Price Levels and the Exchange Rate in the Long Run
Chapter 15

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To Accompany

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by **Paul R. Krugman and Maurice Obstfeld**

Chapter Organization

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- The Law of One Price
- Purchasing Power Parity
- A Long-Run Exchange Rate Model Based on PPP
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Chapter Organization

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Introduction

- The model of long-run exchange rate behavior provides the framework that actors in asset markets use to forecast future exchange rates.

- Predictions about long-run movements in exchange rates are important even in the short run.

- In the long run, national price levels play a key role in determining both interest rates and the relative prices at which countries' products are traded.

  - The theory of **purchasing power parity (PPP)** explains movements in the exchange rate between two countries' currencies by changes in the countries' price levels.

The Law of One Price

- **Law of one price**
  - Identical goods sold in different countries must sell for the same price when their prices are expressed in terms of the same currency.
    - This law applies only in competitive markets free of transport costs and official barriers to trade.
      - Example: If the dollar/pound exchange rate is $1.50 per pound, a sweater that sells for $45 in New York must sell for £30 in London.

The Law of One Price

– It implies that the dollar price of good i is the same wherever it is sold:

$$P^i_{US} = (E_{\$/€}) \times (P^i_{E})$$

where:

P^i_{US} is the dollar price of good i when sold in the U.S.

P^i_{E} is the corresponding euro price in Europe

$E_{\$/€}$ is the dollar/euro exchange rate

Purchasing Power Parity

- **Theory of Purchasing Power Parity (PPP)**
  - The exchange rate between two counties' currencies equals the ratio of the counties' price levels.
  - It compares average prices across countries.
  - It predicts a dollar/euro exchange rate of:

$$E_{\$/€} = P_{US}/P_E \qquad (15\text{-}1)$$

where:

P_{US} is the dollar price of a reference commodity basket sold in the United States

P_E is the euro price of the same basket in Europe

Purchasing Power Parity

- By rearranging Equation (15-1), one can obtain:

$$P_{US} = (E_{\$/€}) \times (P_E)$$

- PPP asserts that all countries' price levels are equal when measured in terms of the same currency.

Purchasing Power Parity

- **The Relationship Between PPP and the Law of One Price**

  - The law of one price applies to individual commodities, while PPP applies to the general price level.

  - If the law of one price holds true for every commodity, PPP must hold automatically for the same reference baskets across countries.

  - Proponents of the PPP theory argue that its validity does not require the law of one price to hold exactly.

Purchasing Power Parity

■ Absolute PPP and Relative PPP

- **Absolute PPP**
  - It states that exchange rates equal relative price levels.
- **Relative PPP**
  - It states that the percentage change in the exchange rate between two currencies over any period equals the difference between the percentage changes in national price levels.
  - Relative PPP between the United States and Europe would be:

$$(E_{\$/€,t} - E_{\$/€,\, t-1})/E_{\$/€,\, t-1} = \pi_{US,\, t} - \pi_{E,\, t} \qquad (15\text{-}2)$$

where:

$\pi_t =$ inflation rate

A Long-Run Exchange Rate Model Based on PPP

- **Monetary approach to the exchange rate**
  - A theory of how exchange rates and monetary factors interact in the long run.

- The Fundamental Equation of the Monetary Approach
  - Price levels can be expressed in terms of domestic money demand and supplies:
    - In the United States:

$$P_{US} = M^s_{US}/L\,(R_\$, Y_{US}) \qquad (15\text{-}3)$$

    - In Europe:

$$P_E = M^s_E/L\,(R_\euro, Y_E) \qquad (15\text{-}4)$$

A Long-Run Exchange Rate Model Based on PPP

- The monetary approach makes a number of specific predictions about the long-run effects on the exchange rate of changes in:
  - Money supplies
    - An increase in the U.S. (European) money supply causes a proportional long-run depreciation (appreciation) of the dollar against the euro.
  - Interest rates
    - A rise in the interest rate on dollar (euro) denominated assets causes a depreciation (appreciation) of the dollar against the euro.
  - Output levels
    - A rise in U.S. (European) output causes an appreciation (depreciation) of the dollar against the euro.

A Long-Run Exchange Rate Model Based on PPP

■ **Ongoing Inflation, Interest Parity, and PPP**

- Money supply growth at a constant rate eventually results in ongoing inflation (i.e., continuing rise in the price level) at the same rate.

  – Changes in this long-run inflation rate do not affect the full-employment output level or the long-run relative prices of goods and services.

- The interest rate is not independent of the money supply growth rate in the long run.

A Long-Run Exchange Rate Model Based on PPP

- The international interest rate difference is the difference between expected national inflation rates:

