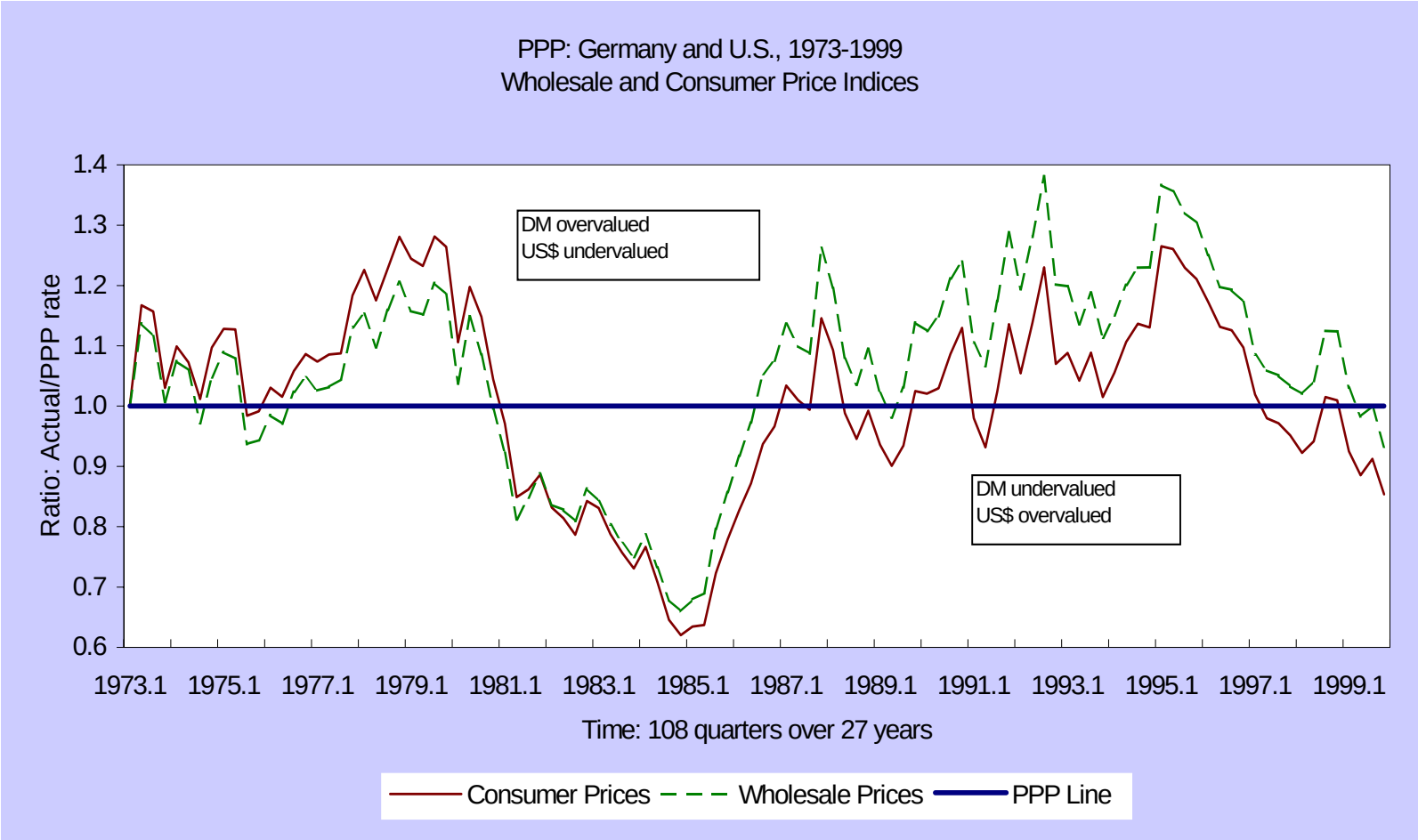
Quarterly Deviations from Relative PPP

CPI: Germany and the United States, 1973-1999



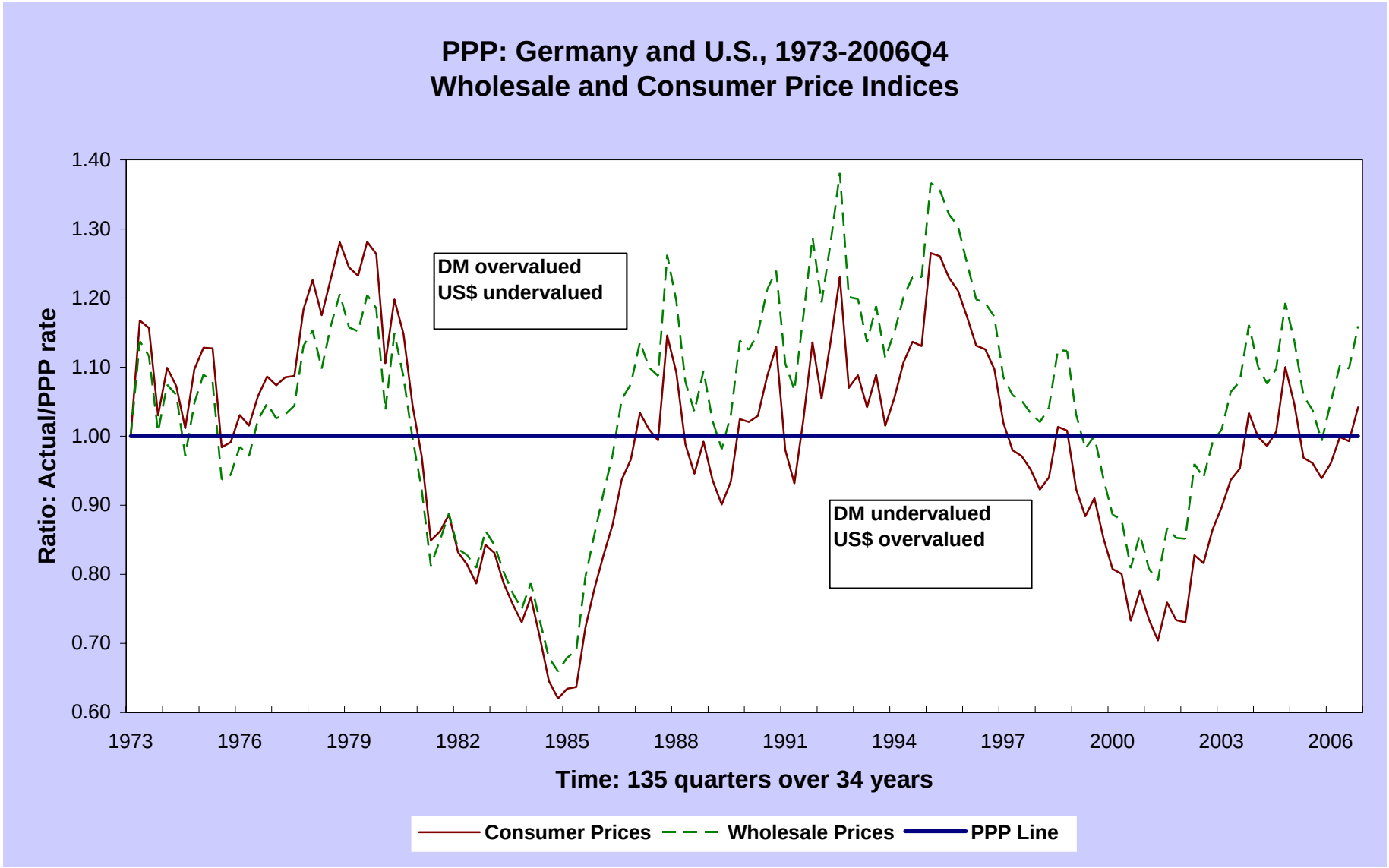
Cumulative Deviations from Relative PPP

Germany and the United States, 1973-1999



Cumulative Deviations from Relative PPP

Germany and the United States, 1973-2006



Real Exchange Rates in the Long Run Appear Stationary
Nominal Rates Appear to Move Randomly