$$R_\$ - R_€ = \pi^e_{US} - \pi^e \qquad\qquad (15\text{-}5)$$

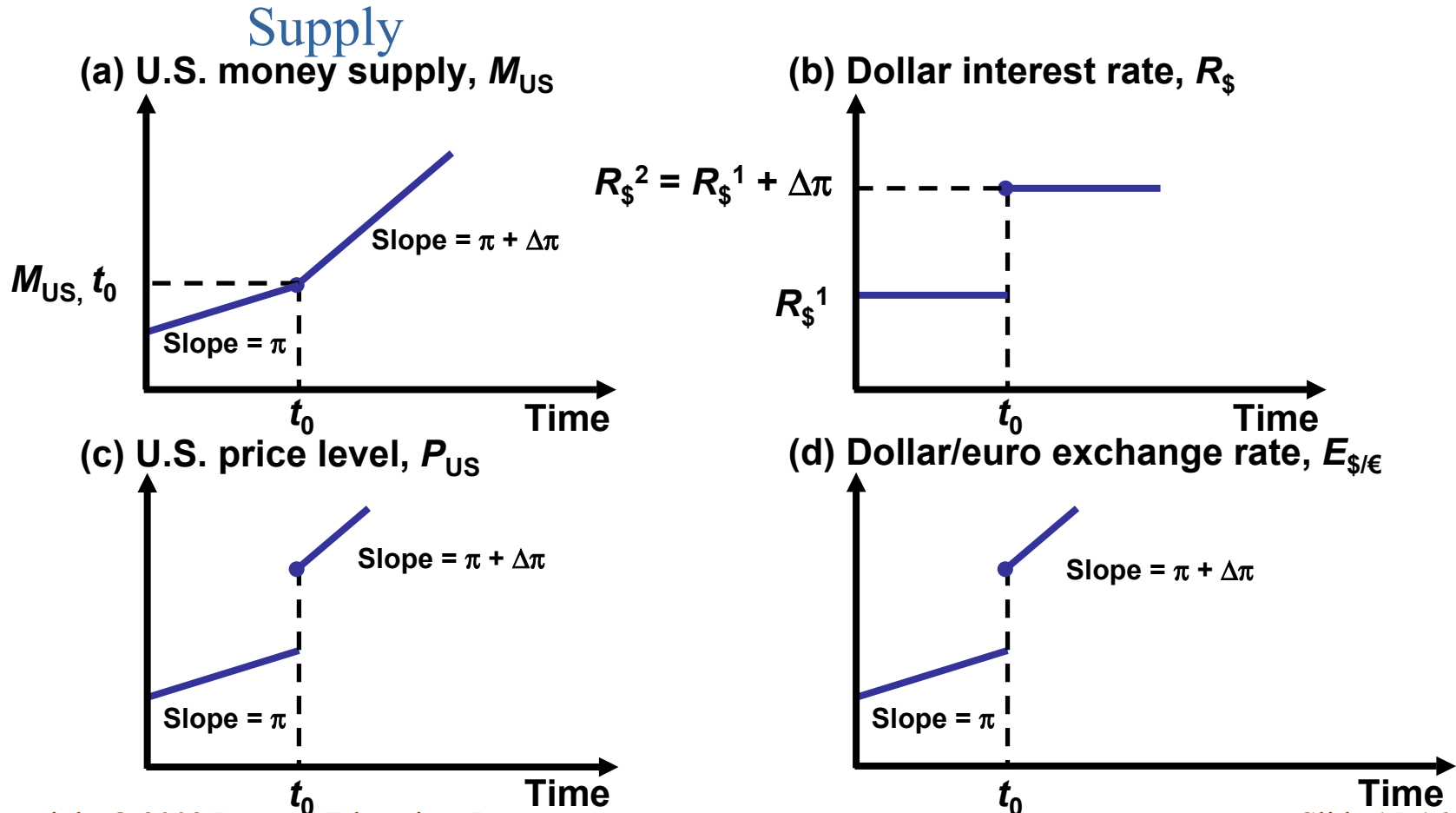# A Long-Run Exchange Rate Model Based on PPP

- **The Fisher Effect**

  - A rise (fall) in a country's expected inflation rate will eventually cause an equal rise (fall) in the interest rate that deposits of its currency offer.

    – Figure 15-1 illustrates an example, where at time t_0 the Federal Reserve unexpectedly increases the growth rate of the U.S. money supply to a higher level.

A Long-Run Exchange Rate Model Based on PPP

Figure 15-1: Long-Run Time Paths of U.S. Economic Variables after a Permanent Increase in the Growth Rate of the U.S. Money Supply

(a) U.S. money supply, M_{US}

M_{US, t_0}

Slope = $\pi + \Delta\pi$

Slope = π

t_0 Time

(b) Dollar interest rate, $R_\$$

$R_\$^2 = R_\$^1 + \Delta\pi$

$R_\$^1$

t_0 Time

(c) U.S. price level, P_{US}

Slope = $\pi + \Delta\pi$

Slope = π

t_0 Time

(d) Dollar/euro exchange rate, $E_{\$/€}$

Slope = $\pi + \Delta\pi$

Slope = π

t_0 Time

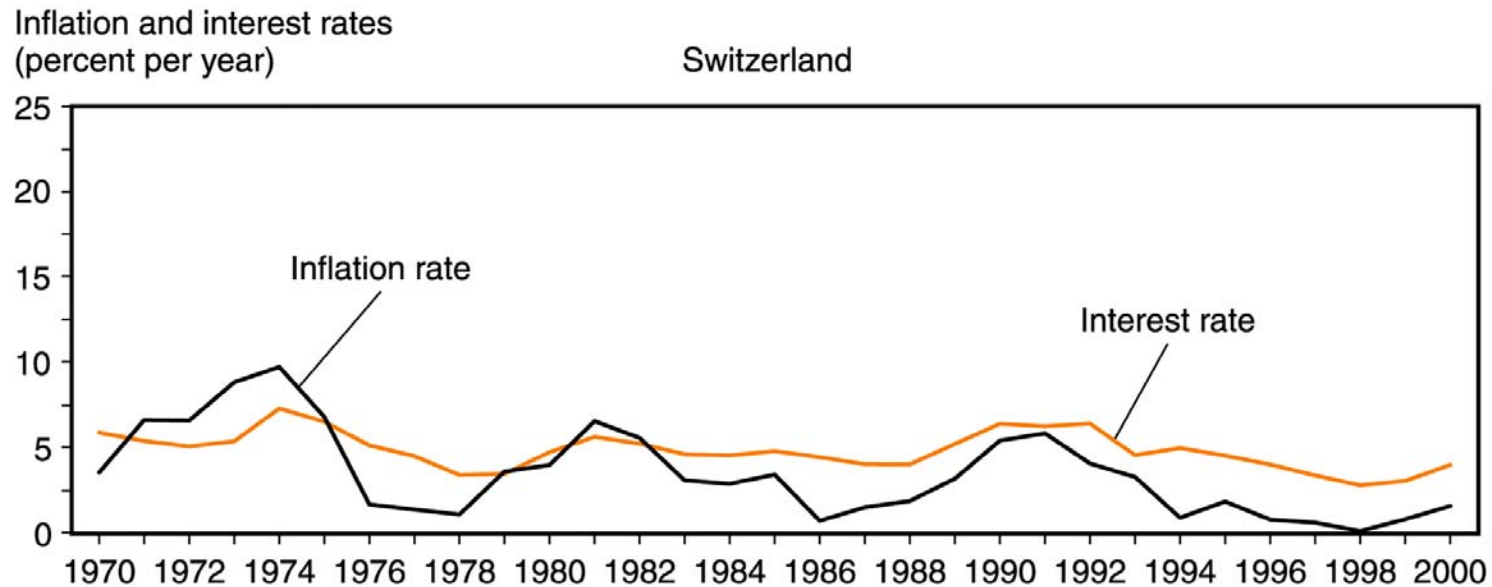# A Long-Run Exchange Rate Model Based on PPP

- In this example, the dollar interest rate rises because people expect more rapid future money supply growth and dollar depreciation.

- The interest rate increase is associated with higher expected inflation and an immediate currency depreciation.

- Figure 15-2 confirms the main long-run prediction of the Fisher effect.

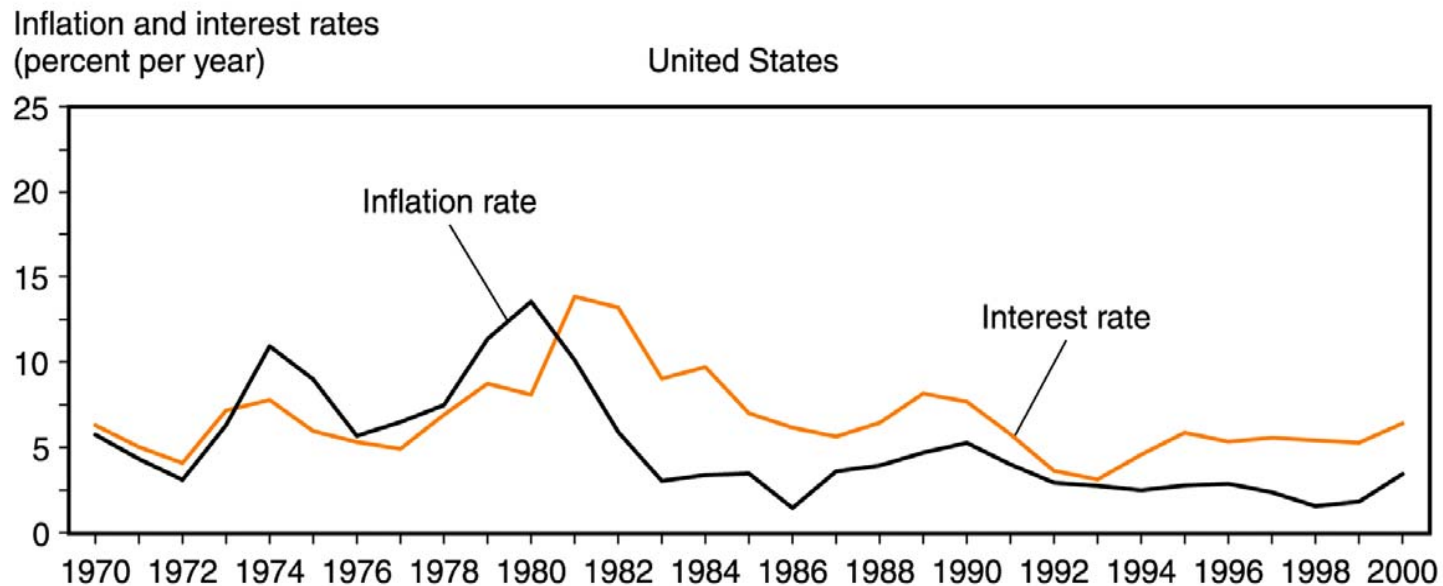# A Long-Run Exchange Rate Model Based on PPP