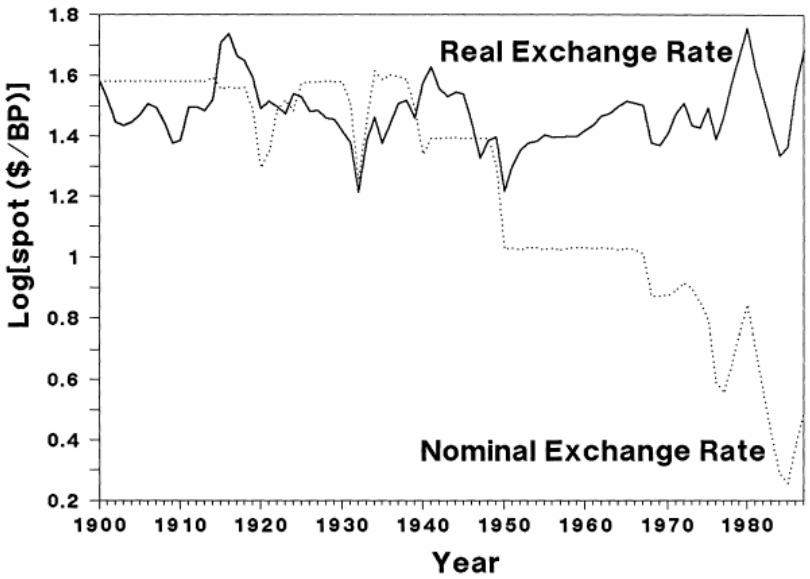


Figure 3. Dollar/pound exchange rate. Time-series plot of the real and nomimal exchange rate of the British pound versus the US dollar ($/BP), based on annual averages. The real exchange rate is obtained by deflating the nominal exchange rate by the ratio of wholesale price indices. The vertical scale is measured as the logarithm of the exchange rate. The real exchange rate is translated so that the 1900 value is equal to that of the nominal exchange rate.

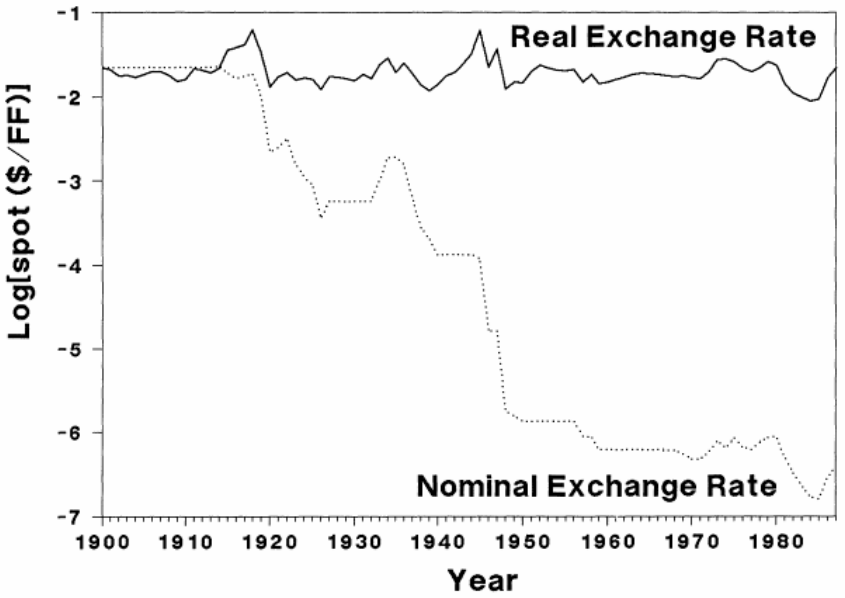


Figure 4. Dollar/French franc exchange rate. Time-series plot of the real and nominal exchange rate of the French franc versus the US dollar ($/FF), based on annual averages.

- Most empirical tests of PPP - unable to reject hypothesis that real exchange rate follows a random walk. Why? Hard to reach definite conclusions unless the sample period covers a number of cycles in deviations from PPP, that is, a large number of years. The empirical results above cast doubt on the hypothesis that the real exchange rate follows a random walk. The results suggest that the first order autoregression coefficient equals 0.98-0.99 for monthly data over the floating rate period. If so, a 50% over-appreciation of a currency with respect to PPP would take 3-5 years to be cut in half. Similarly, analyzing annual data over the period 1900-1972 reveals that a period of 3 years is needed for such a reversal.

- Source: Abuaf and Jorion, “PPP in the Long Run,” *Journal of Finance*, 1990.

Random Walk vs. Mean Reversion

Why are you so sensitive?