Figure 15-2: Inflation and Interest Rates in Switzerland, the United States, and Italy, 1970-2000
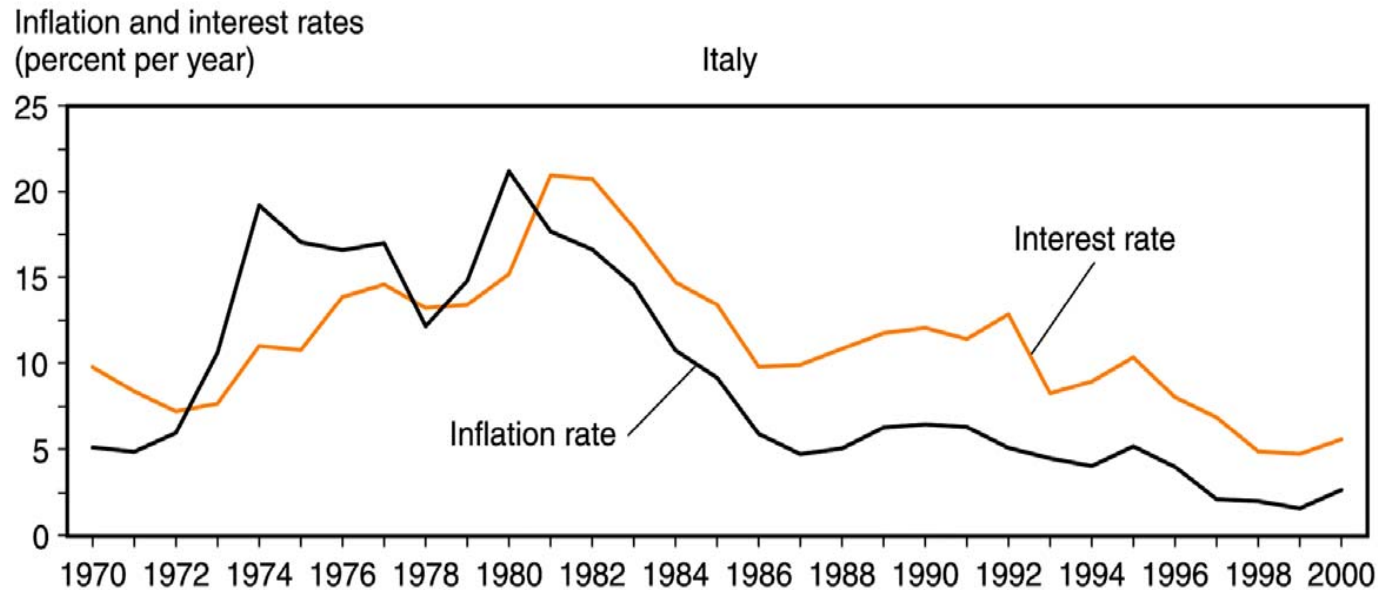
A Long-Run Exchange Rate Model Based on PPP

Figure 15-2: Continued

A Long-Run Exchange Rate Model Based on PPP

Figure 15-2: Continued

Inflation and interest rates
(percent per year)

Italy

Interest rate

Inflation rate

Inflation and interest rates show
a long-run tendency to move together,
as the Fisher effect suggests.

Source: OECD, *Main Economic Indicators.*
Inflation rates are year-to-year percentage
changes in consumer price indexes.

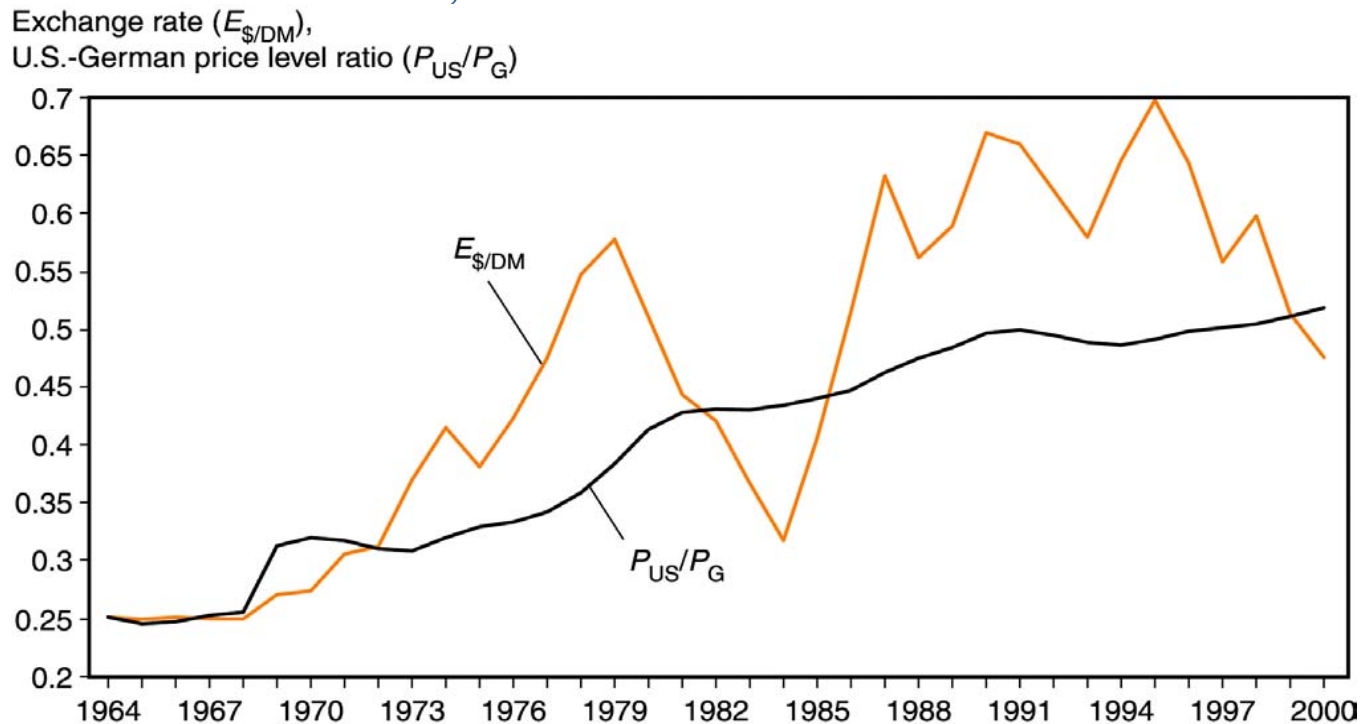# Empirical Evidence on PPP and the Law of One Price

- The empirical support for PPP and the law of one price is weak in recent data.

  - The prices of identical commodity baskets, when converted to a single currency, differ substantially across countries.

  - Relative PPP is sometimes a reasonable approximation to the data, but it performs poorly.

Empirical Evidence on PPP and the Law of One Price

Figure 15-3: The Dollar/DM Exchange Rate and Relative U.S./German Price Levels, 1964-2000

Exchange rate ($E_{\$/DM}$),
U.S.-German price level ratio (P_{US}/P_G)

The graph shows that relative PPP did not explain the dollar/DM exchange rate after 1970.

Source: OECD, *Main Economic Indicators*. Exchange rates and price levels are end-of-year data.

Explaining the Problems with PPP

- The failure of the empirical evidence to support the PPP and the law of one price is related to:
  - Trade barriers and nontradables
  - Departures from free competition
  - International differences in price level measurement

Explaining the Problems with PPP

- **Trade Barriers and Nontradables**
  - Transport costs and governmental trade restrictions make trade expensive and in some cases create nontradable goods.
    - The greater the transport costs, the greater the range over which the exchange rate can move.

Explaining the Problems with PPP

- **Departures from Free Competition**
  - When trade barriers and imperfectly competitive market structures occur together, linkages between national price levels are weakened further.
  - **Pricing to market**
    - When a firm sells the same product for different prices in different markets.
    - It reflects different demand conditions in different countries.
      - Example: Countries where demand is more price-inelastic will tend to be charged higher markups over a monopolistic seller's production cost.
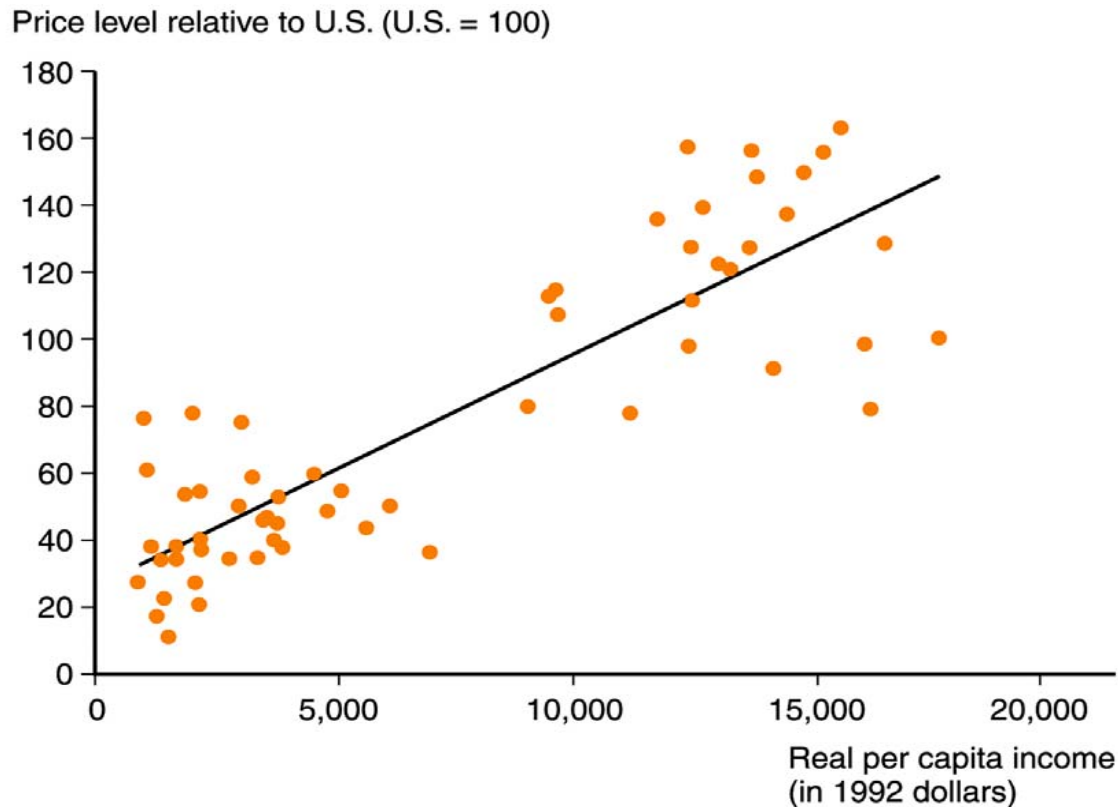
Explaining the Problems with PPP

- **International Differences in Price Level Measurement**
  - Government measures of the price level differ from country to country because people living in different counties spend their income in different ways.