- Let Z_t = deviation from PPP at time *t*
- First order autoregressive process

$$Z(t) = \alpha_1 \; Z(t-1) + \varepsilon(t)$$

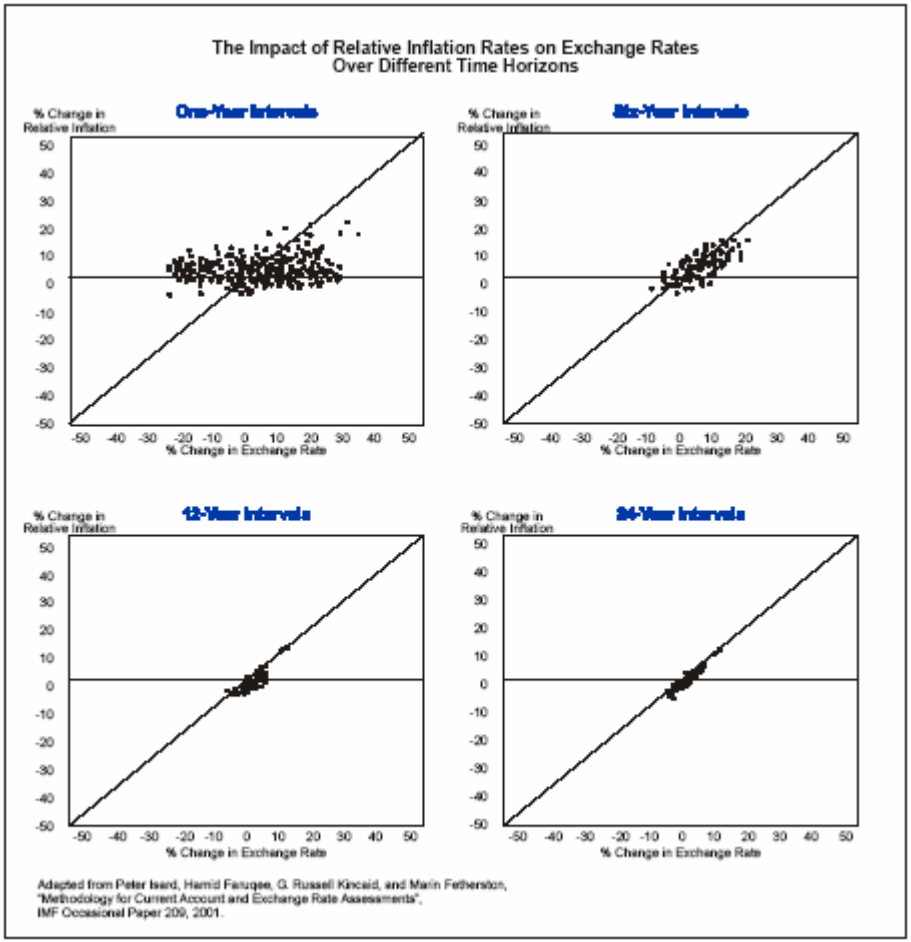
- To forecast an AR(1)

$$E[Z(t+n)] = \alpha_1^n \; Z(t)$$

- Half-Life = Time for deviation from PPP to be reduced by one-half.
  - » α_1 = .98, monthly data. $1 \times 0.98^{34} = 0.5031 \Rightarrow$ 34 months
  - » α_1 = .97, monthly data. $1 \times 0.97^{23} = 0.4963 \Rightarrow$ 23 months
  - » α_1 = .85, yearly data. $1 \times 0.85^{4.2} = 0.5053 \Rightarrow$ 4.2 years
  - » α_1 = 1.0, then …??? (See Box 8.1 in text for more.)

Another Look at PPP in the Long Run

- There exists a huge volume of empirical work on whether or not PPP represents a valid tool for forecasting purposes. The weight of evidence suggests that although there are often significant and persistent departures from PPP in both the short and medium term, exchange rates do exhibit a tendency to gravitate toward their PPP values in the long run.
- The consensus among academic researchers is that the speed of convergence to PPP is quite slow—PPP deviations appear to dampen at a rate of roughly 15% per year.
- This places the half-life of PPP deviations at around 4½ years for exchange rates in industrial nations. In other words, for any given deviation of an exchange rate from its estimated PPP value, roughly half of that deviation should be removed in 4½ years' time. As the charts below show, there is no positive relationship between changes in exchange rates and changes in relative inflation rates on a one-year basis. However, as the time horizon is lengthened, to six years and beyond, a strong positive relationship becomes apparent.



Based on Flood and Taylor (1996). Plots constructed using average annual data for 20 industrial countries versus the US$ along with corresponding consumer prices for the 24-year period 1976-2000. N=480 1-year intervals, N=80 6-year intervals, N=40 12-year intervals, and N=20 24-year intervals. All intervals are non-overlapping.

Empirical Evidence on
Prices and Exchange Rates

- During a hyperinflation period, even the demanding regression-style test tends to support PPP. This is due in some degree to *dollarization*.
- Long-run data indicated that the real exchange rate did not evolve as a *random walk*, but demonstrated a clear tendency to revert back to its central value.