- **PPP in the Short Run and in the Long Run**
  - Departures from PPP may be even greater in the short-run than in the long run.
    - Example: An abrupt depreciation of the dollar against foreign currencies causes the price of farm equipment in the U.S. to differ from that of foreign's until markets adjust to the exchange rate change.

Explaining the Problems with PPP

Figure 15-4: Price Levels and Real Incomes, 1992

Countries' price levels tend to rise as their real incomes rise. Each dot represents a country. The straight line indicates a statistician's best prediction of a country's price level relative to the United States based on knowing its real per capita income.

Beyond Purchasing Power Parity: A General Model of Long-Run Exchange Rates

- **The Real Exchange Rate**
  - It is a broad summary measure of the prices of one country's goods and services relative to the other's.
  - It is defined in terms of **nominal exchange rates** and price levels.
  - The real dollar/euro exchange rate is the dollar price of the European basket relative to that of the American:

$$q_{\$/€} = (E_{\$/€} \times P_E)/P_{US} \qquad (15\text{-}6)$$

  - Example: If the European reference commodity basket costs €100, the U.S. basket costs $120, and the nominal exchange rate is $1.20 per euro, then the real dollar/euro exchange rate is 1 U.S. basket per European basket.

Beyond Purchasing Power Parity: A General Model of Long-Run Exchange Rates

- **Real depreciation** of the dollar against the euro
  - A rise in the real dollar/euro exchange rate
    - That is, a fall in the purchasing power of a dollar within Europe's borders relative to its purchasing power within the United States
    - Or alternatively, a fall in the purchasing power of America's products in general over Europe's.

- A **real appreciation** of the dollar against the euro is the opposite of a real depreciation.

Beyond Purchasing Power Parity: A General Model of Long-Run Exchange Rates

- **Demand, Supply, and the Long-Run Real Exchange Rate**
  - In a world where PPP does not hold, the long-run values of real exchange rates depend on demand and supply conditions.

Beyond Purchasing Power Parity: A General Model of Long-Run Exchange Rates

- There are two specific causes that explain why the long-run values of real exchange rates can change:
  - A change in world relative demand for American products
    - An increase (fall) in world relative demand for U.S. output causes a long-run real appreciation (depreciation) of the dollar against the euro.
  - A change in relative output supply
    - A relative expansion of U.S (European) output causes a long-run real depreciation (appreciation) of the dollar against the euro.

Beyond Purchasing Power Parity: A General Model of Long-Run Exchange Rates

- **Nominal and Real Exchange Rates in Long-Run Equilibrium**
  - Changes in national money supplies and demands give rise to the proportional long-run movements in nominal exchange rates and international price level ratios predicted by the relative PPP theory.
  - From Equation (15-6), one can obtain the nominal dollar/euro exchange rate, which is the real dollar/euro exchange rate times the U.S.-Europe price level ratio:

$$E_{\$/\text{€}} = q_{\$/\text{€}} \times (P_{\text{US}}/P_{\text{E}}) \qquad (15\text{-}7)$$

Beyond Purchasing Power Parity: A General Model of Long-Run Exchange Rates

- Equation (15-7) implies that for a given real dollar/euro exchange rate, changes in money demand or supply in Europe or the U.S. affect the long-run nominal dollar/euro exchange rate as in the monetary approach.

  – Changes in the long-run real exchange rate, however, also affect the long-run nominal exchange rate.

Beyond Purchasing Power Parity: A General Model of Long-Run Exchange Rates

- The most important determinants of long-run swings in nominal exchange rates (assuming that all variables start out at their long-run levels):
  - A shift in relative money supply levels
  - A shift in relative money supply growth rates
  - A change in relative output demand
  - A change in relative output supply

Beyond Purchasing Power Parity: A General Model of Long-Run Exchange Rates

- When all disturbances are monetary in nature, exchange rates obey relative PPP in the long run.
  - In the long run, a monetary disturbance affects only the general purchasing power of a currency.
    - This change in purchasing power changes equally the currency's value in terms of domestic and foreign goods.
  - When disturbances occur in output markets, the exchange rate is unlikely to obey relative PPP, even in the long run.

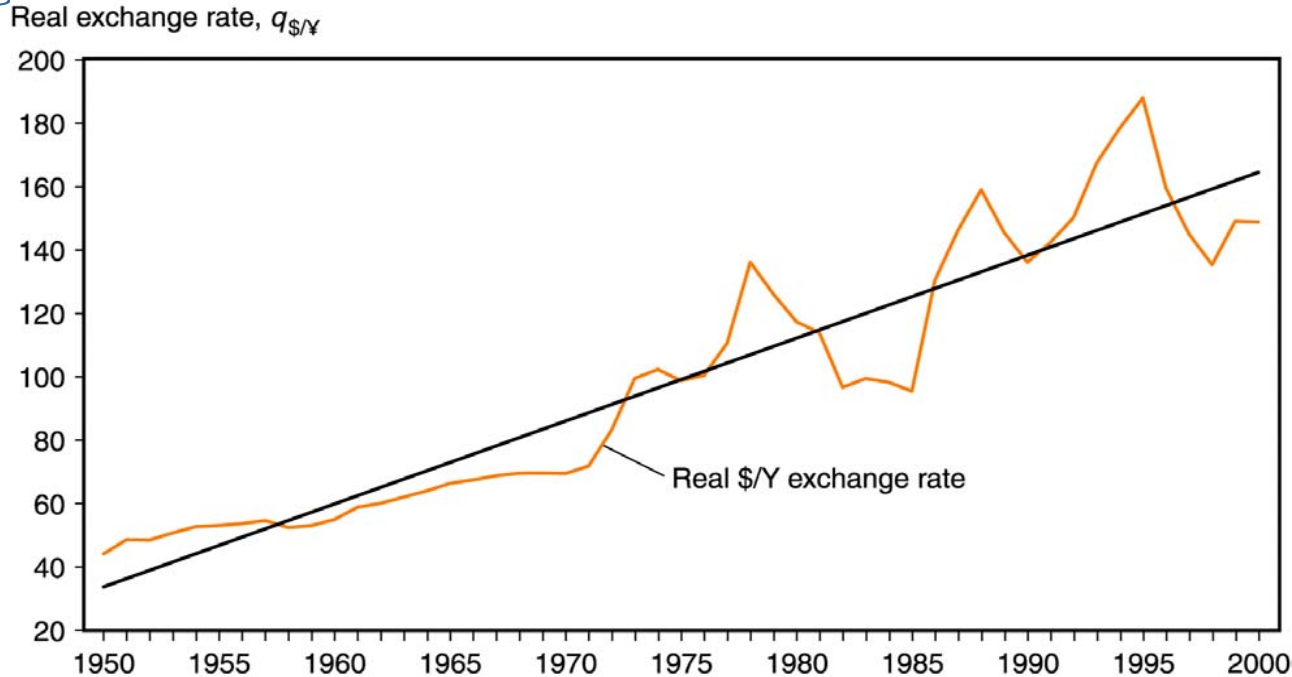# Beyond Purchasing Power Parity: A General Model of Long-Run Exchange Rates

Table 15-1: Effects of Money Market and Output Market Changes on the Long-Run Nominal Dollar/Euro Exchange Rate, $E_{\$/\euro}$

Change	Effect on the long-run nominal dollar/euro exchange rate, $E_{\$/\euro}$
Money market	
1. Increase in U.S. money supply level	Proportional increase (nominal depreciation of $)
2. Increase in European money supply level	Proportional decrease (nominal depreciation of euro)
3. Increase in U.S. money supply growth rate	Increase (nominal depreciation of $)
4. Increase in European money supply growth rate	Decrease (nominal depreciation of euro)
Output market	
1. Increase in demand for U.S. output	Decrease (nominal appreciation of $)
2. Increase in demand for European output	Increase (nominal appreciation of euro)
3. Output supply increase in the United States	Ambiguous
4. Output supply increase in Europe	Ambiguous

Figure 15-5: The Real Dollar/Yen Exchange Rate, 1950-2000

Real exchange rate, $q_{\$/\yen}$

The U.S. dollar has steadily depreciated in real terms against Japan's yen. (The straight line indicates the average trend over time in the real exchange rate.)
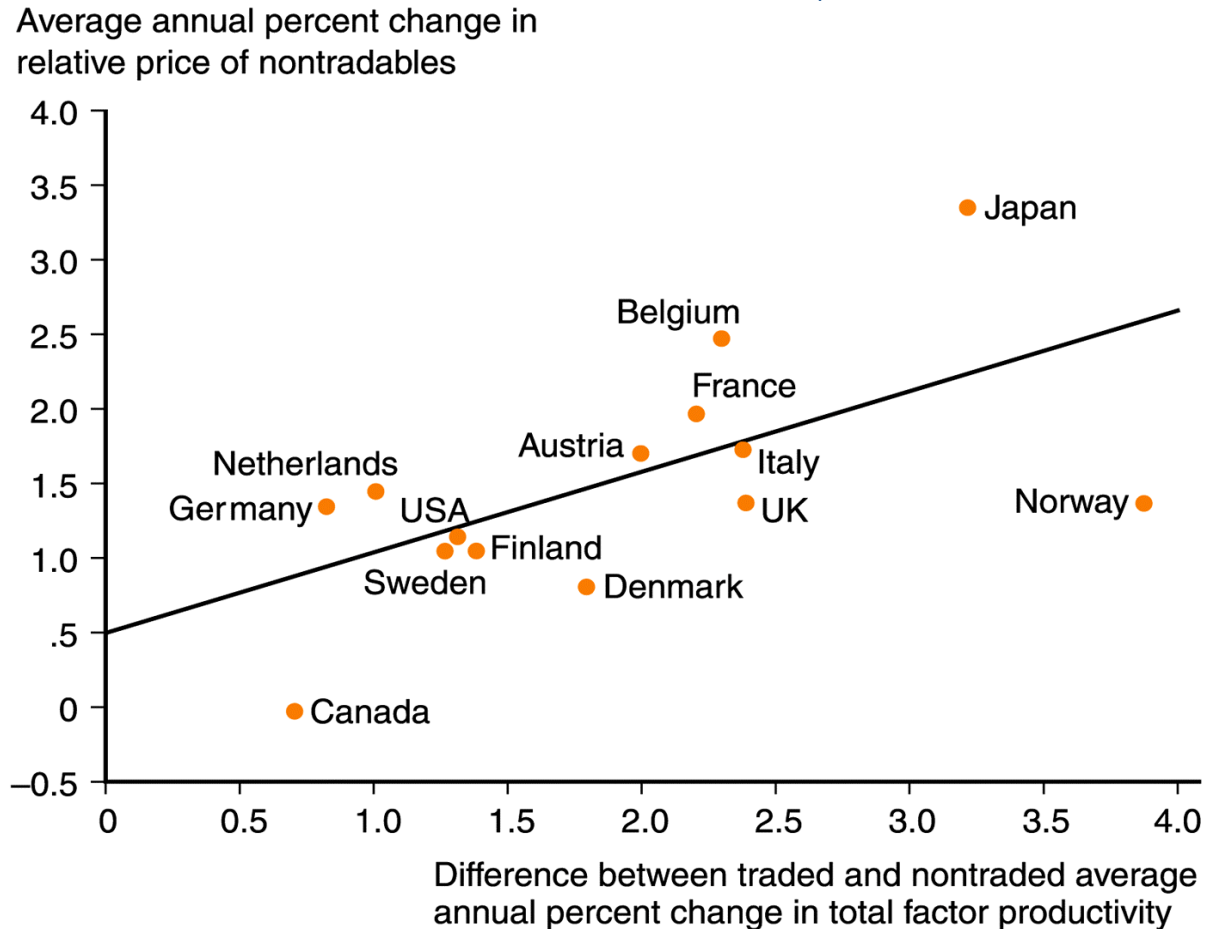
Source: Penn World Table, Mark 5.6, as described by Robert Summers and Alan Heston, "The Penn World Table (Mark 5); An Expanded Set of International Comparisons, 1950–1988." *Quarterly Journal of Economics* 106 (May 1991), pp. 327–368. Data for 1993–2000 from International Monetary Fund, *International Financial Statistics Yearbook 1997, 2001.*