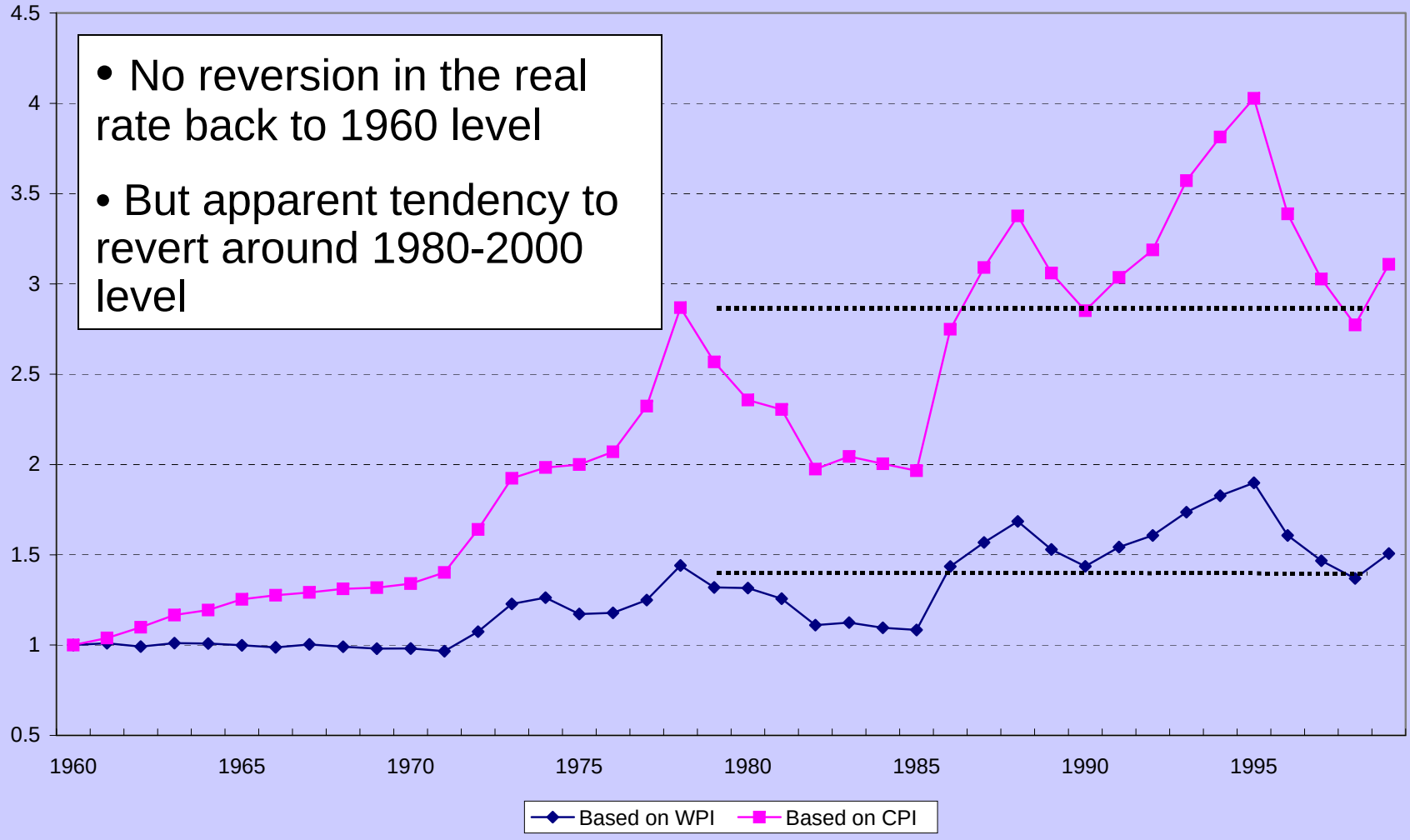
Empirical Evidence on Prices and Exchange Rates

- Note that the real exchange rate itself may not be constant.
  - » It may change on a permanent basis if a real shock affected one country but not its trading partners.
  - » The Balassa-Samuelson hypothesis states that countries that have experienced high productivity gains, higher real income growth and higher real incomes should have appreciating real exchange rates.

Cumulative Deviations from Relative PPP

Germany and the United States, 1973-1999

Figure 4.6
Real Yen/$ Exchange Rate



Is it Balassa-Samuelson or a Deviation from PPP?

Czech Republic's Real Effective Exchange Rate

Source: Institute of International Finance

Poland's Real Effective Exchange Rate

Source: Institute of International Finance

Hungary's Real Effective Exchange Rate

Source: Institute of International Finance

Russia's Real Effective Exchange Rate

Source: Institute of International Finance

Summary on PPP

- Empirical tests confirm that ...
  - » PPP is a poor descriptor of exchange rate behavior in the short run, where the rates are quite volatile and domestic prices are somewhat sticky.
  - » But in longer-run analysis, it appears that PPP offers a reasonably good guide
- Usefulness of PPP
  - » An indicator of changes in competitiveness + over and undervaluation against the PPP standard
  - » Mean reversion may guide long run FX changes