Figure 15-6: Sectoral Productivity Growth Differences and the Change in the Relative Price of Nontraded Goods, 1970-1985

A higher traded–nontraded productivity growth difference is associated with a higher rate of increase in the relative price of nontradables.

International Interest Rate Differences and the Real Exchange Rate

- In general, interest rate differences between countries depend not only on differences in expected inflation, but also on expected changes in the real exchange rate.

- Relationship between the *expected* change in the real exchange rate, the *expected* change in the nominal rate, and *expected* inflation:

$$(q^e_{\$/€} - q_{\$/€})/q_{\$/€} = [(E^e_{\$/€} - E_{\$/€})/E_{\$/€}] - (\pi^e_{US} - \pi^e_{E}) \ (15\text{-}8)$$

International Interest Rate Differences and the Real Exchange Rate

- Combining Equation (15-8) with the interest parity condition, the international interest gap is equal to:

$$R_\$ - R_\euro = [(q^e_{\$/\euro} - q_{\$/\euro})/q_{\$/\euro}] + (\pi^e_{US} - \pi^e_E) \qquad (15\text{-}9)$$

  - Thus, the dollar-euro interest difference is the sum of two components:
    - The expected rate of real dollar depreciation against the euro
    - The expected inflation difference between the U.S. and Europe
  - When the market expects relative PPP to prevail, the dollar-euro interest difference is just the expected inflation difference between U.S. and Europe.

Real Interest Parity

- Economics makes an important distinction between two types of interest rates:
  - **Nominal interest rates**
    - Measured in monetary terms
  - **Real interest rates**
    - Measured in real terms (in terms of a country's output)
    - Referred to as expected real interest rates

Real Interest Parity

- The expected real interest rate (r^e) is the nominal interest rate (r) less the expected inflation rate (π^e).

- Thus, the difference in expected real interest rates between U.S. and Europe is equal to:

$$r^e_{US} - r^e_E = (R_\$ - \pi^e_{US}) - (R_€ - \pi^e_E)$$

- By combining this equation with Equation (15-9), one can obtain the desired real interest parity condition:

$$r^e_{US} - r^e_E = (q^e_{\$/€} - q_{\$/€})/q_{\$/€} \qquad (15\text{-}10)$$

Real Interest Parity

- The real interest parity condition explains differences in expected real interest rates between two countries by expected movements in the real exchange rates.

- Expected real interest rates in different countries need not be equal, even in the long run, if continuing change in output markets is expected.

Summary

- Absolute PPP states that the purchasing power of any currency is the same in any country and implies relative PPP.

- Relative PPP predicts that percentage changes in exchange rates equal differences in national inflation rates.

- The law of one price is a building block of the PPP theory.
  - It states that under free competition and in the absence of trade impediments, a good must sell for a single price regardless of where in the world it is sold.

Summary

- The monetary approach to the exchange rate uses PPP to explain long-term exchange rate behavior exclusively in terms of money supply and demand.
  - The Fisher effect predicts that long-run international interest differentials result from different national rates of ongoing inflation.
- The empirical support for PPP and the law of one price is weak in recent data.
  - The failure of these propositions in the real world is related to trade barriers, departure from free competition and international differences in price level measurement.

Summary

- Deviations from relative PPP can be viewed as changes in a country's real exchange rate.

- A stepwise increase in a country's money stock leads to a proportional increase in its price level and a proportional fall in its currency's foreign exchange value.

- The (real) interest parity condition equates international differences in nominal (real) interest rates to the expected percentage change in the nominal (real) exchange rate.

Appendix: The Fisher Effect, the Interest Rate, and the Exchange Rate Under the Flexible-Price Monetary Approach

Figure 15A-1: How a Rise in U.S. Monetary Growth Affects When Goods Prices are Flexible